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# Revising the effectiveness of municipal waste management in Hong Kong

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Although there have been many studies related to the municipal solid waste (MSW) problem in Hong Kong, only limited research has recently discussed the spatial variation of citizens' environmental awareness in different geographical constituencies. Also, the relationship between environmental awareness of citizens and the effectiveness of waste management has been poorly understood. This research aims to evaluate the effectiveness of three proposed approaches; investigate whether the environmental awareness of citizens will affect the effectiveness of current waste management strategies; and examine the differences in the level of environmental awareness of residents in different geographical constituencies, so we can provide suggestions to help mitigate the solid waste problem. In addition, the hypothesis is that there is a relationship between environmental awareness of citizens and its effectiveness. This research adopted quantitative observations and questionnaires as well as qualitative interviews to understand the public perception about the proposed MSW charging, plastic shopping bag charging and recycling in Hong Kong. This research confirmed that the environmental awareness of Hong Kong citizens varies among various geographical constituencies. Residents in Kowloon West have comparatively lower environmental awareness may due largely to the socio-economic background of residents and comparatively unhygienic environment, and they often do not support plastic shopping bag charging and recycling. In addition, males have a lower environmental awareness than females as their attitude towards charging policy may not have much impact on their lifestyle. It is not surprising that low environmental awareness of citizens will reduce the effectiveness of current environmental policies. MSW charging tends to be effective and should be implemented in Hong Kong. Furthermore, plastic shopping bag charging can be effective in the short term but ineffective in the long term, and recycling tends to be invalid as Hong Kong has not developed a circular economy. The limitations of each policy should be considered, and more studies are needed to improve the existing policies as well as exploring novel ways to solve the MSW problem.

## KEYWORDS

municipal solid waste (MSW), waste management, municipal solid waste charging, plastic shopping bag charging, recycling, Hong Kong

## 1 Introduction

Municipal waste management is a pressing issue that challenges every country as massive amount of waste in landfills and incinerators contributes to global warming (Calabro, 2009; Hoornweg and Bhada-Tata, 2012). Waste hierarchy provides guidance for handling Municipal Solid Waste (MSW). In the waste hierarchy, there is a ranking among

prevention (minimization), reuse, recycling, recovery, and disposal (Bartl, 2014). Prevention is the utmost important while disposal is the least important. Prevention includes changing citizens' behavior to reduce waste generation and be more environmentally friendly, such as the proposed MSW charging scheme and plastic bag levy (Gregson et al., 2013). This can be achieved by enhancing product durability and extending product life cycle (Cole et al., 2019). Reuse is the mending of materials and using them more than once (Gharfalkar et al., 2015). Recycling means turning waste into new substances or products (Pires & Martinho, 2019). Recovery suggests incineration to turn waste into energy (Teigiserova et al., 2020). Disposal is the final way to handle solid waste, which comprises transporting waste to landfills (Van Ewijk and Stegemann, 2016).

The MSW charging scheme was proposed in 2012 in Hong Kong and the public was consulted based on Polluter-Pays Principle (PPP). Polluters should compensate for the damage caused and pay for the cost of handling MSW (Chamizo-González et al., 2018). MSW charging encourages waste reduction instead of cost recovery (Wut et al., 2020). It is noteworthy that charging based on bags and stickers as well as weight can motivate citizens to reduce waste and provide revenue to the government, while the weight-based charging mechanism can be more precise in understanding differences in waste generation (Alzamora and Barros, 2020). Nevertheless, effective MSW charging requires monitoring and enforcement to prevent counterfeiting and violation of laws. For instance, Yang and Innes (2007) revealed more illegal waste dumping shall be induced by a charging scheme. Japan is an example showing the cases of illegal dumping increased after introducing law restrictions on domestic waste (Lee and Na, 2010). Developing countries with lower *per capita* Gross Domestic Product (GDP) and Human Development Index (HDI) usually use flat rate for MSW charging, have lower recycling rate and lower *per capita* solid waste generation; while developed countries with higher *per capita* GDP and HDI tend to use flat rate or Pay as you throw (PAYT) for MSW charging, and have higher recycling rate as well as higher *per capita* solid waste generation (Alzamora and Barros, 2020). This may be owing to higher education levels leading to higher environmental awareness as well as luxurious lifestyles of citizens in developed countries, and *vice versa*.

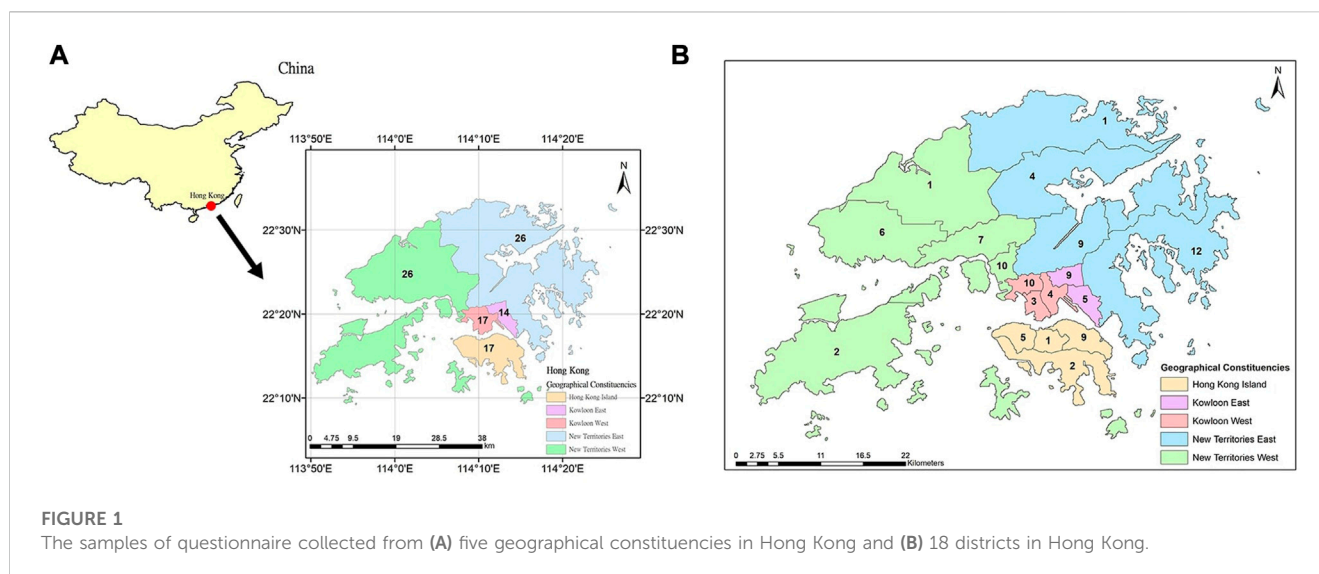
By implementing PPP, the Producer Responsibility Scheme (PRS) requires corresponding stakeholders, including importers, manufacturers, wholesalers, retailers and consumers, to share the responsibility of collecting, recycling, treating and discarding waste products (Gottberg et al., 2006). Most countries implementing plastic bag charging policies have reduced their consumption of plastic bags by at least about half (Nielsen et al., 2019). For example, Ireland reduced plastic bag consumption by 90% (Convery et al., 2007); England reduced plastic bag consumption by 85% after implementing plastic bag charging levy (Poortinga et al., 2016). However, the effectiveness is usually short-term, since most policies have been implemented in recent years, the plastic bag sales may rebound in the long term (Chandra, 2020). For instance, in Sweden, plastic bag levy first caused plastic bag sales to fall by 42%, but then it increased by 23% between 2004 and 2016 (Nielsen et al., 2019). However, the cumulative impact of the plastic bag charging policies on a global scale is still uncertain, and the exact impact of such policies on reducing global plastic pollution is also doubtful. Plastic shopping bag charging is a price-based instrument implemented in

2009 in Hong Kong based on PRS to reduce public consumption of plastic bags. Unless there is an exemption, retailers should charge at least HK\$0.5 for each plastic bag provided to consumers (Wan et al., 2018).

A circular economy is constructed in which raw materials are designed, manufactured into products, distributed, consumed and recycled (Stahel, 2016). Recycling plays a vital role in a circular economy. Many developing countries and developed countries have utilized recycling to reduce MSW. On the one hand, developed countries usually use roadside recycling programmes to collect and sort waste for recycling (Troschinetz and Mihelcic, 2009). On the other hand, developing countries use social sectors called scavengers for such activities (Troschinetz and Mihelcic, 2009). Scavengers are low-income or no-income citizens who collect materials scattered throughout the city or concentrated at dumpsites (Wilson et al., 2006). They sell the recyclables to recycling shops, middlemen or exporters (Troschinetz and Mihelcic, 2009). Scavengers are usually forced to work in harsh conditions, putting their health and safety at risk (Nas and Jaffe, 2004). They play a vital role in saving resources and conserving the environment (Sembiring and Nitivattananon, 2010). MSW management personnel education, waste collection and segregation, and government finances are the three biggest obstacles to recycling in developing countries (Troschinetz and Mihelcic, 2009). The challenge of plastic recycling is reflected in the low recycling rate –14% of plastics are collected for global recycling, while 58% of paper and 70%–90% of iron and steel are recycled (Neufeld et al., 2016).

Hong Kong is one of the most densely populated cities with a population of more than seven million people. With high population density, however, Hong Kong has limited land for development, particularly for waste management. Thus, handling solid waste, especially municipal solid waste (MSW), is a pressing issue in Hong Kong as MSW has induced a lot of environmental problems, such as land and groundwater pollution. As such, proper handling of MSW in Hong Kong is of the utmost importance to achieve sustainable development. This study mainly focuses on MSW charging, plastic shopping bag levy and recycling, which cover prevention, recycling, and disposal in the waste hierarchy. Nevertheless, MSW charging, plastic bag levy and recycling in Hong Kong, especially the variation between different territories, have been poorly investigated/understood. In addition, public environmental awareness may affect the effectiveness of waste management in Hong Kong, but not many studies have been conducted in this aspect. This study can be used to supplement the existing literature to understand the differences of environmental attitude of people in different parts of Hong Kong.

In addition, many researchers have employed quantitative research approaches to study the effectiveness of waste management, such as MSW charging (Alzamora and Barros, 2020; Yeung and Chung, 2018), plastic bag levy (He, 2012; Muralidharan and Sheehan, 2016), and recycling (Ko et al., 2020; Lawrence et al., 2020). These previous studies were mostly based on quantitative questionnaires and secondary datasets. Furthermore, the opinion from government officials and NGO members are omitted. The objectives of this research are to 1) evaluate the effectiveness of the proposed MSW charging scheme, plastic shopping bag charging, and recycling; 2) investigate whether the environmental awareness of citizens will affect the effectiveness of



current waste management strategies; and 3) examine whether there were any spatial differences in the level of environmental awareness of residents in different geographical constituencies to provide suggestions to help mitigate the solid waste problem. The findings of this work provide insight to improve the existing municipal waste management policies as well as exploring new ways to solve the MSW problem.

## 2 Materials and methods

### 2.1 Study area

Hong Kong, is a coastal city, located in southeast tern of China (Figure 1A). The population of Hong Kong was 7.34 million in 2016, more than double that of 1961; the proportion of the elderly in the population had also increased to 16%, while the proportion of children had dropped to 11% (Census and Statistics Department, 2015). This had shown a densely populated and ageing society. The sex ratio (referring to the number of males per thousand females) had been declining since the 1980s (Census and Statistics Department, 2012). Also, the education level of the population continued to improve. In 2016, nearly one-third of the population had attended post-secondary education programs (Census and Statistics Department, 2015). There was an increasing number of females entering the labor market (Census and Statistics Department, 2015). The median monthly income from major occupations of the working population (excluding foreign domestic helpers) was HK\$15,500 in 2016, a significant increase of 29.2% compared with HK\$12,000 in 2011 (Census and Statistics Department, 2017). Due to population growth and a rising living standard, a considerable amount of solid waste was discarded by citizens every day. 18 districts in Hong Kong were grouped into five geographical constituencies (Figure 1B). The focus of this study was the time period from 2000 to 2020, particularly in 2020 when COVID-19 pandemic was prevailing in Hong Kong, the social distancing policies were crucial for the MSW generation.

There were 9 recycling stations, 22 recycling stores, and some recycling spots in Hong Kong to facilitate recycling (EPD, 2021a; EPD, 2021b). The Environmental Protection Department (EPD) also set up some outreach teams called “Green Outreach” to offer on-site briefings for property management companies and the residents to comprehend waste classification and clean recycling (EPD, 2018). Besides, the government encouraged the recycling of Waste Electrical and Electronic Equipment (WEEE) by setting up e-waste collection stations in 18 districts during Saturdays and Sundays (Ko, 2020).

### 2.2 Research design

This study depended on primary and secondary data obtained from diverse sources. Primary data included quantitative observations and questionnaires, as well as qualitative interviews. In terms of field observation, two recycling facilities, including recycling bins situated on streets, and reverse vending machines placed in shopping malls and supermarkets, would be selected to understand the operating mechanism of recycling as well as plastic shopping bag charging. Moreover, questionnaires would be distributed to gather the behavior of citizens and their comments towards the effectiveness of MSW charging, plastic shopping bag charging and recycling. Besides, three online interviews were conducted with various stakeholders, such as an official from the EPD, an employee of a local glass bottle recycling company, and the senior project officer of an environmental organization, Community Leap, to collect their opinion towards 1) environmental awareness of citizens, 2) effectiveness of MSW charging pilot scheme, plastic shopping bag charging and recycling in Hong Kong, 3) limitations of their own parties, and 4) suggestions to improve current waste management system. To protect the privacy of interviewees and encourage responses, only the names of the interviewees who agreed to disclose their names would be shown; the name, title or organization of other interviewees were not shown when expressing opinions in this research. Some data might also come from previous field visits related to recycling companies and

**TABLE 1** The Sample size of the survey according to geographical constituencies.

Geographical constituencies (GC)	Samples	Districts included in GC (samples collected from the survey)
Hong Kong Island	17	Central and Western (5), Wan Chai (1), Eastern (9), Southern (2)
Kowloon West	17	Yau Tsim Mong (3), Sham Shui Po (10), Kowloon City (4)
Kowloon East	14	Wong Tai Sin (9), Kwun Tong (5)
New Territories West	26	Tsuen Wan (7), Tuen Mun (6), Yuen Long (1), Kwai Tsing (10), Islands (2)
New Territories East	26	North (1), Tai Po (4), Sha Tin (9), Sai Kung (12)
Total samples	100	

landfills, as well as part-time work experience related to the proposed MSW charging pilot scheme.

Regarding field observation, site visits were conducted from September 2020 to February 2021 during daytime and nighttime to collect primary data after designing the routes and locations. It aimed to figure out the operation mechanisms of the recycling facilities as well as the popularity of people using recycling facilities and purchasing plastic shopping bags. The observations associated with the said recycling facilities and supermarket were conducted in the morning (8:30 a.m. to 12:30 p.m.), afternoon (1:00 p.m. to 5:00 p.m.), and evening (5:30 p.m. to 9:30 p.m.) during a weekday and a public holiday. During the observation period, the number of people using recycling facilities as well as the number of customers buying plastic bags were recorded.

A survey in terms of a questionnaire was conducted between December 2020 and February 2021 (Supporting Material). The questionnaire would investigate 1) public habits of solid waste disposal and 2) the knowledge and opinions of citizens on solid waste treatment by using stratified random sampling. The sample size was 100. The entire population was separated into groups (strata) based on the numbers of seats in five geographical constituencies of the Hong Kong Legislative Council Election in 2016, including New Territories West (26 samples), New Territories East (26 samples), Hong Kong Island (17 samples), Kowloon West (17 samples) and Kowloon East (14 samples) (Table 1; Figure 1). Samples were collected from each stratum and every district by utilizing simple random sampling. Mainly semi-closed multiple-choice questions and 5-point Likert Scale questions to measure assent of respondents with 1–5 rating scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree) would be asked to gather public behavior and perceptions. Microsoft Excel and ArcGIS (Version 10.8.1) were used for data analysis.

After realizing the pattern of the public using recycling facilities, the number of people purchasing plastic shopping bags in a given period of time, and their views on waste management in Hong Kong, interviews with the EPD official, an employee from a local glass bottle recycling company, and senior project officer of Community Leap were carried out in February 2021. The interviews hoped to further explore the environmental awareness of citizens, the effectiveness of the three waste management approaches, limitations of different stakeholders in waste management, and suggestions to improve the waste management strategies in Hong Kong. Both open-ended

and closed-ended questions were asked, but open-ended questions accounted for the majority.

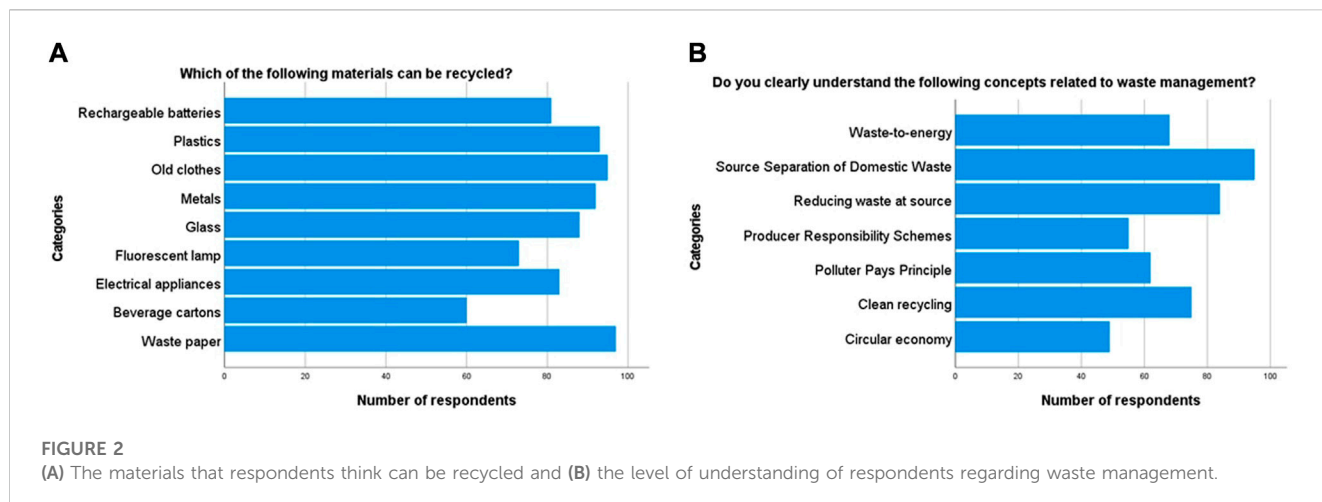
## 2.3 Statistical analysis

With the intention of a more comprehensive analysis, this study emphasized the use of both quantitative and qualitative methodological approaches. On the one hand, quantitative methods were used to quantify the number of people using recycling facilities and buying plastic shopping bags; and through observation and questionnaire surveys, the behavior and opinions of citizens related to waste disposal as well as waste management were acquired. Then trends could be shown by using quantitative approaches. The data were analyzed by using chi-square test, independent-samples *t*-test, and one-way analysis of variance (ANOVA) in the SPSS. Chi-square test and the independent samples *t*-test were used to compare the mean score between citizens with different demographic characteristics. One-way ANOVA was used to compare the mean score among districts. Also, the mean score of some questions in the questionnaires would be presented in the form of geographic information system (GIS) maps. On the other hand, qualitative methods were used to get a thorough understanding about waste management, explain how the environmental awareness of citizens affect the current waste management and help various actors (government and NGOs) to boost the recycling rate through conducting interviews.

## 3 Results

### 3.1 Environmental awareness of citizens in Hong Kong

In the interview, the interviewees from the EPD, a local glass bottle recycling company, and Community Leap revealed that the environmental awareness of citizens had been divided into two distinct groups. On the one hand, females, adolescents and high-income groups tended to have higher environmental awareness and attitude. They would attempt to reduce waste at source and carry out more recycling. On the other hand, males, middle-aged and elderly people and low-income group tended to have lower environmental awareness in a sense that the MSW problem in Hong Kong had nothing to do with them, and it was inconvenient for them to



conduct environmentally friendly measures. According to the MSW charging pilot scheme conducted by Community Leap, approximately 70%–80% of participants supported MSW charging after joining the pilot scheme.

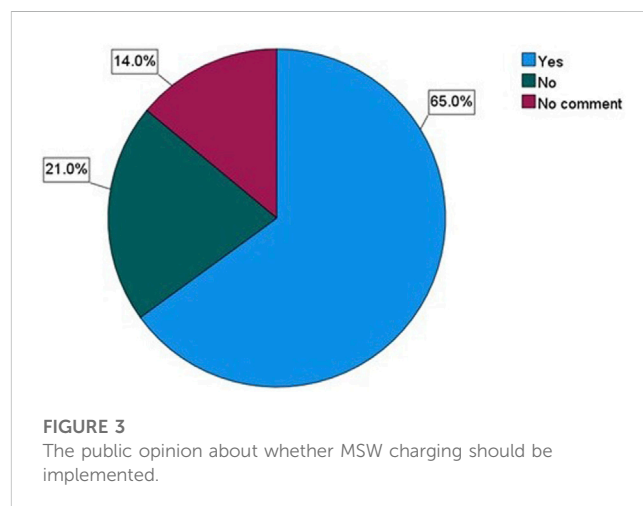
The survey revealed citizens’ understanding about environmental knowledge. Respondents had to recognize the materials that were recyclables. Among 100 respondents, most of the respondents could recognize that waste paper was recyclable (97%), followed by old clothes (95%), plastics (93%), and metals (92%) (Figure 2A). However, the fewest respondents recognized that fluorescent lamps (73%) and beverage cartons (60%) were recyclables. In fact, all of the listed materials were recyclables but not all respondents were acquainted with all of the recyclables in Hong Kong (Supporting Material).

Also, respondents had a relatively high understanding about the concepts related to waste management (Figure 2B). Among 100 respondents, most of the respondents comprehended source separation of domestic waste (95%), followed by reducing waste at source (84%) and clean recycling (75%) (Figure 2B). Those three concepts were related to reducing waste and recycling. However, only about half of the respondents (49%) understood the concept of the circular economy, which implied that Hong Kong citizens paid less attention to the development of the circular economy.

### 3.2 MSW charging

Judging from the interview, Community Leap conducted a MSW charging pilot scheme in five housing estates that covered more than 100 households, in which three to four blocks were invited to take part in the pilot scheme. After the first month of implementation of the pilot project, the waste generation rate of the housing estates was reduced by 18%, and recycling rate was increased by 29% till the last month of implementation. This indicates that MSW charging could effectively reduce MSW in Hong Kong.

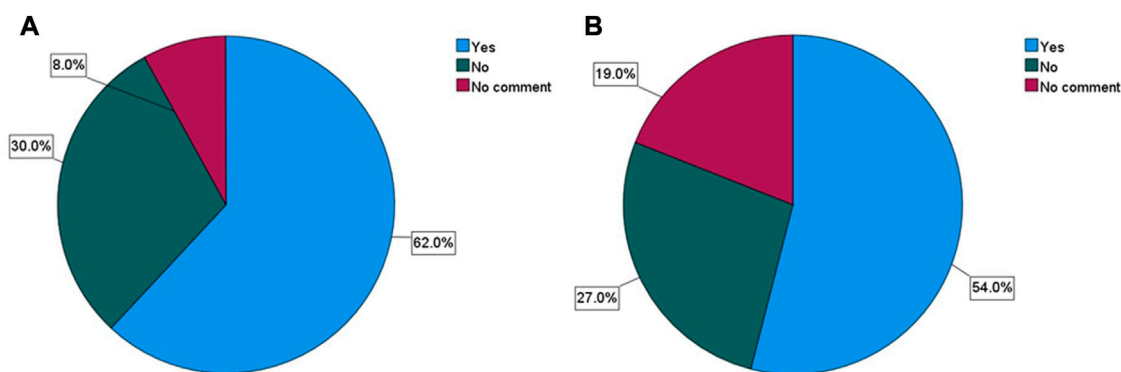
Regarding the implementation of MSW charging in Hong Kong, amid 100 respondents, 65 respondents (65%) agreed that MSW charging should be established, while 21 respondents (21%) opposed this proposed policy and 14 respondents (14%) had no comment (Figure 3). There was a significant difference between age and the



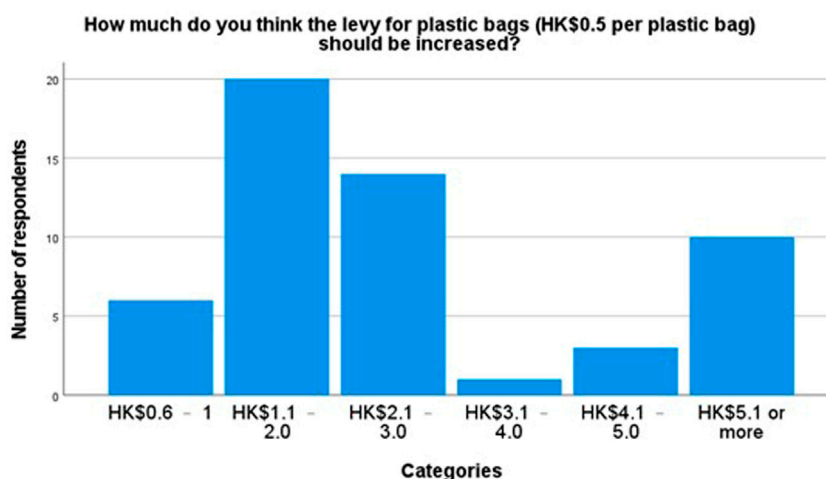
willingness of respondents to implement MSW charging,  $X^2(4, N = 100) = 11.08, p < 0.05$ . People at the age of 35 or below (young adults) tended to support the implementation of MSW charging while people at the age of 36 or above (adults) tended not to support MSW charging.

### 3.3 Plastic shopping bag charging

Concerning the effectiveness of plastic bag levy, amid 100 respondents, 62% of the respondents considered that this policy could encourage them to reduce the generation of plastic waste while 30% of respondents thought that this policy could not encourage them to reduce plastic waste production (Figure 4A). There was a significant difference between residing districts and whether plastic bag levy could encourage them to reduce the production of plastic waste,  $X^2(8, N = 100) = 20.780, p < 0.05$ . Most residents in Hong Kong Island tended to perceive that this policy was effective, followed by that of Kowloon East and New Territories East. More residents in Kowloon West believed that this policy was ineffective, followed by that of New Territories West.



**FIGURE 4** Respondents' opinion about (A) whether plastic bag levy can encourage them to reduce the production of plastic waste and (B) whether the amount of plastic bag levy should be raised.



**FIGURE 5** The charge of plastic bag levy that respondents want to raise.

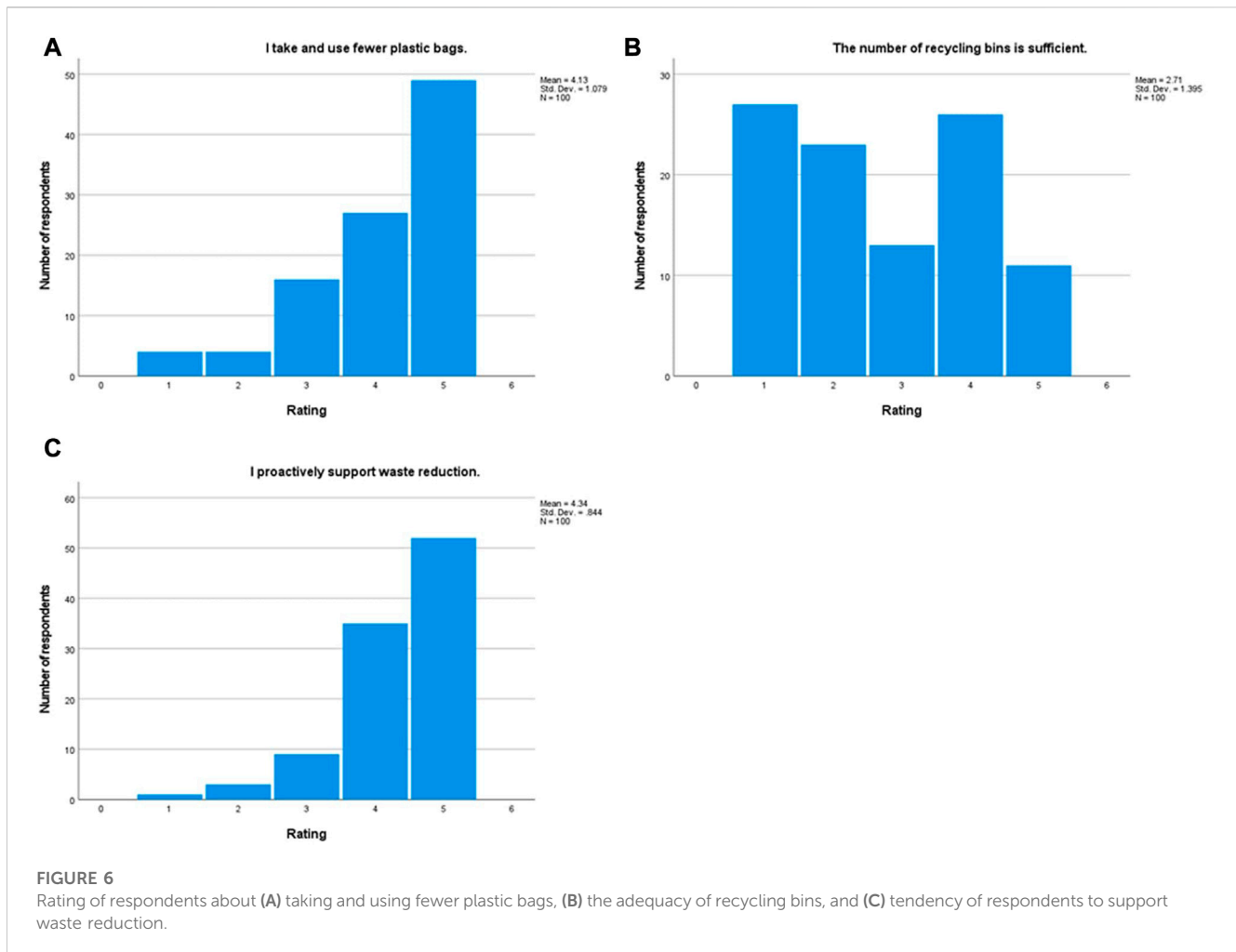
The charge of the plastic bag levy sparked off great controversy. Among 100 respondents, more than half of the respondents (54%) thought that the amount of plastic bag levy (HK\$0.5 per plastic bag) should be increased. 27% of the respondents did not support the rise in plastic bag charges and 19% of respondents had no comment (Figure 4B).

Among those 54 respondents who agreed with the increase in plastic bag levy, 37% of respondents considered that the amount of plastic bag levy should be raised to HK\$1.1–\$2 ( $n = 20$ ), 25.9% of respondents suggested that the levy should be raised to HK\$2.1–\$3 ( $n = 14$ ) and 18.5% of respondents conceived that the levy should be raised to HK\$5.1 or higher ( $n = 10$ ) (Figure 5).

Regarding the rating and spatial distribution of tendency of respondents taking and using fewer plastic bags, amid 100 respondents, about half of respondents (49%) strongly agreed with the statement that they would take and utilize fewer plastic

bags, whereas 27% of respondents agreed with this statement (Figures 6A,7). In particular, respondents in Hong Kong Island gave the highest mean rating in this statement (mean score = 4.47), followed by that of Kowloon East (mean score = 4.43) and New Territories East (mean score = 4.08). Respondents in the New Territories West gave the lowest mean rating in this statement (mean score = 3.85), followed by respondents in Kowloon West (mean score = 4.06). This indicated that Hong Kong citizens used fewer plastic bags, particularly those who lived in Hong Kong Island and Kowloon East.

As for the field observation conducted in a ParknShop (a large scale supermarket in Hong Kong) in the Sai Kung district, the proportion of customers who bought plastic bags in a supermarket was similar to the proportion of customers who did not buy plastic bags in a supermarket. This reflected that plastic bag levy might not be effective in the long term after a few years of the implementation of plastic bag levy.



Moreover, some interviewees put forward that there was a lack of law enforcement since some small-scale shop owners would provide free plastic shopping bags to customers to carry the pre-packaged food, such as canned food, and did not charge the customer for the plastic shopping bag.

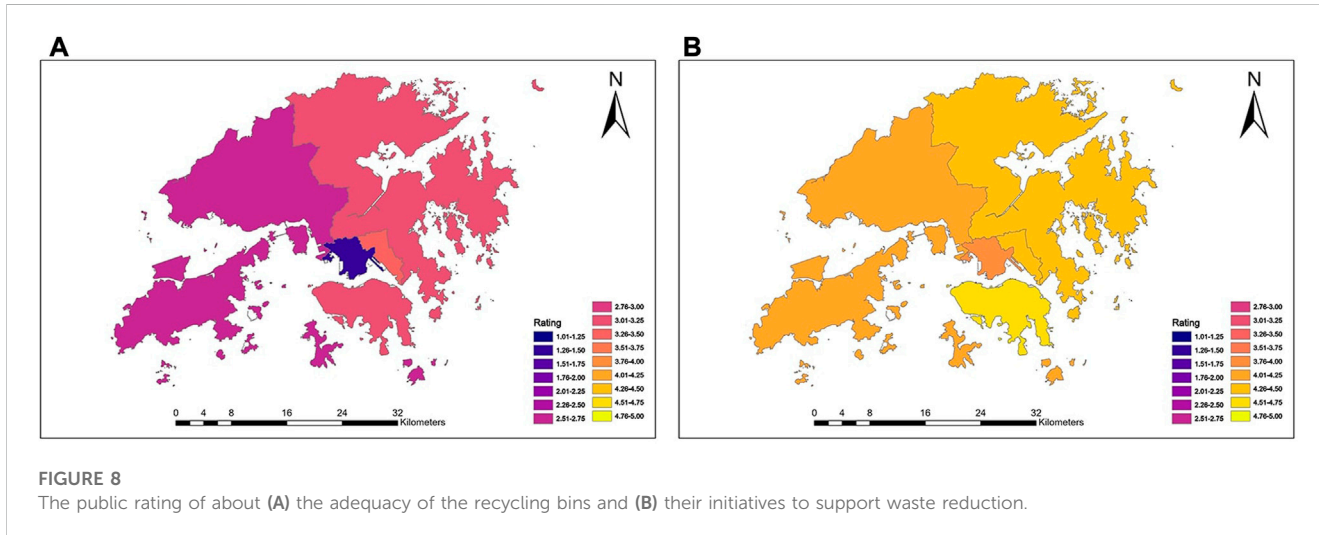
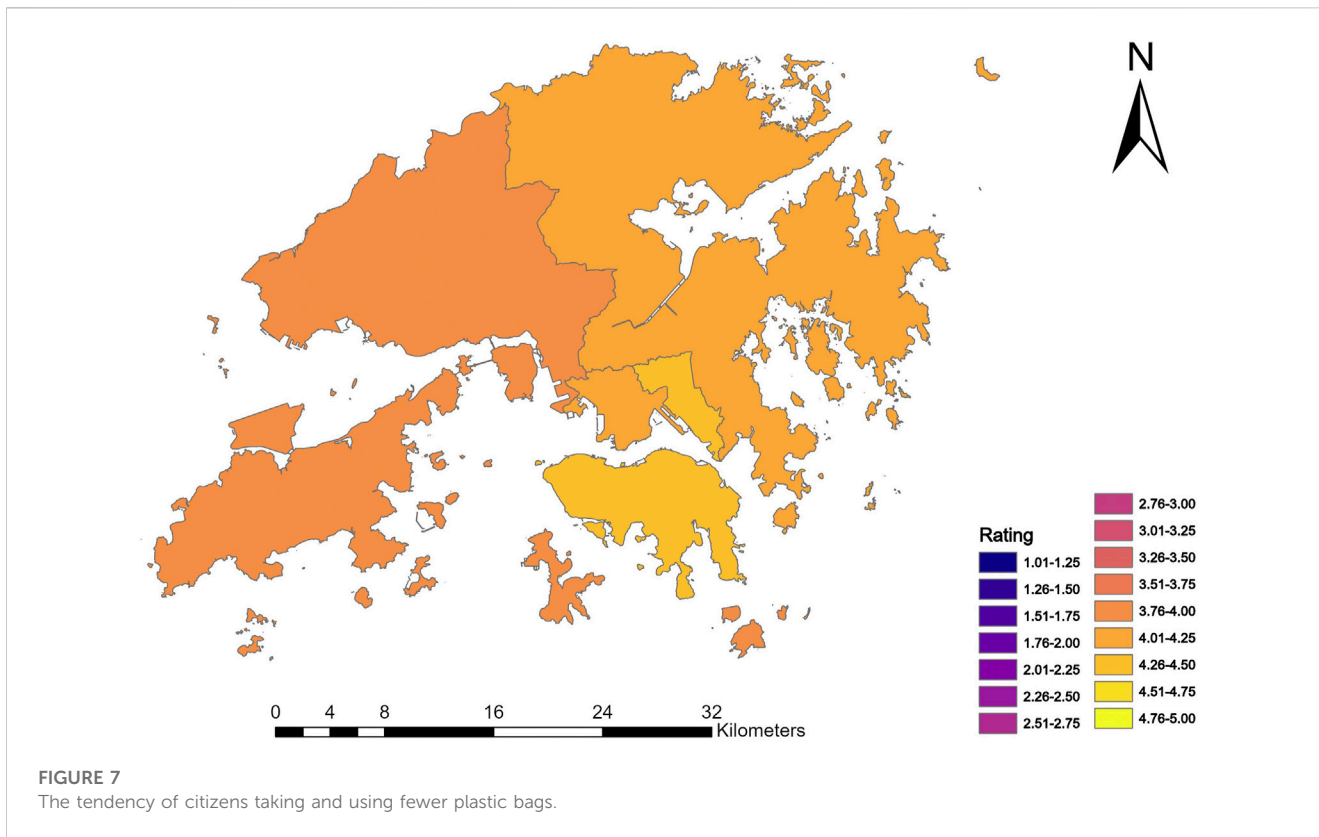
### 3.4 Recycling

Concerns regarding the environmental awareness of citizens in recycling were more widespread, in general, 27% of the respondents strongly disagreed that the number of recycling bins was sufficient, and 23% disagreed with this statement (Figures 6B, 8A). It was noted that 26% of respondents agreed with this statement. In particular, there was also a significant difference between different residing districts,  $F(4, 95) = 6.699, p < 0.05$ . The rating was statistically significantly between people living in Hong Kong Island ( $3.06 \pm 1.519, p < 0.05$ ), Kowloon East ( $3.29 \pm 1.49, p = 0.000$ ), New Territories East ( $3.12 \pm 1.177, p < 0.05$ ), and New Territories West ( $2.65 \pm 1.355, p < 0.05$ ) compared to Kowloon West ( $1.35 \pm 0.493$ ). Respondents in Kowloon East gave the highest mean rating in this statement (mean score = 3.29), followed by that of New Territories East (mean score = 3.12). Respondents in the Kowloon West gave the lowest mean rating in this statement (mean

score = 1.35). Therefore, the inadequate number of recycling bins is more obvious and of concern to residents in Kowloon West. This study found that there was also a statistically significant difference between different occupations as determined by one-way ANOVA,  $F(2, 97) = 4.074, p < 0.05$ . A Tukey *post hoc* test revealed that the rating was statistically significantly between people who worked ( $2.26 \pm 1.268, p < 0.05$ ) and people who were unemployed or retired ( $3.4 \pm 1.298$ ). There was no statistically significant difference between people who worked ( $p < 0.05$ ) and people who were unemployed or retired ( $p < 0.05$ ) compared to students ( $2.82 \pm 1.424$ ).

Concerning the tendency and spatial distribution of the rating of respondents to support waste reduction, more than half of the respondents (52%) strongly agreed that they proactively reduced waste, followed by 35% of respondents agreeing with the statement (Figures 6C, 8B). In particular, respondents in Hong Kong Island gave the highest mean rating in this statement (mean score = 4.65), followed by that of Kowloon East (mean score = 4.5). Respondents in the Kowloon West gave the lowest mean rating in this statement (mean score = 4). An independent sample test showed that males had a significantly lower consent ( $4.16 \pm 0.999$ ) towards supporting waste reduction than females ( $4.49 \pm 0.663$ ),  $t(98) = -2.008, p < 0.05$ .

More users utilized the reverse vending machine than recycling bins, and people tended to recycle more on public holidays than on



weekdays. Also, there were more users in the afternoon as compared to the morning and evening. However, the number of people who recycled within 4 hours was merely about ten, which might imply a relatively low recycling rate compared with the entire population of Hong Kong. Also, it was worrying that there was some garbage mixed with the recyclables inside the recycling bins. For instance, some tissue papers were put into the waste paper recycling bin. Some beverage containers were not clean and could not be recycled, they might even contaminate other recyclables inside the recycling bin.

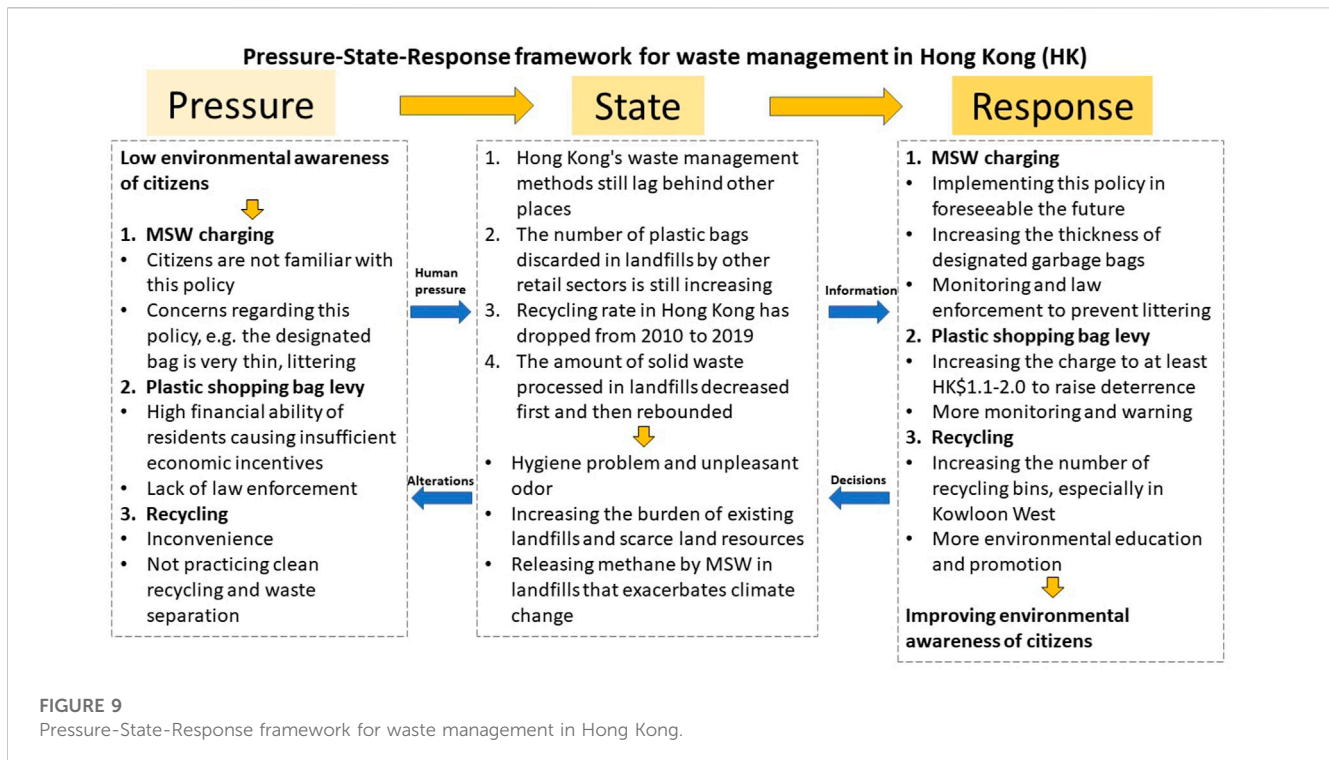
## 4 Discussion

### 4.1 Factors that affect the environmental awareness of Hong Kong citizens

#### 4.1.1 Pressure-State-Response framework for waste management

The Pressure-State-Response framework is proposed by the Organisation for Economic Co-operation and Development (OECD) to highlight the interconnection between human





activities and the environment (Levrel et al., 2009). Human activities put pressure on the environment (pressure) and influence the environmental quality (state); society responds to these changes through changing the environment, overall economic and sectoral policies, and altering consciousness as well as behavior (social response) (Levrel et al., 2009). This research adopts the Pressure-State-Response model to explain the linkage between human activities and the MSW problem (Figure 9).

#### 4.1.2 Pressures on MSW charging

In general, though the environmental awareness of residents has already improved as compared with that of citizens 20 years ago, the environmental awareness of local citizens was insufficient for them to reduce waste generation. Recently, the government proposed the MSW charging and this policy could increase citizens' environmental awareness. The difference in the level of support for the implementation of MSW charging may indicate that young people (who are aged at 35 or below) are more environmentally aware than adults (who are aged at 36 or above). In recent decades, young people may receive more environmental education than middle-aged and elderly people. Since middle-aged and elderly people have graduated for a long time, they may not be familiar with this policy. They may not be educated about MSW charging, because this is a novel concept. They may receive information about MSW charges from fewer channels. Due to technological advancements, young people are more likely to receive information from schools, the Internet and mass media (Szeberényi, 2017). Also, parenting plays an important role in affecting the autonomous motivation to take environmentally friendly actions (Autio and Wilska, 2005). If parents can encourage pro-environmental autonomy through communicating

with their children, then teenagers will tend to engage in more pro-environmental behaviors (Autio and Wilska, 2005). Therefore, it is important to publicize garbage charging to gain the support of middle-aged and elderly people, as well as conducting more environmental education in schools to successfully implement MSW charging.

Despite the fact that MSW charging can be beneficial for waste reduction in Hong Kong, some citizens may still have some concerns about this policy, leading to lower supporting rate in middle-aged and elderly people as they are the major users of garbage bags. Firstly, middle-aged and elderly people prefer to reuse unclean plastic shopping bags as garbage bags instead of designated garbage bags, because using designated garbage bags may generate more plastic waste, unclean plastic bags are forced to be discarded. Secondly, some residents are dissatisfied with the design of designated garbage bags (such as too thin, insufficient garbage bag size). Thirdly, these groups of people may be less confident about the MSW charging as they believe that there is a lack of monitoring and law enforcement for this policy. Although citizens must use designated plastic bags to discard waste, street garbage bins are difficult to regulate. It is impossible that every trash bin will be equipped with closed-circuit television or manual monitoring. Illegal disposal of waste may be resulted, and huge costs are involved. Lastly, some low-income citizens may have financial problems, especially during the COVID-19 when the unemployment rate in Hong Kong has increased to 7.0% from November 2020 to January 2021, which is the peak in nearly 17 years (Census and Statistics Department, 2021). Thus, the above concerns should be addressed by solving the plastic waste problem, improving the design of designated garbage bags, monitoring as well as law enforcement to gain public support.

### 4.1.3 Pressures on plastic shopping bag charging

The plastic bag levy prescribes the level of levy of at least \$0.5/plastic bag. This can establish opposite stimuli and enhance avoidance behavior (Kwong, 2014). However, HK\$0.5 is a relatively small amount of charge compared with the living standards of citizens, and it is acceptable for citizens, which is reflected by the behavior of citizens (purchasing plastic bags) (Kwong, 2014). Also, more citizens tend to support raising the charge of plastic shopping bags. They want to increase the plastic bag levy from HK\$0.5 per bag to at least HK\$1.1–\$2, followed by HK\$2.1–\$3. Some respondents even want to increase the plastic bag levy to HK\$5.1 or more to enhance the deterrent effect of this policy.

Once the plastic bag levy has been implemented, it may be effective for a short period of time, but not in the long term. On the one hand, citizens might be stimulated and motivated to buy fewer plastic bags in a short term. On the other hand, citizens may have adapted to the policy, and they might be willing to pay for the charge (Kwong, 2014).

### 4.1.4 Pressures on recycling

Many citizens think it may not be necessary to recycle because it is troublesome for them to recycle, or they do not know where the recycling facility is located (Wan et al., 2014). Also, some of them may have a low environmental awareness. During observation, some people would not practice waste separation and clean recycling during recycling. Nowadays, some of the three-color recycling bins are located in some hidden places (Wan et al., 2014). In Hong Kong, three-colour waste separation bins (three-colour recycling bins) are not common, and some property management company may not properly handle the recyclables. Additionally, most recycling bins are perceived as general garbage bins in which recyclables are mixed with trash, this may be caused by lack of environmental education, so some clean recyclables cannot be properly recycled.

Citizens who have a higher environmental awareness will recycle more. They would act as a role model to educate their relatives and friends about recycling. The major motivation for citizens to recycle is convenience. If the recycling bins can be located near the garbage bin or at a prominent location, people may be more likely to recycle. However, if there is no recycling bin nearby, residents will tend not to recycle. Many citizens in Hong Kong believe that the number of recycling bins is inadequate to collect their recyclables, especially those who live in the Kowloon West. Because of the relatively large number of tenement buildings in Kowloon West and the lack of management services in these tenement buildings, there are limitations in the setting up of recycling bins (Drakakis-Smith, 1976). Also, there is always a high flow of people, the ratio of recycling bins to the local population and visitors may be low (Yim et al., 2014). Besides, people who work tend to think that the number of recycling bins may be insufficient since their workplace may not have sufficient recycling bins. The inadequacy of recycling bins can hinder the willingness of citizens to recycle as well. Instructions can be placed near the recycling bins so that citizens will understand the correct procedures of clean recycling.

Waste reduction is another way to lead an environmentally friendly lifestyle. An increasing number of citizens will attempt to reduce their own waste. Residents in Hong Kong Island may have a

higher environmental awareness and be more proactive to reduce their waste whereas people in Kowloon West may have a lower environmental awareness and be least proactive to generate less waste. People living in Hong Kong Island tend to be wealthier and they may receive more environmental education, so they will be more likely to be aware of their behavior and surrounding environment. It is perceived that the environmental hygiene is relatively poor in Kowloon West than in other places, and there are more elderly and homeless residing in Kowloon West, especially Sham Shui Po. They may have a lower education level as well as lower environmental awareness and they may be less likely to reduce their waste. Males may have a lower environmental awareness than females and less likely to reduce their waste at source as well. Women's environmental behaviors are affected by social norms and lifestyle towards charging policies (Wut et al., 2020). However, men's attitude towards charging policy does not have much association with their lifestyle (Wut et al., 2020). Thus, females may be more likely to engage in environmental behaviors than males.

According to the field observation, more people recycle during weekends and public holidays and in the afternoon as they may have more time to recycle. They often recycle during their spare time (Williams and Taylor, 2004). Compared with recycling bins, people tend to use more reverse vending machines for recycling, because reverse vending machines provide people with economic incentives to recycle (Tomari et al., 2017). Therefore, this is a reward program that can increase public awareness and interest in plastic recycling (Tomari et al., 2017). However, there are only reverse vending machines for recycling plastic bottles, and no other recyclable materials. In addition, many recycling bins only collect waste paper, plastic and metal, but not other types of recyclables that present in the questionnaires. If the variety of recyclable items that can be received by reverse vending machines and recycle bins increase, more people are likely to recycle. However, there are some challenges of different stakeholders in waste reduction and recycling.

### 4.1.5 State of the MSW problem–COVID-19 pandemic

During the COVID-19 pandemic, the Hong Kong government gazetted that the public should wear mask when one is boarding or on board a public transport carrier, entering or presenting in an MTR paid area, or entering or present in public place (indoor and outdoor) under the Prevention and Control of Disease (Wearing of Mask) Regulation (Cap. 599I) (The Government of the HKSAR, 2020b). Thus, every citizen produces at least one disposable mask every day when they go out. This will generate a huge amount of MSW and add burden on the existing landfills.

Moreover, the local government has implemented two rounds of regulations that during 6 p.m. to 4:59 a.m. of the next day, restaurants can merely provide takeaway service and delivery instead of dine-in services (The Government of the HKSAR, 2020a). Since dining in restaurants is banned during dinner time, many people order food by using take-out or delivery services, which utilizes massive amounts of plastic packaging and contributes to a significant amount of plastic waste. Furthermore, since employees need to work from home for a certain period of time, they may have more time to stay at home and online shopping is facilitated. Online

shopping may utilize more packaging to prevent goods being damaged during delivery, more solid waste may be generated.

## 4.2 Responses from stakeholders and recommendations

### 4.2.1 MSW charging

Hong Kong relies on large-scale infrastructure to solve the waste problem, but it believes that the use of incineration and landfilling to treat waste is an expensive and a temporary solution, as landfills may be saturated in the foreseeable future. MSW charging can be an effective and successful environmental policy which has been demonstrated by many countries and cities. This policy should be implemented as soon as possible to combat the growing problem of MSW. Regarding the design of the policy, nowadays, the government has proposed to charge oversized waste for HK\$11 by using designated labels (GovHK, 2021). The government may also consider providing citizens with an option to purchase designated labels instead of designated bags. If citizens have their own plastic garbage bags, they can simply purchase the designated label and stick it on their plastic bags to replace designated bags. In this way, plastic waste can be further reduced since an additional plastic bag for holding rubbish could be avoided. As for the concerns of the designated plastic garbage bags, the thickness of the designated bags should be increased so that it will not be easily tattered.

### 4.2.2 Plastic shopping bag charging

As reported by the citizens, the current plastic shopping bag charge (HK\$0.5) may be too low, and the charge should be raised to at least HK\$1.1 so as to increase the economic incentives for the public to reduce the use of plastic shopping bags. When buying goods and services, customers like a round, whole-dollar amount, followed by half-dollar amounts (Knotek II, 2008). It will be convenient for customers to pay for the plastic shopping bag if the amount is set at HK\$0.5. In addition, more surveillance, inspections, and enforcement actions should be implemented to prevent store owners from providing plastic bags without charging consumers.

Moreover, the government may cooperate with NGOs to organize workshops as well as distributing leaflets and posters to the residents so that they can better understand the details of the plastic shopping bag levy, such as the purpose and details of its implementation, and its importance to the Hong Kong community. The target population may be men, students, people who work, and residents of West Kowloon and New Territories West who have low environmental awareness of the policy.

### 4.2.3 Recycling

Recycling is an essential waste management method and needs to be encouraged. A circular economy can be established if more recycling companies can recycle the materials locally and make them into new products. For example, Mil Mill is a Hong Kong wastepaper recycling company that recycles and recovers beverage cartons provided by citizens. It also cooperates with some corporations to recycle their waste papers, make them into recycled paper tissue and sell it in the market. If the government can

carry out green procurement, buying recycled goods and services that have minimal negative environmental impact, other merchants may follow suit (Varnäs et al., 2009). Procurement rules for recycled products could be provided by the government. More businesses may be driven to buy recycled products and services as a result. When more people buy green items, the price may drop when the production costs start to decrease, and more people can afford to buy them.

## 4.3 Implications for MSW policy

This study provides insights in raising public environmental awareness, gaining public support towards MSW charging, and boosting the supporting rate of plastic shopping bag levy and recycling. The most effective way to reduce MSW production and disposal is reducing waste at source. On-site observations have proved that many citizens lack awareness of garbage sorting and clean recycling. This directly causes the reduction of the recycling rate. In light of this, MSW charging scheme is indispensable for emphasizing the importance of PPP, encouraging citizens to bear self-responsibility of environmental protection. Environmental education is also a possible way to raise public awareness to enhance the continuity of MSW charging scheme. The “10Rs” principle (reduce, recover, refill, refuse, repair, repurpose, rethink, regift, reuse, and restore) should be introduced to the public and then raise citizens’ environmental awareness.

MSW charging scheme should be more emphasis as it is one of the top of the waste management hierarchy to reduce waste source. But, the current policy of plastic shopping bag levy has rooms for improvement. Since the current charge of plastic shopping bags is negligible to people with different social stratum. To be more specific, the government can review and adjust the levy level of plastic shopping bags periodically according to the economic environment of the society and the usage of plastic bags. As a result, plastic shopping bag levy can remain at a reasonable level so that the policy can take into account both the affordability of the public and effectiveness. For the sake of raising public confidence in recycling, it is of paramount importance for the government to increase the transparency of recycling process. As a role of monitor, the government can cooperate with recycling companies to disclose the information about the process and desired outcomes of recycling, such as converting to more useful products. With the concerted effort of different parties and the successful implementation of the above schemes, sustainable waste management may be achieved. By reducing MSW and increasing recycling rate, the negative impacts caused by waste problems can be minimized.

## 5 Conclusion

The results support and prove the hypothesis that there is a relationship between environmental awareness of citizens and the effectiveness of current waste management strategies in Hong Kong. As some groups of citizens may have lower environmental awareness, this may hinder the effectiveness of the three waste management approaches. There is a temporal variation that this MSW problem is expected to exacerbate as COVID-19 pandemic

that has not come to an end. There is also spatial variation between different geographical constituencies, in which residents in New Territories West and Kowloon West tend to have lower environmental awareness.

There are several implications provided by the research findings. Firstly, MSW charging is likely to be effective and should be implemented in Hong Kong though the contextual factors of Hong Kong are different from that of other places. However, there are some loopholes that need to be plugged. Secondly, plastic shopping bag charging can be effective in the short run but ineffective in the long run. The charge should be raised to create more economic incentives. Thirdly, circular economy is not promoted in Hong Kong. Actions have to be taken to address the problems caused by those three environmental policies. Although recycling is a crucial step in achieving sustainable waste management, our observations and field visits also found that recycling facilities are finite and scattered, which may reduce the effectiveness of recycling. Future studies can focus more on investigating the effectiveness of other waste management approaches, such as reuse, upcycling, incineration and landfilling. Also, more research is needed to supplement the spatial and temporal variation of MSW problem in Hong Kong Naughton, 2020, Tsien, 2014, Zhu, 2006.

## Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by Human Research Ethics Committee (HREC), The University of Hong Kong. The patients/participants provided their written informed consent to participate in this study.

## References

- Alzamora, B. R., and Barros, R. T. d. V. (2020). Review of municipal waste management charging methods in different countries. *Waste Manag.* 115, 47–55. doi:10.1016/j.wasman.2020.07.020
- Autio, M., and Wilksa, T.-A. (2005). Young people in knowledge society: Possibilities to fulfil ecological goals. *Prog. Industrial Ecol.* 2 (3–4), 403–426. doi:10.1504/pie.2005.007817
- Bartl, A. (2014). Ways and entanglements of the waste hierarchy. *Waste Manag.* 34 (1), 1–2. doi:10.1016/j.wasman.2013.10.016
- Calabro, P. S. (2009). Greenhouse gases emission from municipal waste management: The role of separate collection. *Waste Manag.* 29, 2178–2187. doi:10.1016/j.wasman.2009.02.011
- Census and Statistics Department (2015). 2016 Population By-census results reveal latest demographic trends. <https://www.bycensus2016.gov.hk/en/Snapshot-01.html>.
- Census and Statistics Department (2017). Population by-census main results. <https://www.statistics.gov.hk/pub/B11200982016XXXXB0100.pdf>.
- Census and Statistics Department (2021). Unemployment and underemployment statistics for november 2020 - january 2021. <https://www.info.gov.hk/gia/general/202102/18/P2021021800319.htm>.
- Census and Statistics Department (2012). Women and men in Hong Kong key statistics. <https://www.censtatd.gov.hk/en/EIndexbySubject.html?rcode=180&rcode=B1130303>.
- Chamizo-González, J., Cano-Montero, E.-I., and Muñoz-Colomina, C.-I. (2018). Does funding of waste services follow the polluter pays principle? The case of Spain. *J. Clean. Prod.* 183, 1054–1063. doi:10.1016/j.jclepro.2018.02.225
- Chandra, G. (2020). Non-monetary intervention to discourage consumption of single-use plastic bags. *Behav. Public Policy* 7 (1), 143–156. doi:10.1017/bpp.2020.9
- Cole, C., Gnanapragasam, A., Cooper, T., and Singh, J. (2019). An assessment of achievements of the WEEE directive in promoting movement up the waste hierarchy: Experiences in the UK. *Waste Manag.* 87, 417–427. doi:10.1016/j.wasman.2019.01.046
- Convery, F., McDonnell, S., and Ferreira, S. (2007). The most popular tax in europe? Lessons from the Irish plastic bags levy. *Environ. Resour. Econ.* 38, 1–11. doi:10.1080/00420987620080571
- Drakakis-Smith, D. (1976). Urban renewal in an asian context: A case study in Hong Kong. *Urban Stud.* 13 (3), 295–305.
- Environmental Protection Department [Epd] (2021). Collection outlets. [https://www.wastereduction.gov.hk/en/community/crn\\_outlets.htm#recyc\\_stores](https://www.wastereduction.gov.hk/en/community/crn_outlets.htm#recyc_stores).
- Environmental Protection Department [Epd] (2021). Green community. [https://www.wastereduction.gov.hk/en/community/crn\\_intro.htm](https://www.wastereduction.gov.hk/en/community/crn_intro.htm).
- Environmental Protection Department [Epd] (2018). Implementation timetable. <https://www.mswcharging.gov.hk/when.php?lang=en>.

## Author contributions

Conceptualization: FM and LR Data curation: FM and TW Formal analysis: FM and CC Investigation: FM Methodology: FM and LR Writing—original draft: FM Writing—review and editing: TW and LR Supervision: LR.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenvs.2023.1178363/full#supplementary-material>

- Environmental Protection Department [Epd] (2020). Waste recycling statistics. [https://www.wastereduction.gov.hk/en/quickaccess/stat\\_recycle.htm](https://www.wastereduction.gov.hk/en/quickaccess/stat_recycle.htm).
- Ewijk, S., and Stegemann, J. (2016). Limitations of the waste hierarchy for achieving absolute reductions in material throughput. *J. Clean. Prod.* 132, 122–128. doi:10.1016/j.jclepro.2014.11.051
- Gharfalkar, M., Court, R., Campbell, C., Ali, Z., and Hillier, G. (2015). Analysis of waste hierarchy in the European waste directive 2008/98/EC. *Waste Manag.* 39, 305–313. doi:10.1016/j.wasman.2015.02.007
- Gottberg, A., Morris, J., Pollard, S., Mark-Herbert, C., and Cook, M. (2006). Producer responsibility, waste minimisation and the WEEE Directive: Case studies in eco-design from the European lighting sector. *Sci. Total Environ.* 359 (1-3), 38–56. doi:10.1016/j.scitotenv.2005.07.001
- GovHK (2021). Municipal solid waste charging. <https://www.gov.hk/en/residents/environment/waste/management/mswcharging.htm>.
- Gregson, N., Crang, M., Laws, J., Fleetwood, T., and Holmes, H. (2013). Moving up the waste hierarchy: Car boot sales, reuse exchange and the challenges of consumer culture to waste prevention. *Resour. Conservation Recycl.* 77, 97–107. doi:10.1016/j.resconrec.2013.06.005
- He, H. (2012). Effects of environmental policy on consumption: Lessons from the Chinese plastic bag regulation. *Environ. Dev. Econ.* 17 (4), 407–431. doi:10.1017/s1355770x1200006x
- Hoorweg, D., and Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management*. World Bank, Washington, DC, USA.
- Knotek, E. S. (2008). Convenient prices, currency, and nominal rigidity: Theory with evidence from newspaper prices. *J. Monetary Econ.* 55 (7), 1303–1316. doi:10.1016/j.jmoneco.2008.07.009
- Ko, C. (2020). Waste management—A case study of producer responsibility scheme (PRS) on waste electrical and electronic equipment (WEEE) in Hong Kong. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3715404](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3715404).
- Kwong, K. L. (2014). Investigation of policies, environmental impacts, consumption and fate of plastic bags. *Plymouth Student Sci.* 7, 100–139.
- Lawrence, K., Cooper, V., and Kissoon, P. (2020). Sustaining voluntary recycling programmes in a country transitioning to an integrated solid waste management system. *J. Environ. Manag.* 257, 109966. doi:10.1016/j.jenvman.2019.109966
- Lee, S. C., and Na, S. I. (2010). E-Waste recycling systems and sound circulative economies in East Asia: A comparative analysis of systems in Japan, South Korea, China and Taiwan. *Sustainability* 2 (6), 1632–1644. doi:10.1007/s10531-008-9507-0
- Levrel, H., Kerbirou, C., Couvet, D., and Weber, J. (2009). OECD pressure–state–response indicators for managing biodiversity: A realistic perspective for a French biosphere reserve. *Biodivers. Conservation* 18 (7), 1719–1732.
- Muralidharan, S., and Sheehan, K. (2016). Tax and “fee” message frames as inhibitors of plastic bag usage among shoppers: A social marketing application of the theory of planned behavior. *Soc. Mark. Q.* 22 (3), 200–217. doi:10.1177/1524500416631522
- Nas, P. J., and Jaffe, R. (2004). Informal waste management. *Informal Waste Manag. Environ. Dev. Sustain.* 6 (3), 337–353. doi:10.1023/b:envi.0000029912.41481.a5
- Naughton, C. (2020). Will the COVID-19 pandemic change waste generation and composition? The need for more real-time waste management data and systems thinking. *Resour. Conservation, Recycl.* 162, 105050. doi:10.1016/j.resconrec.2020.105050
- Neufeld, L., Stassen, F., Sheppard, R., and Gilman, T. (2016). *The new plastics economy: Rethinking the future of plastics*. World Economic Forum, Cologny, Switzerland.
- Nielsen, T. D., Holmberg, K., and Stripple, J. (2019). Need a bag? A review of public policies on plastic carrier bags – where, how and to what effect? *Waste Manag.* 87, 428–440. doi:10.1016/j.wasman.2019.02.025
- Pires, A., and Martinho, G. (2019). Waste hierarchy index for circular economy in waste management. *Waste Manag.* 95, 298–305. doi:10.1016/j.wasman.2019.06.014
- Pooritinga, W., Sautkina, E., Thomas, G. O., and Wolstenholme, E. (2016). *The English plastic bag charge: Changes in attitudes and behaviour*, Cardiff University, Cardiff, United Kingdom.
- Sembing, E., and Nitivattananon, V. (2010). Sustainable solid waste management toward an inclusive society: Integration of the informal sector. *Resour. Conservation Recycl.* 54 (11), 802–809. doi:10.1016/j.resconrec.2009.12.010
- Stahel, W. R. (2016). The circular economy. *Nat. News* 531 (7595), 435–438. doi:10.1038/531435a
- Szeberényi, A. (2017). Environmentally conscious lifestyle analysis among high school and University students in a Hungarian rural town of the Heves County. *Visegrad J. Bioeconomy Sustain. Dev.* 6 (2), 74–78. doi:10.1515/vjbsd-2017-0013
- Teigiserova, D. A., Hamelin, L., and Thomsen, M. (2020). Towards transparent valorization of food surplus, waste and loss: Clarifying definitions, food waste hierarchy, and role in the circular economy. *Sci. Total Environ.* 706, 136033. doi:10.1016/j.scitotenv.2019.136033
- The Government of the HKSAR (2020a). The Government of the Hong Kong special administrative region [The Government of the HKSAR]. *Dine-in service rule exemption set*. News.gov.hk. Retrieved from [https://www.news.gov.hk/eng/2020/07/20200716/20200716\\_181658\\_782.html](https://www.news.gov.hk/eng/2020/07/20200716/20200716_181658_782.html).
- The Government of the HKSAR (2020b). The Government of the Hong Kong special administrative region [The Government of the HKSAR]. *Government amends the prevention and control of disease (wearing of mask) regulation and extends social distancing measures*. Press Releases. Retrieved from <https://www.info.gov.hk/gia/general/202008/25/P2020082500904.htm?fontSize=1>.
- Tomari, R., Kadir, A. A., Zakaria, W. N. W., Zakaria, M. F., Abd Wahab, M. H., and Jabbar, M. H. (2017). Development of reverse vending machine (RVM) framework for implementation to a standard recycle bin. *Procedia Comput. Sci.* 105, 75–80. doi:10.1016/j.procs.2017.01.202
- Troschinetz, A. M., and Mihelcic, J. R. (2009). Sustainable recycling of municipal solid waste in developing countries. *Waste Manag.* 29 (2), 915–923. doi:10.1016/j.wasman.2008.04.016
- Tsien, T. (2014). Ageing in place in Hong Kong, *Annual scientific conference on ageing*, Hong Kong Polytechnic University, Singapore.
- Varnäs, A., Balfors, B., and Faith-Ell, C. (2009). Environmental consideration in procurement of construction contracts: Current practice, problems and opportunities in green procurement in the Swedish construction industry. *J. Clean. Prod.* 17 (13), 1214–1222. doi:10.1016/j.jclepro.2009.04.001
- Wan, C., Shen, G. Q., and Choi, S. (2018). Differential public support for waste management policy: The case of Hong Kong. *J. Clean. Prod.* 175, 477–488. doi:10.1016/j.jclepro.2017.12.060
- Wan, C., Shen, G. Q., and Yu, A. (2014). The role of perceived effectiveness of policy measures in predicting recycling behaviour in Hong Kong. *Resour. Conservation Recycl.* 83, 141–151. doi:10.1016/j.resconrec.2013.12.009
- Williams, I., and Taylor, C. (2004). Maximising household waste recycling at civic amenity sites in Lancashire, England. *Waste Manag.* 24 (9), 861–874. doi:10.1016/j.wasman.2004.02.002
- Wilson, D. C., Velis, C., and Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. *Habitat Int.* 30 (4), 797–808. doi:10.1016/j.habitatint.2005.09.005
- Wut, T. M., Ng, P., Kan, H. K. M., and Fong, C. S. (2021). Does gender matter? Attitude towards waste charging policy and pro-environmental behaviours. *Soc. Responsib. J.* 17 (8), 1100–1115. doi:10.1108/srj-03-2020-0102
- Yang, H. T., and Innes, R. (2007). Economic incentives and residential waste management in Taiwan: An empirical investigation. *Environ. Resour. Econ.* 37 (3), 489–519. doi:10.1007/s10640-006-9040-0
- Yeung, I. M., and Chung, W. (2018). Factors that affect the willingness of residents to pay for solid waste management in Hong Kong. *Environmental Science and Pollution Research* 25, 7504–7517.
- Yim, S. H., Fung, J. C. H., and Ng, E. Y. (2014). An assessment indicator for air ventilation and pollutant dispersion potential in an urban canopy with complex natural terrain and significant wind variations. *Atmos. Environ.* 94, 297–306. doi:10.1016/j.atmosenv.2014.05.044
- Zhu, J. (2006). Inspiration to Shanghai from waste charging in Singapore. *Environ. Sanit. Eng.* 14, 19–21.