

Influencing Factors on Public Participation in Solid Waste  
Source-Separated Collection in Guilin, China

by

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## **Abstract**

Key factors of social dimensions influencing public participation in solid waste source-separated collection in China are identified through analyses of extensive survey data collected from Guilin, China, which is representative of wider areas located in-land and having GDP around the national average. A systematic literature review methodology was first utilized to compile a relatively comprehensive list of publications on the related peer-reviewed literature around the globe published between 1980 and 2014 with a focus on vulnerability, public participation, attitude and behavior, and policy. Inequitable global distribution and insufficient research work regarding social dimensions of municipal solid waste management were noticed. Subsequently, in-person interviews documented using questionnaires in both urban and rural areas of Guilin, Guangxi Zhuang Autonomous Region, China, were conducted during 2014. The collected data were analyzed by employing appropriate theoretical models and statistical tools. Specifically, 1) the statistical data analyses for both urban and rural areas focused on public participation in solid source-separated collection in terms of public perception, public awareness, public attitude, and willingness to pay; and 2) the potential influencing factors on public behavior were evaluated by employing the Theory of Planned Behavior. Some major findings are as follows: i) signs on dustbins are effective and cost-efficient methods for public education; ii) waste transportation in a mixed way is the most significant factor influencing public attitude; iii) individuals' attitude is the major predictor of their behavioral intention, while perceived behavioral control is important in predicting their behaviors; iv) rural residents have low public awareness and care more about environmental issues closely related to their daily lives; and v) village committees play a very important role in knowledge dissemination. All of these findings provide valuable guidance to

decision makers for designing more effective education campaigns and waste management programs.

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*To*

桃涵

*E.M.M.A, My precious, a lovely girl who likes her English Name to be written in capital characters :-)*

*Mum loves you forever!*

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# Chapter 1

## Introduction

Explosive population growth, ongoing energy crises, and environmental pollution and degradation have undermined economic and social development around the world (Homer-Dixon, 1999). These challenges have led people to rethink their own individual behavior and societal priorities, and have resulted in attempts to reconcile economic development and environmental conservation (United Nations, 1992). This reappraisal was epitomized by the ubiquitous concept of “sustainable development”, which is widely accepted as meaning “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland Commission, 1987). Production and, in turn, consumption have become the fuel that has enabled development - a process that also generates a corresponding amount of waste. The management of this waste has emerged as one of the world’s most critical environmental issues (Chang and Pires, 2015; Giusti, 2009), and when properly implemented, can play an important role in increasing the quality of people’s lives around the world by helping guarantee healthy and sanitary living conditions.

### 1.1 Background of municipal solid waste (MSW)

Though “waste” is widely understood as a concept, it has no consistent definition. Solid waste is commonly defined as “all solid or semisolid materials discarded from residential and commercial sources that the possessor no longer considers of sufficient value to retain” (Vergara and

Tchobanoglous, 2012, p. 279). As shown in Table 1.1, municipal solid waste (MSW) “consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries” (US EPA, 2016). According to the Global Waste Management Outlook (UNEP, 2015), the global annual rate of increase of MSW is about 2 billion tons. In addition, the composition of MSW is becoming more and more complex. It has been widely recognized that these two trends (both increased generation and composition complexity) in MSW have induced severe degradation of air quality, water quality, and public health, and also have contributed to climate change (for example, the release of methane gas). Effective and efficient MSW management is, thus, one of the most important and challenging issues throughout the world (Vergara and Tchobanoglous, 2012).

MSW management is undergoing an evolution from mere disposal, such as landfill, to sustainable management, such as 3R (reuse, recycle, reduce) (Agamuthu and Fauziah, 2011; Li et al., 2013; Shekdar, 2009). In Europe, the concept of waste hierarchy has been proposed, which consists of five steps: prevention, reuse and preparation for reuse, recycle, recovery, and disposal (Waste Framework Directive, 2008). The goal is to achieve waste minimization by source-reduction, waste diversion, and “non-diverted wastes” disposal through incineration and landfilling (Achillas et al., 2011; Ahsan et al., 2012; McBean et al., 1995; Neo, 2010; Taylor, 2000).

**Table 1.1** Sources of solid waste within a community (Tchobanoglous, et al., 1993).

<i>Source</i>	<i>Typical facilities, activities, or locations where waste is generated</i>	<i>Types of solid wastes</i>
Residential	Single family and multifamily detached dwellings; low-, medium-, and high-rise apartments; etc.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cans, aluminum, other metals, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), household hazardous wastes
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes (see above), hazardous wastes, etc.
Institutional	Schools, hospitals, prisons, governmental centers	As above in commercial
Construction and demolition	New construction sites, road repair/renovation sites, razing of buildings, broken pavement	Wood, steel, concrete, dirt, etc.
Municipal services (excluding treatment facilities)	Street cleaning, landscaping, catch basin cleaning, parks and beaches, other recreational areas	Special wastes, rubbish, street sweepings, landscape and tree trimmings, catch basin debris; general wastes from parks, beaches, and recreational areas

Treatment plant sites; municipal incinerators	Water, wastewater, and industrial treatment processes, etc.	Treatment plant wastes, principally composed of residual sludge
Municipal solid waste <sup>a</sup>	All of the above	All of the above
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc. non-industrial wastes including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, hazardous wastes
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes

<sup>a</sup>The term municipal solid waste (MSW) normally is assumed to include all of the waste generated in a community with the exception of industrial process wastes and agricultural solid wastes.

## **1.2 Source-separated collection in MSW management and its status in China**

MSW management is a highly complex system, consisting of a large number and diversity of technologies and processes. In terms of its functional elements, the system can be divided into six components: waste generation, waste handling at the source, collection, transport, processing and transformation, and disposal (Tchobanoglous and Kreith, 2002). As the first step in MSW processing, MSW source-separated collection plays a critical role in determining the efficiency of the follow-up processing of waste destined for landfills, recyclable products, or green waste (McDougall et al., 2001). Industrialized countries initiated research on MSW source-separated

collection in the 1960s in response to the scarcity of natural resources and highly visible environmental degradation, and such initiatives have been put into operation since the 1970s (Yu, 2010).

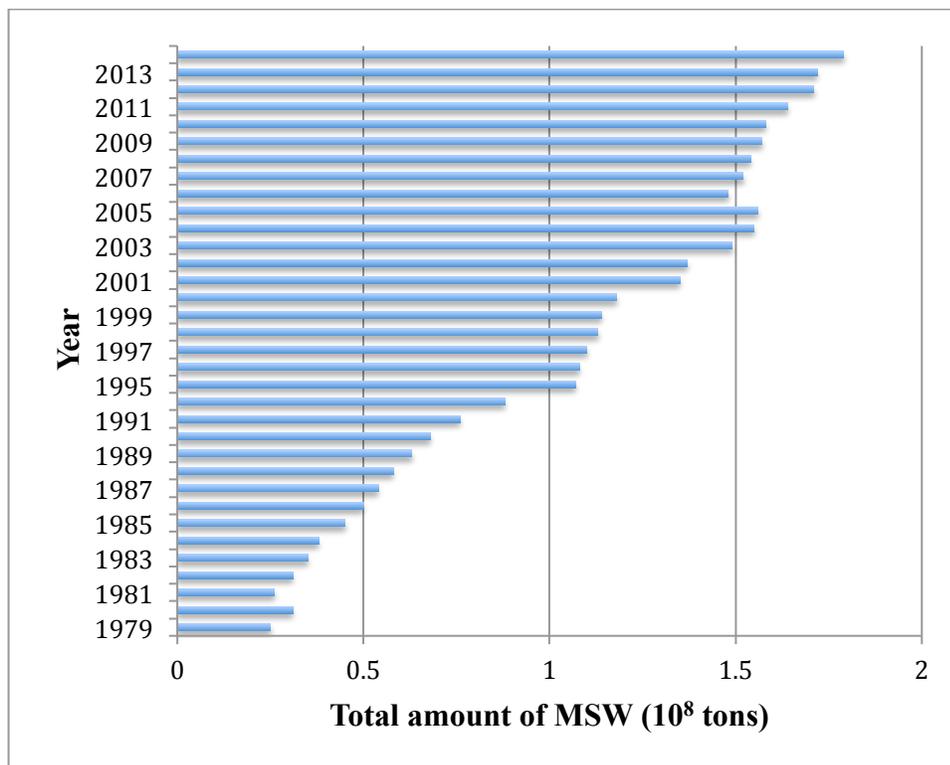
Although some progress has been made towards the source-separated collection of MSW in China, its status in China pales in comparison to that of some industrialized countries such as Germany and Japan, which have achieved remarkable results in MSW management and circular economy (Huang et al., 2006; Vehlow, 1996). Currently, most parts of China still use mixed collection methods (Sun et al., 2009) and landfill is still the main disposal method (Du et al., 2006).

The implementation of source-separated collection is compromised by many factors, including the lack of effectiveness of existing policies and management systems (Wang and Nie, 2001); the centralization of services including monitoring, supervision, waste collection, and disposal into one agency; inadequacy of financial support (Zhang et al., 2010); ineffective disposal treatment; and the lack of public awareness and participation (Zhang et al., 2011). Recently, studies on MSW source-separated collection in China have been carried out in some cities. For example, Zhang and Wen (2014) evaluated residents' activities in household solid waste source separation in Suzhou. Xu et al. (2016) studied impact factors on source separation pilot programs in Shanghai. Public participation in source-separated collection in Guangzhou was addressed by Chung and Poon (2001). The status of source separation was investigated in Hangzhou (Zhuang et al., 2007), Beijing (Qu et al., 2009), and Tianjin (Geng et al., 2007). However, most of these studies focused on developed coastal regions and little attention (Chu et al., 2013) has been given to inland and under-developed areas.

### 1.3 Research motivation

As the globe’s most rapidly industrializing and populous country, China is now facing the largest and fastest increase in solid waste quantities in the world (Dong et al., 2001; Liu and Diamond, 2005). As shown in Figure 1.1, the total amount of MSW collected and transported in China increased six-fold in 30 years, from 31.3 million tons in 1980 to 179 million tons in 2014 (Ministry of Environmental Protection of the People’s Republic of China, 2015). It has been predicted that this number will exceed 480 million tons by 2030 (World Bank, 2005). Thus, solid waste management has undoubtedly become a prominent problem in China.

**Figure 1.1** Total amount of municipal solid waste collected and transported in China.



Data sources: 1979-2002 data from (Li, 2008); 2003-2014 data from (National Bureau of Statistics of China, 2014)

Although many studies have been conducted on waste management in China, most are restricted to technological or scientific perspectives and fewer incorporate social, political, or cultural

dimensions (Che et al., 2013; Chung and Lo, 2008; Huang et al., 2008). Likewise, most studies have focused on urban rather than rural regions (Chung and Poon, 2001; Liu et al., 2005; Luo, 2006; Yao et al., 2009; Zheng and Liang, 2010). In addition, it has been shown that inclusive processes involving the public in MSW management are rarely used in China, although they act to reduce controversy and to increase acceptability of otherwise contentious environmental issues including waste-related policy-making and management (Wang et al., 2013; Wiedemann and Fermers, 1993).

## **1.4 Research purpose and objectives**

The overall purpose of this thesis focuses on promoting understanding of the social dimensions of source-separated collection in MSW management in China, especially in terms of public perception, public awareness and knowledge, public attitude, and behavior.

Specific objectives are as follows:

1. Explore the social dimension of MSW management around the globe.
2. Describe the factors that have significant impacts on public participation in MSW source-separated collection in China. Carry out an extensive survey to collect the real data.
3. Analyze the influencing factors on MSW source-separated collection behavior by using the Theory of Planned Behavior.
4. Evaluate public participation in Rural Domestic Waste source-separated collection in China from social dimensions.

## **1.5 Organization of the thesis**

The remainder of this thesis is organized as follows. Chapter 2 explores social dimensions of municipal solid waste management around the globe by carrying out a systematic literature review. Motivated by the research outcomes from Chapter 2, an extensive survey to collect the real data was carried out in Guilin, China. The status and influencing factors on public participation in municipal solid waste source-separated collection in China was described in Chapter 3. To further study influencing factors on municipal solid waste source-separated collection behavior in China, the analyses based on the Theory of Planned Behavior are presented in Chapter 4. Chapter 5 extends the research works on MSW management to rural domestic solid waste source-separated collection in China. The social dimensions in public participation are also the analysis emphases. Conclusions remarks and future research work are listed in Chapter 6.

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# Chapter 2

## **Exploring Social Dimensions of Municipal Solid Waste Management around the Globe – A Systematic Literature Review**

In this chapter, a systematic literature review was carried out to characterize and critically evaluate the published literature on the social dimensions of MSW management from 1980 to 2014 in terms of vulnerability, public participation, public attitude and behavior, and policy. A keyword searching was first performed by using the Institute for Scientific Information (ISI) Web of Science, which retrieved 1,843 documents. After removing the papers that were not closely related to the topic, 200 articles were retained for an in-depth review. In each category, major research issues and observations are summarized, and important insights are obtained.

### **2.1 Introduction**

Today, one of the critical issues accompanying global economic and social development is the significant increase of the amount of waste generated. Besides the explosive growth in the weight and volume, the composition of the MSW is becoming more and more complex. It has been widely recognized that these two trends (both increased generation and composition complexity) in MSW have induced severe degradation of air quality, water quality, and public health, and also have contributed to climate change. Effective and efficient MSW management is, thus, one of the most important and challenging issues throughout the world (Vergara and Tchobanoglous, 2012).

Currently, MSW management is undergoing an evolution from mere disposal to sustainable management. This new trend pushes MSW management beyond the scope of technology and requires the involvement of all stakeholders, including product manufacturers, government institutions, private businesses, and householders. Thus, the success of an MSW management system not only depends on technical innovation, but is also significantly influenced by social, economic, and psychological factors, such as public participation, policy, and public attitude and behavior. Hence, it is important for researchers to understand, design, and evaluate MSW management from a social dimensions point of view.

In this chapter, a preliminary and exploratory systematic literature review methodology was employed for globally tracking issues in the social dimensions of MSW management. Based on a preliminary literature review, four major research topics were emphasized. The first was vulnerability. Vulnerability pertains to the influence of MSW on subpopulations (such as children, women, and minorities) in terms of health, income, access to services, and environmental justice. Although these subpopulations are vulnerable, their opinions and situations are ordinarily less of a concern to decision makers. The second were public attitude and behavior. This topic deals with the influencing factors on participating in MSW management at the individual level. The third was public participation. This topic addresses participation in MSW management at the organizational level. Specifically, the discussions focused on public education, public-private-partnership (PPP), and informal sector. The fourth and final was policy, which concerns the effects of legislation and incentives on promoting the involvement of stakeholders in MSW management. Publications in the peer-reviewed literature were used as a proxy sample in order to i) characterize and critically evaluate these topics in the social dimensions of MSW management; ii) illustrate how these studies vary with respect to time and

location; and iii) identify any important gaps in understanding. Peer reviewed studies constitute reliable, reputable and rigorous resources for assessing knowledge and developing scientific syntheses (Arnell, 2010; Berrang-Ford et al., 2011; Ngai et al., 2008).

## **2.2 Methodology**

To better understand the state of research on the social dimensions of MSW management, the published literature in related areas were characterized and critically evaluated, which further results in an informative reference list. This approach consists of two main steps: reviewing documents, and selecting the critically appraised, relevant research (Petticrew and Roberts, 2006). Although a systematic literature review has been widely used in health science (Ford and Pearce, 2010), its potential in MSW management studies, a field with extensive research, has not been well exploited (Berrang-Ford et al., 2011).

### **2.2.1 Document selection**

A keyword search was performed in the search engine called the Institute for Scientific Information (ISI) Web of Science in April 2015. The reason for the selection of ISI Web of Science is that it is one of the most powerful, up-to-date, comprehensive, and widely used search engines for the analysis of interdisciplinary, peer-reviewed literature (Jasco, 2005). A list of key topic terms was developed, as shown in Table 2.1<sup>1</sup>. The search focused on peer-reviewed literature published between 1980 and 2014 in order to cover a relatively comprehensive set of publications. The search retrieved 1,843 documents. All retrieved documents were reviewed based on the title and abstract to evaluate their suitability for inclusion in the final

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<sup>1</sup> The topic terms were refined throughout the whole procedure of the analysis so that they were sufficient to locate most major documents I was interested in.

categorizations. However, in some cases when sufficient information was not available in titles and abstracts, a full-text review was also conducted. Only articles explicitly discussing the social dimensions of MSW management were selected. In this chapter, the emphasis is on the issues in social dimensions related to vulnerability of any subpopulations, public participation, attitude and behavior, and policy. If there are duplicate results in the various search outcomes, the categorization is based on the major topic addressed in these papers.

### 2.2.2 Document review

After document screening (papers not fitting the scope of the discussion were removed), 200 articles were retained for an in-depth review. A recording form was then developed to document and characterize specific details in the social dimensions related to MSW management, and examine key trends and associations. The recording form begins with categories related to the general characteristics of articles in terms of authorship, article title, year published, document type, first author affiliation, and region of interest. The main section consists of fixed forced choice questions focusing on vulnerable population category, vulnerability category, public participation category, attitude and behavior category, policy category, system component under consideration, and method.

**Table 2.1** List of key topic terms used for literature searching in the Institute for Scientific Information Web of Science.

<b>Topic Terms for “Vulnerability”</b>
Solid waste; Vulnerab*; Marginal*; Minorit*; Low income; Woman or women; Poverty*; Illiteracy; Education; Child*; Eld* or old; Poor; Disadvantage
<b>Topic Terms for “Public Participation”</b>
Solid waste; Participat*

<b>Topic Terms for “Attitude and Behavior”</b>
Municipal solid waste; Attitude*; Behavior*; Residence; Public; Human; Household*; Community
<b>Topic Terms for “Policy”</b>
Municipal solid waste; Polic*; Government*; Law*; Regulation*

\* Indicates that Web of Science searches all words and phrases starting with the letters to the left of the star (\*)

## 2.3 Results

The major observations from the review are summarized in this section following the categories given in Table 2.1.

### 2.3.1 Vulnerability

The disposal of MSW (such as plastics, chemicals, and toxic substances) and the presence of microorganisms during processing, storage, and utilization, may cause environmental contamination. Such contamination may be spread or concentrated in the soil, water, air, and biota, as well as products made from MSW. This in turn can potentially impact the health of exposed populations, especially those with vulnerabilities (Deportes et al., 1995). Based on the vulnerable subjects, the screened papers can be classified into four categories: children, women, low-income/poor, and minorities. The distributions of articles with respect to these four categories were 41%, 36%, 18%, and 5%, respectively. Since health risks to informal collectors, informal recyclers, or to people working within the informal sectors are mostly occupational, the associated papers are included in the “Public Participation” category, although some risks may result from lack of support in terms of finance and health due to marginalization and societal exclusion (Binion and Gutberlet, 2012). The effects from MSW on “Children” attracted the most

attention, followed by “Women.” This is based on the intuition that children and women are the two most vulnerable populations.

According to risk types, the screened papers can also be classified into four groups: health (77%), economic/wage inequity (5%), environmental injustice (9%), and inequity in service provisioning (9%). The details of each group are provided in the following paragraphs. One can see that health risks due to MSW dominate the risk research.

The research on “vulnerability” contains controversial conclusions. For all of the screened papers, some showed a significant increase of health risks from MSW to the exposed populations, while others revealed no clear trend. For example, Silveira Correa et al. (2011) indicated the high risk of respiratory disease in children due to living close to a landfill, while no clear evidences on increased risks of mortality and morbidity were observed by Ranzi et al. (2011).

For almost all cases, children were more vulnerable than adults (Candela et al., Cordier et al., 2010; Deportes et al., 1995; Ma et al., 2012; Parveen and Faisal, 2005; Sun et al., 2013; 2013), except for the research of Reis et al. (2007) and Mari et al. (2007). This is attributed to children having greater exposure to contaminations from hand-mouth contact and ingestion. For example, children’s high ingestion rate of dust from the soil (100 mg/day and even 5g/day for a child with geophagy) makes them more exposed to the contamination contained in the soil (Deportes et al., 1995). Some other examples include dioxin exposure via daily food intake (Ma et al., 2012), mercury exposure from inhalation (Sun et al., 2013), respiratory disease (Silveira Correa et al., 2011), preterm delivery (Candela et al., 2013), and urinary tract birth defects (Cordier et al., 2010).

Similar to children, women face a higher risk from the pollution of MSW than men. Greater cancer mortality (e.g., stomach, colon, liver and breast cancer) (Ranzi et al., 2011), greater dioxin levels in breast milk (Giovannini et al., 2014), and greater concentrations of PCDD/Fs (particle-bound polychlorinated dibenzo-p-dioxins and dibenzofurans) and marker PCBs (polychlorinated biphenyls) (Parera et al., 2013) have been observed among women living in close proximity to incinerators. In addition, female waste separators have greater accident rates (Hoefel et al., 2013). However, there are reports that showed no clear relationship between exposure to dioxins emissions from municipal waste incinerators and the risk of miscarriage and birth defects in offspring (Viel et al., 2008; Vinceti et al., 2008).

Methodological limitations are commonly deemed as the major cause of conflicting observations on the health risks of MSW to children and women. For example, it is argued that some other factors, such as parental education level, lifestyle behaviors (e.g., smoking mothers), and income level, may be overlooked, which may affect the observations (Silveira Correa et al., 2011). Also, it is necessary to consider the coexistence of other sources of pollution (Mari et al., 2007). For a “no clear trend” finding, it is argued that such an observation should be treated cautiously if the possible accumulation of pollutants due to the long residence time of these contaminations and possible repeated applications (e.g., using compost in agriculture) (Deportes et al., 1995) are not taken into account. The observation may also depend on whether the incinerator under examination is equipped with advanced pollution control technology (Vinceti et al., 2008).

Besides health risks, in some countries, female waste workers experience greater vulnerability in terms of income and adaptive capacity. For example, in Vietnam, although women constitute almost 50% of employees in the MSW management industry (4,500 as itinerant buyers and 500

as shopkeepers) and contribute significantly to MSW management, these female workers suffer from low payment and are more vulnerable to the system changes because of low education levels and lack of capital (Mehra et al., 1996). In addition, female waste workers commonly suffer from gender discrimination (Nunn, 2013).

In order to reduce the risks from MSW to vulnerable populations, some initiatives need to be carried out. For example, source-separated collection can be effective to reduce contamination in composite products by removing recyclable components, such as batteries, glassware, plastics, and ferrous materials, which may contain mercury, lead, chromium, cadmium, zinc, and copper (Deportes et al., 1995). Appropriate MSW management policies are also considered as solutions, which may promote source-separated collection, safer processing, and more constraints on emissions of hazardous substances (Veeken and Hamelers, 2002; Woon and Lo, 2013). For instance, in China, the Ministry of Environmental Protection (MEP) of China proposed a new emissions guideline in 2010 for MSW incinerators, in which dioxin emission levels are to be reduced from 1.0 to 0.1 ng TEQ/Nm<sup>3</sup> (nanograms of dioxin toxic equivalent per cubic meter in normal conditions) (Ma et al., 2012). Public awareness, public participation, and technical innovation can also contribute to the reduction of contamination from MSW (Mari et al., 2007; Silveira Correa et al., 2011).

Other effects of MSW to vulnerable populations include environmental injustice to low-income populations. Environmental injustice means putting a disproportionate waste burden on the poor by locating MSW sites and dumping of hazardous wastes in poor communities (Gandy, 2006). One example of such injustice occurred in Accra, Ghana, where the city's waste-collection and waste-disposal services were unequally distributed between high-income and low-income areas.

Such inequality resulted in the rich living in a clean and healthy environment, while the poor areas provided dumping grounds for the city's waste and were exposed to elevated pollution (Baabereyir et al., 2012). Since the major cause of this phenomenon is the existing political and economic advantages of high-income communities, the suggested potential solutions highlight the importance of public participation, public education, and decentralized governance (Ahmed and Ali, 2004; Deacon and Baxter, 2013; Ebreo and Vining, 2000; Kironde and Yhdego, 1997).

In some cases, minorities suffer from not having access to organized MSW disposal services. One example is the Bedouin, an indigenous population living in the Negev area of Israel. Because of the marginalization of this population, there is no waste management infrastructure for the Bedouin, which, however, exists for other populations living in the same geographical area. The absence of waste management services results in backyard burning, which can introduce pollution and increased health risks to women and children, such as diarrhea and respiratory illness (Meallem et al., 2010).

### **2.3.2 Public participation**

The screened papers in this area consist of four categories: public education (distribution of 15%), public-private partnership (39%), informal sector (38%), and others (such as overview papers) (8%). The contents included in the "others" category are referred to within the first three categories when appropriate.

#### **2.3.2.1 Public education**

Public knowledge is a key factor affecting public awareness of why, what, and how to implement an MSW management system (De Feo and De Gisi, 2010). Lack of public knowledge has been widely accepted as one of the most important barriers, called an information barrier, to the

success of any MSW management system (Read, 1999a). Intuitively, it is impossible to correctly participate in the recycling program if there is no correct instructional information.

The effectiveness of public education is affected by many economic-societal factors, such as personal behavior in terms of reading newspapers and books, watching TV and using the Internet (De Feo and De Gisi, 2010). In addition, as pointed out by Bortoleto and Hanaki (2007) and other authors, public education is a long-term commitment for present and future governments so as to create a strong environmental consciousness among all stakeholders.

The ways to implement public education need to be specific, and their contents and timing should be well planned (Yedla, 2012). For example, for respondents who were classified as non-recyclers but were motivated by concerns for the environment, a social marketing campaign targeting these individuals might capitalize on their concern for the environment (Ebreo and Vining, 2000). However, recent research on solid waste management in Italy showed that a non-discriminatory campaign may be more effective (Del Cimmuto et al., 2014).

In summary, the discussion on public education has been far from sufficient (McComas, 2003). Moreover, most research on the role of educational programs focuses on the effects of these interventions on conservation behavior, while few studies have examined the impact of these interventions on people's beliefs, motivations, and attitudes toward policies and programs (Ebreo and Vining, 2000).

### **2.3.2.2 Public-private partnership**

Public-private partnership (PPP) focuses on the privatization of MSW service from the public sector to the private sector. The definition of PPP is “the transfer and control of a good or a service currently provided by the public sector, either in whole or in part, to the private sector”

(Massoud and El-Fadel, 2002, p. 621). Ahmed and Ali (2004) and Oteng-Ababio (2010) extended the definition of PPP to include formal sectors, informal sectors, private waste contractors, and comparatively formal entities like CBOs (community based organizations) and NGOs (non-governmental organizations). Rathi (2006) differentiated the informal sector from the private sector and denoted the informal sector as community participation.

Most research on PPP has focused on industrializing countries. This is because there are a large number of people living under the private sector in these countries. For example, in India there are over 20,000 women who work as paper pickers in the city of Ahmedabad and up to 150,000 waste pickers in the municipal corporation of the Delhi area (Ahmed and Ali, 2004).

The tendency toward PPP results from the fact that the private sector commonly operates with more innovative technology, greater cost efficiency, more highly skilled personnel, and more broad capital resources compared to the public sector (Massoud et al., 2003). Thus, by involving the private sector in MSW management, the public sector can improve its service provisioning and management efficiency, and can relieve its financial burden (King and Gutberlet, 2013; Massoud and El-Fadel, 2002; Oduro-Kwarteng and van Dijk, 2013; Omran et al., 2009; Rajamanikam et al., 2014; Tilaye and van Dijk, 2014). In fact, there exist incentives for engaging in PPP for both the public and private sectors. The advantages to the public sector of adopting PPP include the following: 1) MSW ordinarily consumes a majority of municipal budgets, while PPP may offer considerable savings on these expenses; 2) PPP can help address the problems of chronic budget deficits, difficulty in expanding the work force, and limitations in meeting public demand; and 3) the public sector may benefit from PPP in terms of preventing corruption and political influence, which hamper efficient delivery of services (Ahmed and Ali, 2004). For the

informal sector, the incentives include the demand from the public, the potential profit (resale of recycled materials), and the existence of a sustainable source of income via the people's willingness to pay for the service (Charuvichaipong and Sajor, 2006; Gutberlet, 2008; Tilaye and van Dijk, 2014).

PPP does not mean zero responsibility of the local government. In fact, PPP in itself does not guarantee improved service provisioning and reduced cost (Awortwi, 2004). It was pointed out by Massoud and El-Fadel (2002, p. 627) that "the desired efficiency of a PPP will materialize only in situations where competition, performance monitoring, and accountability exist." Thus, local government still plays an important role in developing policies and strategic plans for private sector participation, monitoring service provisioning, assessing service quality, and providing services not covered by the private sector. This was justified by a case study in Ghana, in which the failure of PPP resulted from weak enforcement of regulations, corruption of public sector officials, lack of political will, lack of finance, and the absence of a monitoring mechanism (Oteng-Ababio, 2010). Fobil et al. (2008) re-analyzed the same situation in Ghana and provided three major reasons for failure from the point of view of institutions and organizations. The first cause is the lack of transparency in the procedure of awarding contracts, franchises, and leases, with the result that the most qualified contractors may not always win the contract. The second reason is the difficulty in the practical implementation of PPP due to ill-defined implementation plans. The third reason is the absence of monitoring mechanisms and lack of enforcement of contract terms. Oduro-Kwarteng and van Dijk (2013) added further factors including weaknesses in proper implementation of formal contracts, delayed payment of subsidies, and low cost recovery.

Despite its advantages in service provisioning, PPP may not always result in positive outcomes, at least to the more vulnerable members of the informal sector. Fahmi (2005) showed that in Cairo, because of privatization, the livelihoods of the Zabbaleen, the traditional waste collectors, were threatened because of losing access to their chief economic asset, waste garbage, and increasing costs of their services due to longer travelling distances.

### **2.3.2.3 Informal sector**

In the literature, there are different definitions of the term “informal sector.” One good example was given by Scheinberg et al. (2010, p. 4): “Individuals or enterprises who are involved in private sector recycling and waste management activities which are not sponsored, financed, recognized, supported, organized or acknowledged by the formal solid waste authorities, or which operate in violation of or in competition with formal authorities.” A wider definition of the informal sector generally includes stakeholders such as waste pickers, itinerant/stationary waste buyers, small-scale recycling industry, large-scale recycling industry, community-based organizations (CBOs), non-governmental organizations (NGOs), and micro-enterprises (Ahsan et al., 2012; Tukahirwa et al., 2013; Yedla, 2012).

Waste collection by the informal sector is more common in the global south, where up to 2% of the population in Asian and Latin American cities depends on waste picking for their livelihood (Gutberlet, 2013). In urban China, this number reaches 3.3 to 5.6 million (0.56% to 0.93% of the urban population) (Linzner and Salhofer, 2014). Recently, the role of the informal sector in MSW management systems has been widely recognized. However, the effects of the informal sector on the environment are two-fold. On the one hand, it has been widely accepted that the informal sector 1) can reduce the cost of formal waste management systems by decreasing the

amount of waste for collection; 2) is an important complement to the public sector, especially for areas without formal municipal systems (such as informal settlement); and 3) provides working opportunities and a livelihood for impoverished, marginalized, and vulnerable individuals or social groups (Campos and Zapata, 2013; Chaerul et al., 2014; Linzner and Salhofer, 2014; Nzeadibe, 2009; Rockson et al., 2013; Sasaki and Araki, 2014a; Sim et al., 2013; Wilson et al., 2006). On the other hand, the informal sector may cause further degradation of the environment because of utilizing inappropriate waste handling methods (such as backyard burning) and incorrect storage (Sembiring and Nitivattananon, 2010; Velis et al., 2012).

Although informal collectors or recyclers have a greater health risk related to “chemical and biological hazards, musculoskeletal damage, mechanical trauma and poor emotional wellbeing” (Gutberlet et al., 2013, p. 4607), in the literature, there is a lack of attention in the health risk related research given to this group. This may be because the complex socioeconomic situations make it difficult to identify whether the observed health risks come from MSW directly or other socioeconomic factors. In addition, limited research timelines make it impossible to evaluate the long-term effects from MSW on vulnerable populations, such as cancers (Binion and Gutberlet, 2012; Ngo, 2013; Oteng-Ababio, 2010).

Creating cooperatives and associations amongst informal recyclers, establishing public-private partnerships, integrating with the formal sector, and enhancing policy enforcement are commonly suggested as possible solutions for informal sectors (Katusiimeh et al., 2013; Masood and Barlow, 2013; Oteng-Ababio et al., 2013; Sasaki et al., 2014b; Wilson et al., 2006). It has been claimed “chemical and biological injuries are preventable and happen because of a failure

in policy enforcement regarding commercial and industrial regulation and residential knowledge awareness” (Binion and Gutberlet, 2012, p. 50).

### **2.3.3 Attitude and behavior**

The literature in this category focuses on the impact of general environmental attitudes and specific attitudes (directly related to MSW) toward behavior (57%), or demographic variables (43%). Studies in the social-psychology literature focus on the link between pro-environmental beliefs and behavior. Public acceptance plays an important role in influencing the effectiveness of any MSW management scheme and its smooth operation. The possible perception of unfair treatment by the public, potential pollutants, and public health issues may diminish social acceptance and evoke the “Not in My Back Yard” (NIMBY) syndrome among the public (Achillas et al., 2011).

Public awareness, public attitude, and public sustainable behavior can be promoted by improving convenience, education, regulations, economic incentives, and public involvement in decision-making (Che et al., 2013; Munoz-Cadena et al., 2012; Park and Berry, 2013; Saphores et al., 2006; Tarasova et al., 2012). A case study in Shanghai, China, identified the lack of separation awareness, inadequate public education, insufficient source separation facilities, and mixed transport and disposal as major barriers that result in poor MSW separation participation (Zhang et al., 2012). Nixon and Saphores (2007) suggested that a high participation level could be achieved through improving recycling convenience, establishing “recycling goals,” assigning neighborhood leaders to encourage participation, and improving public education. The importance of the availability of curbside collection and convenience was further confirmed by researchers (Chen and Tung, 2010; Gonzalez-Torre et al., 2003; Largo-Wight et al., 2013;

Rousta and Ekstrom, 2013; Wagner et al., 2013; Wang et al., 1997). The effects of education on bridging the gap between “having the right attitude and actualizing that in behavior” were highlighted by Neo (2010) and Massawe et al. (2014).

There are many studies exploring links between demographic and socioeconomic characteristics and recycling. The examination variables used in the screened papers include gender, age, income, education, dwelling type, and family size. The major observations are summarized as follows<sup>2</sup>:

- Gender: Both genders contribute equally to MSW production (Munoz-Cadena et al., 2012). Females are more willing to recycle, or participate in waste reduction (Bench et al., 2005; Saphores et al., 2006; Tonglet et al., 2004). However, men are slightly more willing to pay than women (Bernad-Beltran et al., 2014; Ezebilo, 2013).
- Age: Observations on the relationship between age and public attitude and behavior are equivocal. Some papers ranked older people as having the highest willingness to recycle (Bench et al., 2005; Nixon and Saphores, 2007; Tonglet et al., 2004), while others showed that people older than 45 years are more opposed to recycling and the most willing age group is between 36 and 65 years old (Chu et al., 2013; Nixon and Saphores, 2007; Saphores et al., 2006). In addition, young people may also be more willing to pay than older people (Bernad-Beltran et al., 2014).

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<sup>2</sup> Note that most of these observations are based on specific contexts so that they should be used with caution.

- Income: Household income has a positive and significant correlation with willingness-to-pay (Chu et al., 2013; Ezebilo, 2013; Rahji and Oloruntoba, 2009;) and willingness-to-participate (Ezebilo and Animasaun, 2011; Zen et al., 2014).
- Education: The education variable is positively related to willingness-to-pay (Bernad-Beltran et al., 2014; Ezebilo, 2013; Rahji and Oloruntoba, 2009; Saphores et al., 2006) and willingness-to-participate (Zen et al., 2014). People with higher education levels rank collection time and frequency as the most important factors which influence their willingness-to-participate (Chu et al., 2013).
- Dwelling type: Larger detached and semi-detached housing units are more likely to participate in waste reduction (Bench et al., 2005; Jones and Atwater, 1991; Zen et al., 2014) and are more willing to pay (Ezebilo, 2013).
- Family size: Smaller family size corresponds with higher willingness to engage in waste minimization behaviors (Tonglet et al., 2004, Ezebilo, 2013).

Vencatasawmy et al. (2000) showed that socioeconomic variables such as gender, number of children, type of house, size of house, and salary are not significant factors regarding recycling behavior. The mixed evidence suggests that one should jointly consider a wide range of socioeconomic variables in order to evaluate which of them dominates the willingness to recycle. Multivariate models may help explain some of the apparent discrepancies in the literature. Nixon and Saphores (2007) also suggested an integrated approach by combining both socioeconomic (such as income, price, and demographics) and psychosocial (such as personal values, beliefs, and attitudes) characteristics.

### **2.3.4 Policies**

In this category, a classification structure of Taylor (2000) was followed, but more recently published articles are provided in each category. Policies can be classified into two categories: laws and regulations, and social-psychological and economic incentives (De Jaeger et al., 2011; Lu et al., 2006; Taylor, 2000, Troschinetz and Mihelcic, 2009). Specifically, laws and regulations include 1) bans (Chang et al., 2013; Fauziah and Agamuthu, 2012, Li et al., 2013; Ono, 2013; Read et al., 1998; Revesz, 2001; Wu and Zhu, 2011); 2) control standards (Fauziah and Agamuthu, 2012; Huang et al., 2006; Li et al., 2013; Mi et al., 2014; Read et al., 1998; Revesz, 2001; Veecken and Hamelers, 2002; Woon and Lo, 2013; Wu and Zhu, 2011); 3) mandatory participation (Fauziah and Agamuthu, 2012; Li et al., 2013; Lu et al., 2006; Moh and Manaf, 2014; Revesz, 2001; Wu and Zhu, 2011; Yang and Innes, 2007); 4) time schedules (Agapitidis and Frantzis, 1998; Acosta et al., 2012; Clarke, 1993; Li et al., 2013; Loureiro et al., 2013; Lu et al., 2006; Revesz, 2001; Wu and Zhu, 2011); and 5) product specifications (Li et al., 2013; Revesz, 2001; Wu and Zhu, 2011).

Incentives include both social-psychological (De Feo and De Gisi, 2010; Hadjilambrinos, 1996; Saphores et al., 2006) and economic inducements. The latter can be further divided into five sub-categories: 1) public subsidies (Chen, 2005; De Jaeger et al., 2011; Palatnik et al., 2005; Taylor, 2000; Troschinetz and Mihelcic, 2009), 2) disposal/tipping fees (Poon et al., 2001), 3) product charges (Ackerman 1997; Dace et al., 2014), 4) deposit refund systems (Mrozek, 2000), and 5) user charges (Callan and Thomas, 1999; De Jaeger and Rogge, 2013; De Jaeger et al., 2011; Lu et al., 2006; Miranda and Aldy, 1998; Palatnik et al., 2005; Price, 2001; Troschinetz and Mihelcic, 2009; Usui and Takeuchi, 2014; Yang and Innes, 2007).

“User charge” is one of the most discussed incentives in the literature, since it is the main charging system for MSW collection and disposal. Depending on whether it is a function of the amount of waste generated, the charging may be flat (monthly or annual) or variable. In practice, a variable user charging system can be implemented through defining 1) a flat rate per container or per kilogram; 2) an adjustable rate for predefined weight ranges; or 3) a fixed pricing structure including both flat and variable rates (Callan and Thomas, 1999; Chowdhury, 2009; Price, 2001). Researchers prefer variable over flat charging systems, since they are more effective in encouraging households to minimize waste generation, especially in a low-income population, so as to avoid increased service payment (Usui and Takeuchi, 2014; Yousif and Scott, 2007). Illegal dumping is the major concern with respect to variable charging systems. However, effective steps are available to deal with this issue, such as improving public acceptance; strengthening public education; locking commercial and office dust-bins; refusing the collection of contaminated recycled items; limiting weight per waste container; and tightening enforcement procedures (Taylor, 2000). De Jaeger et al. (2011) and De Jaeger and Rogge (2013) showed that weight-based pricing, public subsidies, and enhanced convenience (weekly instead of bi-weekly collection) were the most effective incentives that did not reduce cost efficiency. In some cases, the effectiveness of economic incentives can be enhanced through improved service delivery (Owusu et al., 2013) and attitudes of convenience (Mueller, 2013).

Policy implementation is another important topic under consideration in this area and a clear gap between the policy-making and implementation is observed. For example, in India, “despite consistent efforts of different regulatory bodies and directives from the Honorable Supreme Court of India and from time to time regulatory bodies, the implementation of these rules is still a distant dream” (Talyan et al., 2008, p. 1278). Deficiencies with respect to financial resources,

technical skilled workforce, public awareness, and public cooperation were considered as major contributions to this failure (Talyan et al., 2008). Another failed example occurred in Addis Ababa, Ethiopia. Although some reorganization of the city administration and changes to MSW management on the ground have been implemented, the established way of exercising power has remained within the new administration. This has resulted in few improvements for MSW disposal service provisioning and increased mistrust among the stakeholders (Bjerkli, 2013). Thus, for local governments, it is necessary to evaluate the suitability of the proposed planning strategies and management systems within the local context (environmental, social, and political) and continuously assess their effectiveness once implemented (Premakumara et al., 2014; Read, 1999b). This requirement further necessitates the development of new assessment tools and decision-making models (Hung et al, 2007) with the integration of appropriate assessment factors (Zaman, 2014) and constructive drivers, such as perception of enablers, perception of benefits, perception of barriers, environmental attitude, and environmental awareness (Victor and Agamuthu, 2013).

Within the screened papers, a similar institutional structure can be observed in different countries. Commonly, governments at the national or state level, such as the federal and state governments in the USA (Taylor, 2000), regional government in Belgium (De Jaeger et al., 2011), Ministry of the Environment in Greece (Agapitidis and Frantzis, 1998), and Ministry of Environment and Forests in India (Talyan et al., 2008), are tasked with policy making, while the local municipal governments are responsible for the actual MSW collection and disposal.

The distribution of papers according to the topics of regulations, incentives, and implementations are 39%, 34%, and 27%, respectively. Note that the papers, which are concerned with both

regulations and incentives, are put into one of the aforementioned categories based on the main topic of discussion.

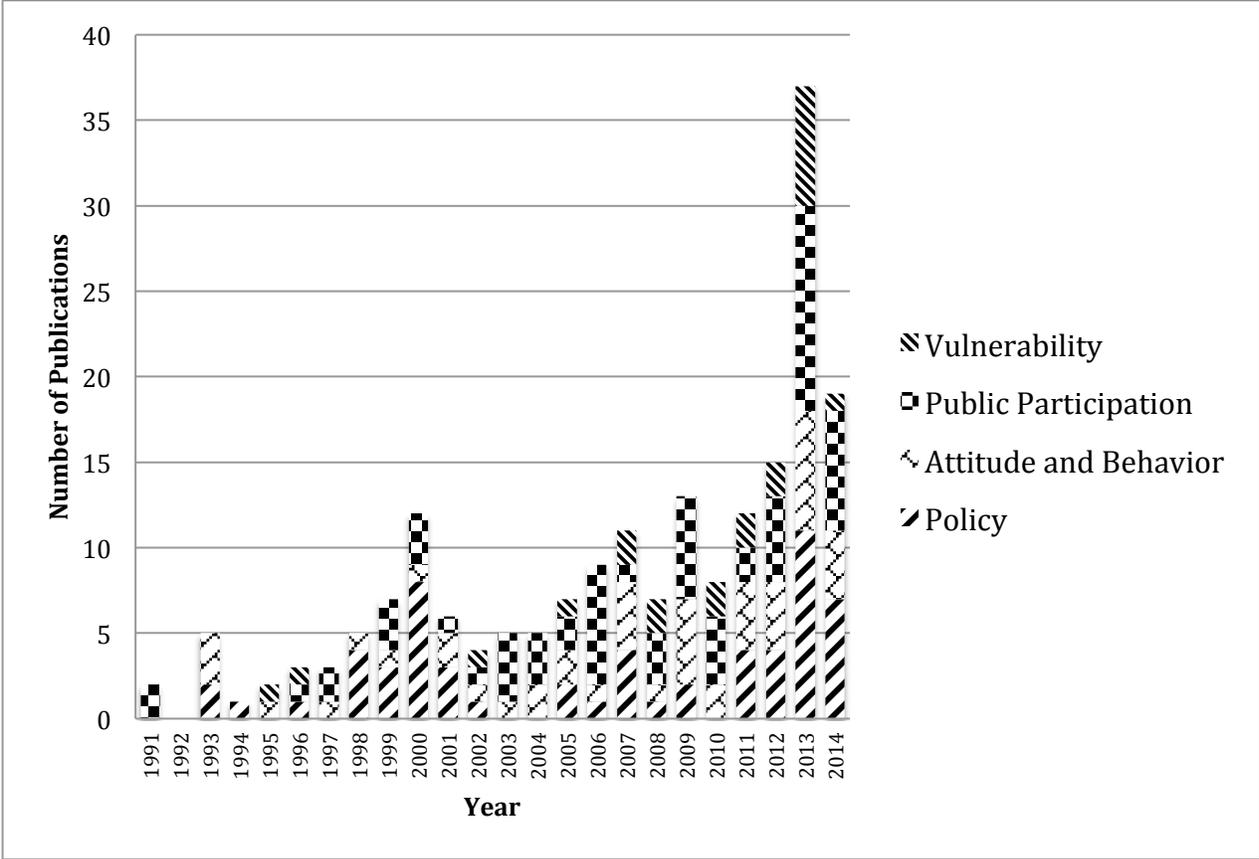
## **2.4 Discussion**

Researchers have recognized the importance of social dimensions in sustainable MSW management more and more widely, although the efforts that have been contributed in this area are far from sufficient. The inherent complexity of MSW management makes the factors in social dimensions intertwine with each other, which further makes the analysis of social dimensions more complicated.

### **2.4.1 Reporting on social dimensions is limited but increasing**

The distribution of papers by year from 1991 to 2014 is presented in Figure 2.1. with research on the social dimensions of MSW management steadily increasing over this timeframe. Although the searching criterion was set from 1980, no related publications are found before 1991. This may be due to the fact that prior to 1991, little attention was paid to the social dimensions of MSW management. The publications for 2014 may not be complete due to delays in the publication process. However, from the figure, it can be expected that a similar increasing trend will be maintained. By using a single key topic term of “municipal solid waste”, the search produced a total of 26,094 publications. Thus, the research related to the social dimensions of MSW management only occupies 0.69% of the total MSW management papers, which indicates that there has been limited focus on this topic.

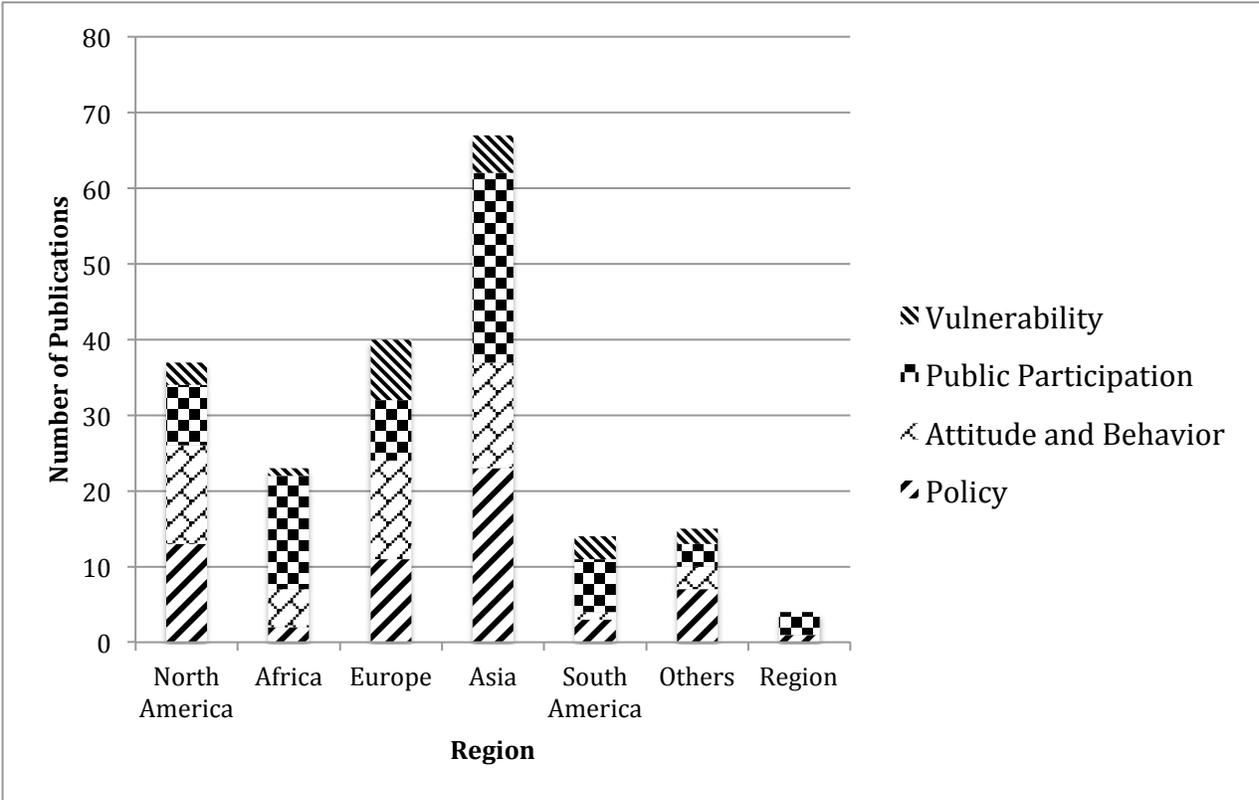
**Figure 2.1** Paper distribution with respect to the year of publication.



**2.4.2 The global distribution of social dimensions reports is inequitable**

The global distribution of publications related to the social dimensions of MSW management is shown in Figure 2.2. The greatest number of publications comes from Asia, followed by Europe, North America, Africa, and South America. In fact, Asia ranks first in all categories, except vulnerability (ranked second). This may be because of its high population density, large urbanization rate, and fast economic development, which may cause more severe MSW management problems. In addition, Asia is also the region consisting of the largest number of industrializing countries, where MSW management faces more challenges and barriers (Shekdar, 2009).

**Figure 2.2** Paper distribution with respect to the region of publication.



In Figure 2.2, the category “Others” represents the papers that do not indicate any specific areas under consideration and more or less belong to a theoretical analysis or an overview. One example in this category is that of Mrozek (2000), who addresses the theoretical model of deposit/refund systems and does not indicate any specific region. It is also clear that the number of papers considering wider areas than a single country is very limited (only five in the category “region”). This finding corresponds with the general opinion that MSW management should be suited to the local conditions and there are no “one-shoe-fits-all” solutions.

**2.4.3 The four categories are interconnected**

Although the screened papers were classified into four categories, they are in fact interconnected. Policy constitutes intervention from the government. It plays the roles of guaranteeing the effective implementation of the whole MSW management system, protecting vulnerable

populations, promoting public awareness, stimulating pro-environmental attitudes, filling the gap between attitude and behavior via incentives, and ultimately improving public participation. For vulnerable populations, promoting their living conditions and reducing their health risks requires not only protecting them through policies, but also encouraging their participation in decision-making. As the major participants, the public's attitude and behavior are key factors influencing the reusing, reducing, and recycling of resources. Understanding the factors that have effects on public pro-environmental attitudes and behavior is important for helping decision makers to strengthen the weak points in the existing policy framework and promote the effectiveness of new incentives. Involving the public in MSW management is one of the most promising ways to achieve sustainable development. Such an initiative clearly depends on appropriate policies and correct attitudes. Involving the public from the early stages of decision making can promote public awareness of the potential risks from MSW facilities, reduce the opposition from the public, and minimize the potential risk, especially to vulnerable populations. For the participation of the informal sector, policy needs to guarantee financial and technical support, attitudes need to be changed by recognizing the contributions from the informal sector, and public participation should establish a suitable partnership between the public and informal sectors. These interconnections make the analyses of MSW management complicated and demand integrated analysis methods, which can deal with both quantitative and qualitative data, and multiple criteria.

#### **2.4.4 Integrated MSW is the new trend for future development**

A new trend for MSW management is to establish an integrated system that involves all stakeholders, including government, the private sector, non-government organizations, and the informal sector, as well as sharing MSW management responsibilities among them. Public-

private-partnerships and decentralization have been widely considered as major components in this integrated system and promising solutions to the ever-worsening MSW problems (Ng et al., 2013; Rathi, 2006; Tilaye and van Dijk, 2014), especially for industrializing countries. Such reformation further requires a coherent framework that integrates technological, economic, cultural, social, and environmental variables of MSW management (Yates and Gutberlet, 2011). A sustainable decision-making model needs to not only accommodate economic, environmental, and social factors simultaneously, but also incorporate public participation into the decision-making process from the beginning to end (Hung et al., 2007). Since adequate information is the prerequisite for the effectiveness of such integration, “communication should reach high standards in an effort to contribute to the maximization of a public consensus” (Achillas et al., 2011, p. 862). It is important that the public be able to access and assess all background information and both negative and positive impacts (Achillas et al., 2011).

## **2.5 Summary**

In this chapter, the state of research on the social dimensions of MSW management was analyzed via a systematic literature review in terms of vulnerability, public participation, attitude and behavior, and policy. By searching on ISI Web of Science, a relatively comprehensive list of publications on the related peer-reviewed literature published between 1980 and 2014 was developed. The major conclusions from the analyses are summarized as follows.

- Research on potential risks to vulnerable populations from MSW focused on health, economic/wage inequity, environmental injustice, and inequity in service provisioning. Among them, health risks to children were investigated most. Further research is needed on other types of risk.

- Promoting public participation requires improved public education, the involvement of the informal sector, and the collaboration between the private and public sectors. All these highlighted the important role of government in MSW management. How to further improve the government functions and administrative structures should be emphasized in future research.
- The level of an individual's participation in MSW management is influenced by his/her awareness and attitude, which are affected by demographics. Thus, designing context-aware MSW management mechanisms are important to further encourage involvement at the individual level.
- Policies, including both regulations and incentives, were shown to be effective in promoting MSW management. However, in reality, the effectiveness of these policies was limited by many implementation issues, and differed from one location to another. Therefore, how to design policies in order to fit the local situation will become a key research issue.
- Compared to technical issues, social dimensions of MSW management have not attracted sufficient attention from researchers. Since the success of MSW management highly relies on the participation of all stakeholders, analyzing social, economic, and psychological factors of MSW management is important and urgent.
- MSW management is a very complicated system with many interacting factors and issues. Therefore, integrated management has become the new trend in MSW management and is necessary to ultimately achieve the goal of sustainable development. In addition, researchers should be very careful in selecting their analysis methods so that more reasonable observations and conclusions can be derived by jointly considering long-term and short-term, local and global.

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# Chapter 3

## **Public Participation in Municipal Solid Waste Source-Separated Collection in China: Status and Influencing Factors**

Currently, China is facing critical problems regarding the management of municipal solid waste (MSW). The Chinese government has recognized the important role of waste separation at the source in the MSW management process, and initiated MSW source-separated collection in eight pilot cities in 2000. However, most of these efforts were not successful. Thus, in order to facilitate the successful implementation of MSW source-separated collection nationally, it is necessary to analyze the factors that have significant impacts on public participation in this activity. To this end, a comprehensive analysis of MSW source-separated collection in central area of Guilin, China was conducted. After introducing methodology used in the analyses, details on analytical results with discussions are presented in terms of public perception, public awareness, public attitude, and willingness to pay. Implications to decision makers are also provided.

### **3.1 Introduction**

Accompany with its fast economic development and urbanization, China is now facing the largest and fastest increase in solid waste generation in the world (Liu and Diamond, 2005; World Bank, 2005). In 2014, the total amount of municipal solid waste (MSW) collected and transported in China is 179 million (Ministry of Environmental Protection of the People's

Republic of China, 2015; Zhang et al., 2010). It has been predicted that this situation will become more severe in the future as population density, urbanization, and industrialization continue to increase (Agdag, 2009; Hong et al., 2010). Currently, MSW management has undoubtedly become a prominent problem in China.

Implementing MSW source-separated collection plays a critical role in determining the efficiency of the follow-up processing of waste destined for landfills, recyclable products, or green waste (McDougall et al., 2001; Vergara and Tchobanoglous, 2012; Zhang et al., 2008). Today, some industrialized countries have achieved remarkable implement in MSW source-separated collection. For example, in 2008, over 25 categories of household waste have been separated at source in some municipalities of Japan (Matsumoto, 2011; Zhang and Wen, 2014). However, MSW source-separated collection is still nonexistent in most cities in China (Cheng and Hu, 2010; Yu, 2009). As indicated by Zhang et al. (2011), the lack of public awareness and participation has been recognized as one of the most important factors to compromise the implementation of MSW source-separated collection.

In the literature, many studies are reported that investigated the determinants of public participation in MSW source-separated collection all over the world. Matsumoto (2011) summarized the related work in this area by categorizing the determinants into socio-demographic variables, pro-environmental attitude, opportunity cost, and knowledge and social norms. In China, studies on MSW source-separated collection have also been carried out in some cities, such as Suzhou (Zhang and Wen, 2014), Shanghai (Xu et al., 2016), and Guangzhou (Chung and Poon, 2001). However, most of these studies focused on developed coastal regions,

which make research outcomes too specific to be extended to most inland and under-developed areas of China.

By considering the fact that MSW management may exhibit significant heterogeneity among regions in China due to highly unbalanced economic development and a wide diversity of social and cultural norms (Hu et al., 1998), this chapter aimed to investigate the status and influencing factors towards households' participation in MSW source-separated collection in Guilin city, Guangxi Zhuang Autonomous Region, a province-level region in the southwestern part of China, which is representative of wider areas located in-land of China and having GDP around the national average (Guangxi was ranked 16<sup>th</sup> out of 27 provinces in China in 2014 with GDP of 1.567 trillion RMB or \$242.376 billion USD (National Bureau of Statistics of China, 2014). However, separate surveys should be carried out at other locations in china in order to determine the real situation at each location and identify any specific local impact factors. Household waste, the major component of MSW, was considered as an example, and public perception, awareness, attitude, and willingness to pay for MSW management charges were analyzed based on the data collected through field surveys in 2014. In addition, since Guilin was one of the pilot cities of MSW source-separated collection program initiated in 2000 by the Ministry of Construction of China (now the Ministry of Housing and Urban and Rural Development of the People's Republic of China (MOHURD)), (MOHURD, 2000), comparison between pilot and non-pilot communities was carried out to learn lessons from pilot program failure. Through the analyses, important implications were acquired for promoting the design of MSW source-separated collection programs and education campaigns. To the best of my knowledge, the research in this chapter is the first to study MSW source-separated collection in Guangxi province and to make comparison between pilot and non-pilot communities.



million with the urban population of about 1.26 million. The per capita disposable income in 2014 was 26,811 RMB (\$4,206 USD) for urban residents (Guilin Bureau of Statistics, 2014). In 2014, Guilin city consisted of 6 districts, 11 counties, 75 towns, and 1654 villages (Guilin People's Government, 2014). With the building of Beibu Gulf Economic Zone and Guilin National Tourism Reform Pilot Area, the city has experienced rapid economic development. Although landfill facilities and composting plants were put into operation in the central city area in 2004 and 2005, respectively, all other areas still dispose MSW by unsanitary landfill (Guilin Environmental Protection Agency, 2006). The pilot program of MSW source-separated collection was not successful in Guilin (Tai et al., 2011).

### **3.2.2 Data collection and analysis**

The field surveys were conducted in April 2014 in urban area of Guilin city. According to the consultation with the city government staff, six residential areas of Guilin were chosen based on the criteria that three of them were pilot communities for MSW source-separated collection within the pilot program, while the other three were non-pilot communities, but with similar living conditions and management patterns. Residents from six residential areas were selected by setting up survey stations on every road and gate surrounding the residential areas that the residents had chance to pass by. Each respondent was interviewed in person via questionnaires. A total of 896 questionnaires were distributed and 848 valid responses were received. Before the field investigation, the questionnaire was revised four times before reaching its final format, in terms of content, clarity of language, and appropriateness of length, based on the comments from individual interviews and responses from testing communities and residents. Samples used in the pre-test were excluded from the actual survey.

The questionnaire incorporated both Likert-scaled, single choice, and multiple-choice questions conducted at the individual level. The questionnaires were consisted of four major themes: i) public knowledge, awareness, and attitudes to MSW source-separated collection; ii) public participation and behaviors; iii) waste management facilities and services; and iv) demographics.

Raw data from the survey was first compiled into EXCEL spreadsheets, and then analyzed by using the Statistical Package for Social Sciences for MAC (SPSS, v22). Statistical analysis tools, such as free samples t-test for the comparison between pilot and non-pilot communities, principal component method for factor reduction, linear and multinomial logistic regression for evaluating relationship between independent and dependent variables, were used (Hosmer and Lemeshow, 2000; Zar, 1999). Kendall's tau-b correlation coefficient was used for correlation analysis. Pearson's correlation coefficient was tested as well. Both approaches provided same observations and results.

### **3.3 Results and discussion**

#### **3.3.1 Demographics**

The demographics of the respondents are summarized in Table 3.1. In the survey, respondents were required to be older than 7 years old (children start their elementary education from age 7 in China) in order to ensure the respondents were able to understand the questionnaire and provide responses. Most respondents were between 19 and 65 years old (77.1%), and there were sufficient numbers of respondents who were either younger (<19) (14.9%) or older (>65) (8.1%). University degrees (undergraduate or graduate) were held by 48.1% of respondents. The largest percentage of the respondents (48.0%) had a monthly income between 1000 RMB (\$157 USD) and 3000 RMB (\$470 USD), and 28.6% of the respondents had a monthly income of between

3000 RMB (\$470 USD) and 5000 RMB (\$784 USD). Only small percentages of respondents had monthly incomes less than 1000 RMB (\$157 USD) (7.6%) or higher than 5000 RMB (\$784 USD) (15.7%). The gender distribution of respondents was imbalanced in terms of the female respondents (66.0%) over the male ones (34.0%). This result may be because female family members take more responsibility for shopping and handling household waste (Sidique et al., 2010; Wang and Geng, 2012).

**Table 3.1** Descriptive statistics of the demographics of the 848 respondents in April 2014.

Item	Response	Percentage (%)
Age	7-18	14.9
	19-24	23.0
	25-36	25.4
	37-50	17.0
	51-65	11.7
	>65	8.1
Gender	Male	34.0
	Female	66.0
Education	Illiterate	0.6
	Elementary school	7.7
	Junior high school	10.9
	Senior high school	18.0
	College/ diploma program	14.7
	University – undergraduate program	33.8
	University – graduate program and above	14.3
Household size	1	5.6
	2	16.1
	3	35.5

	4	21.6
	5	14.9
	6	4.8
	>6	1.5
Monthly Income	0-1000 RMB (\$157 USD)	7.6
	1001-3000 RMB (\$157- 470 USD)	48.0
	3001-5000 RMB (\$470- 784 USD)	28.6
	5001-8000 RMB (\$784- 1256 USD)	10.3
	>8000 RMB (\$1256 USD)	5.4

### 3.3.2 Public perception

The evaluation of public perception consisted of two parts. The first part dealt with the perception at the community level in terms of community sanitary condition, careless littering, the number of dustbins, the locations of dustbins, and the waste collection time. The second part focused on the perception at a more general level, considering legislation/policy on waste source-separated collection, enforcement of the legislation, professionalism, media, non-governmental organizations (NGOs), public awareness of waste source-separated collection, and public awareness of environmental conservation.

The community sanitary condition was evaluated on a scale of “1: very clean”, “2: clean”, “3: needs improvement”, and “4: poor”. The mean value (in the form of “mean value  $\pm$  standard deviation”) is  $2.62 \pm 0.822$ , which indicates that the respondents on average thought the community sanitary condition was acceptable.

The situation regarding careless littering was evaluated on a scale of “1: often”, “2: occasionally”, and “3: never”. The mean value is  $1.85 \pm 0.636$ , meaning that careless littering occurred occasionally in the community.

The evaluation regarding satisfaction with waste management facilities (the number of dustbins, the locations of dustbins, and the waste collection time) was based on a scale of “1: satisfied”, “2: fair”, and “3: dissatisfied”. The mean values were calculated as shown in Table 3.2. All three means are around 2, which means the MSW management facilities and services in the communities are only acceptable and need further improvement.

**Table 3.2** Mean values of public perceptions on waste management facilities.

	Mean
Number of dustbins	1.93 ± 0.727
Locations of dustbins	1.82 ± 0.665
Scheduled collection	1.56 ± 0.691

**Table 3.3** Mean values of public perceptions at the general level.

	Mean
Legislation/Policy on MSW source-separated collection	2.45 ± 1.132
Enforcement of the legislation	2.16 ± 1.119
Professionalism	2.78 ± 1.244
Media	2.74 ± 1.261
Non-governmental organizations (NGOs)	2.63 ± 1.133
Public awareness of MSW source-separated collection	2.23 ± 1.116
Public awareness of environmental conservation	2.35 ± 1.160

At the general level, the evaluation was based on a 5-level scale from “1: strongly dissatisfied” to “5: strongly satisfied”. The calculated mean values with respect to the seven aspects under consideration are shown in Table 3.3. Respondents felt more or less dissatisfied on all aspects under testing, especially with respect to enforcement. Later analysis of the respondents’ attitudes on participating waste separation showed that 20.9% of respondents were willing to participate only if there was enforcement from laws or regulations. This finding is consistent with the

observation from (Sukholthaman and Sharp, 2016). Therefore, developing comprehensive laws and regulations with sufficient enforcement should be emphasized by the decision makers for promoting public participation in MSW separation.

**Table 3.4** The outputs from the t-test for the comparison of average public perception between pilot and non-pilot communities at both community and general levels.

	Mean (Pilot community)	Mean (Non-pilot community)	<i>p</i>
Community sanitary condition	2.70 ± 0.835	2.48 ± 0.779	<0.001*
Careless littering	1.86 ± 0.765	2.13 ± 0.732	<0.001*
Number of dustbins	2.02 ± 0.747	1.84 ± 0.781	0.001*
Locations of dustbins	1.93 ± 0.709	1.73 ± 0.727	<0.001*
Scheduled collection	2.08 ± 1.148	1.97 ± 1.169	0.198
Legislation/Policy on MSW source-separated collection	2.50 ± 1.124	2.34 ± 1.141	0.062
Enforcement of the legislation	2.20 ± 1.149	2.10 ± 1.058	0.204
Professionalism	2.80 ± 1.255	2.75 ± 1.225	0.573
Media	2.78 ± 1.296	2.67 ± 1.190	0.201
NGOs	2.66 ± 1.155	2.58 ± 1.092	0.302
Public awareness of MSW source-separated collection	2.18 ± 1.113	2.32 ± 1.117	0.074
Public awareness of environmental conservation	2.35 ± 1.180	2.33 ± 1.124	0.842
* Significant at 0.05 level			
** Significant at 0.01 level			

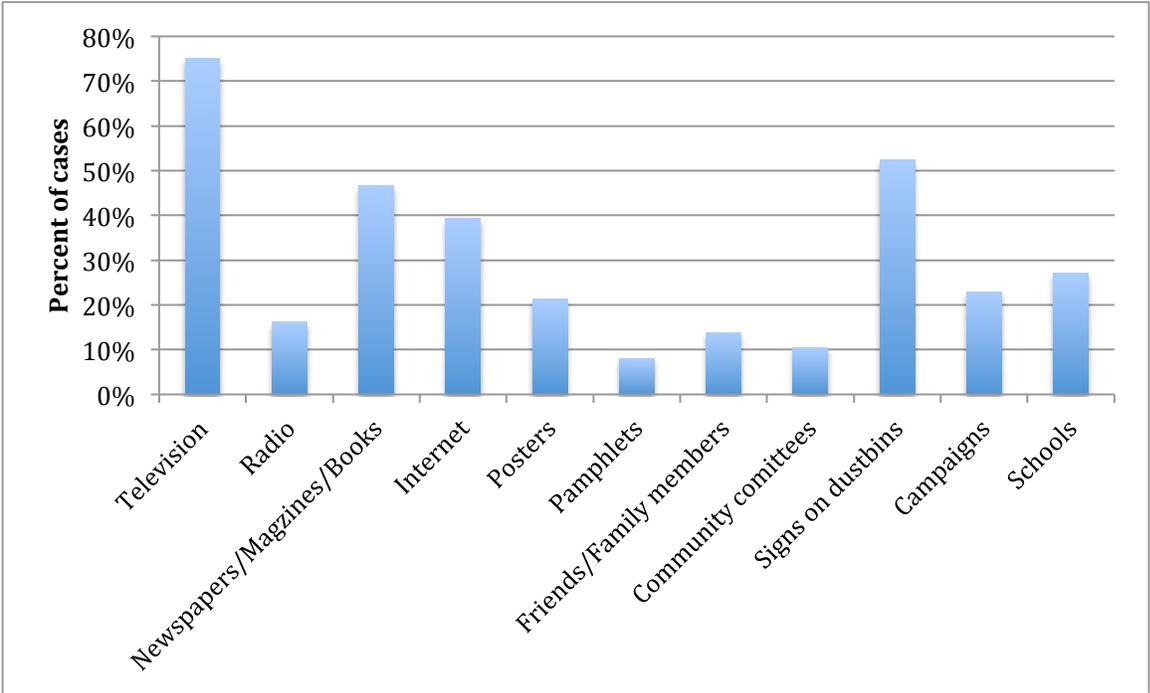
The difference of public perception between the respondents from pilot and non-pilot communities was further compared by using an independent samples t-test. The *p*-values from the t-test are presented in Table 3.4. The analytical results show that at the community level,

respondents from pilot and non-pilot communities had significantly different perceptions on all items under testing except “scheduled collection”. Specifically, the respondents from pilot communities had less satisfaction with regard to “community sanitary condition”, “the number of dustbins”, and “locations of dustbins”. Additionally, less careless littering was found in the pilot communities. Since the data before the initiation of the pilot program were not available, it is unclear whether the observed difference is a result of the pilot program or not. At the general level, there is no significant difference between the two communities.

**3.3.3 Public awareness**

Public awareness was evaluated by measuring the knowledge of the respondents regarding MSW source-separated collection. All respondents were asked whether they were in possession of the related information and where they gained this information.

**Figure 3.2** Percentage distribution of respondents’ selections on different knowledge sources for acquiring the information on municipal solid waste source-separated collection.

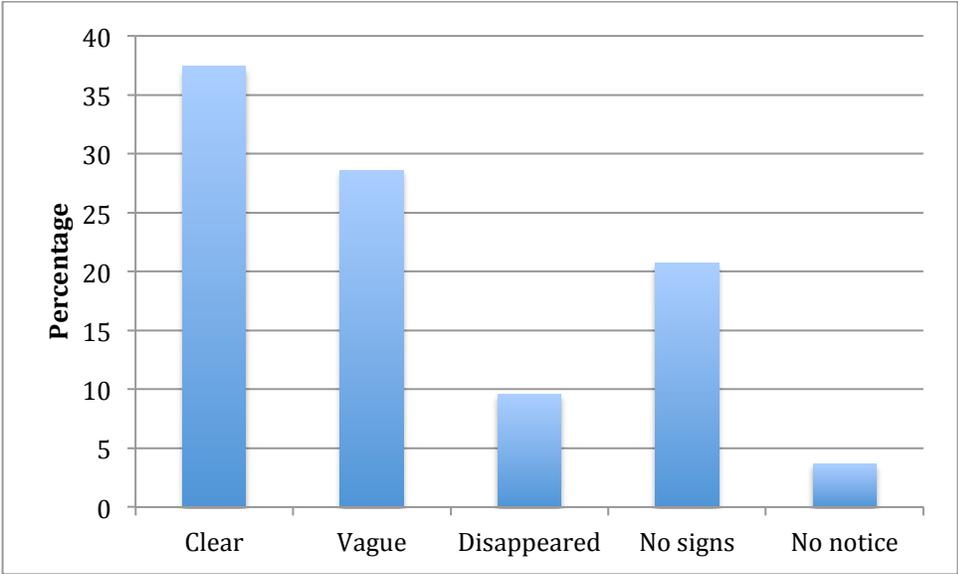


Among all respondents, only 2% of respondents have never been educated waste source-separated collection, which indicates a high public awareness in Guilin residents. However, such high public awareness did not translate into positive public attitudes to participating the waste separation (36% of respondents showed negative attitudes), which was consistent with previous work (Chung and Poon, 2001). Thus, further analysis is needed to evaluate respondents' knowledge level and the correlation between knowledge and attitude.

Figure 3.2 shows the distribution of knowledge sources used by the respondents to acquire the information on MSW source-separated collection. Television (75.1%) is the most popular source for the respondents to gain knowledge on MSW source-separated collection, followed by signs on dustbins (52.5%), newspapers/magazines/books (46.7%), and the Internet (39.3%). One interesting observation, which, to the best of my knowledge, has not been well addressed in the existing literature, is the significant role of signs on dustbins in educating the public on MSW source-separated collection. However, the follow-up analyses on the status of signs on dustbins in the communities, as shown in Figure 3.3, shows that 58.9% of respondents reflected that the signs on dustbins in their communities were “vague”, “disappeared”, or “missing”. In addition, during the field test, it was found that a consistent classification sign system on the dustbins was not available. These disappointing results significantly limit the educational efficacy of signs on dustbins, and suggest that the central government and local authorities should design dustbin signs that are more consistent, clearer and more easily understandable. In addition, pamphlets, the most commonly used method by the local authorities for marketing and campaigns, only contributed 8.1% of MSW source-separated collection education. Such a low contribution may imply that pamphlets are not an effective means of MSW source-separated collection education,

or the implementation of pamphlets (design, content, etc.) may need improvement in order to attract more attention from the public. Further analysis should be carried out in this area.

**Figure 3.3** Percentage distribution of statuses of signs on dustbins based on the feedbacks from the respondents.

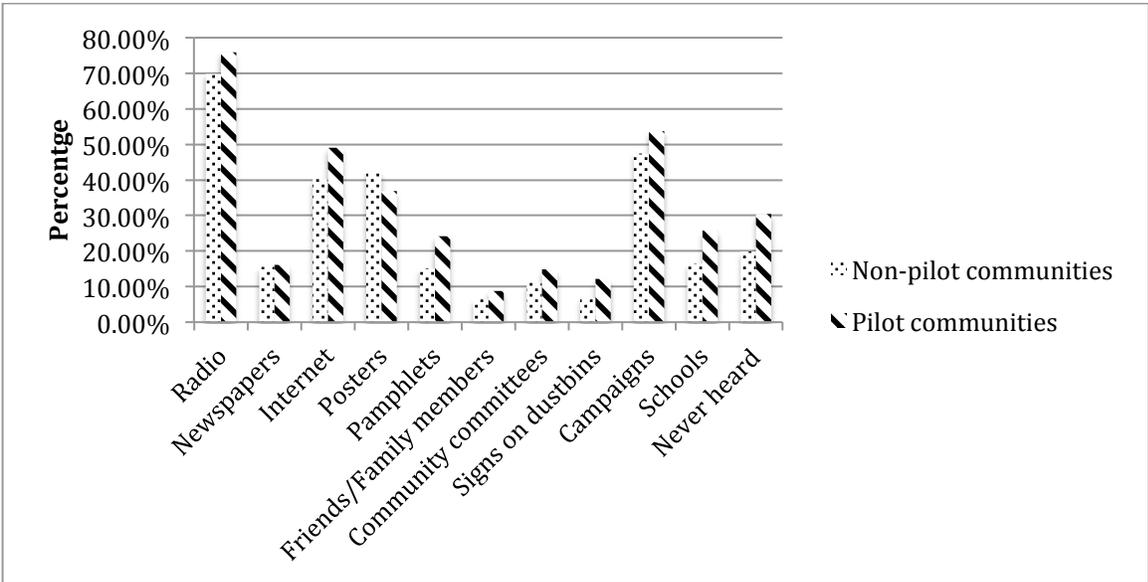


**Table 3.5** Top three information sources for different age groups. The numbers shown in parentheses indicate the percentages in each age group who made the associated selection.

Age	7-18	19-24	25-36	37-50	51-65	>65
Information sources	School (64.2%)	Television (77.0%)	Television (72.2%)	Television (79.3%)	Television (87.9%)	Television (86.9%)
	Television (56.9%)	Signs on Dustbins (66.1%)	Signs on Dustbins (48.3%)	Internet (51.9%)	Newspapers, Magazines, Books (44.0%)	Signs on Dustbins (42.6%)
	Signs on Dustbins (56.1%)	Newspapers, Magazines, Books (53.6%)	Newspapers, Magazines, Books (45.4%)	Signs on Dustbins (50.4%)	Signs on Dustbins (39.6%)	Newspapers, Magazines, Books (41.0%)

To evaluate the preference difference among different age groups, the top three information sources for each age group are listed in Table 3.5. Overall, different age groups showed different preferences with respect to information sources. However, “television”, “signs on dustbins” and “newspapers, magazines, books” were common to almost all age groups, except very young respondents (<19 years old), who obtained more education from school, and middle age respondents (37-50), who used the Internet more often. In addition, Table 3.5 further highlighted the important role of “signs on dustbins” in disseminating waste separation knowledge.

**Figure 3.4** Percentage distribution of different knowledge sources selected by pilot and non-pilot communities.



The findings from analyzing public awareness have important implications for the campaigns to promote awareness on MSW source-separated collection among residents. The decision makers should design campaigns that reinforce the functions of effective channels of communication and at the same time promote the effectiveness of other knowledge sources. In addition, the

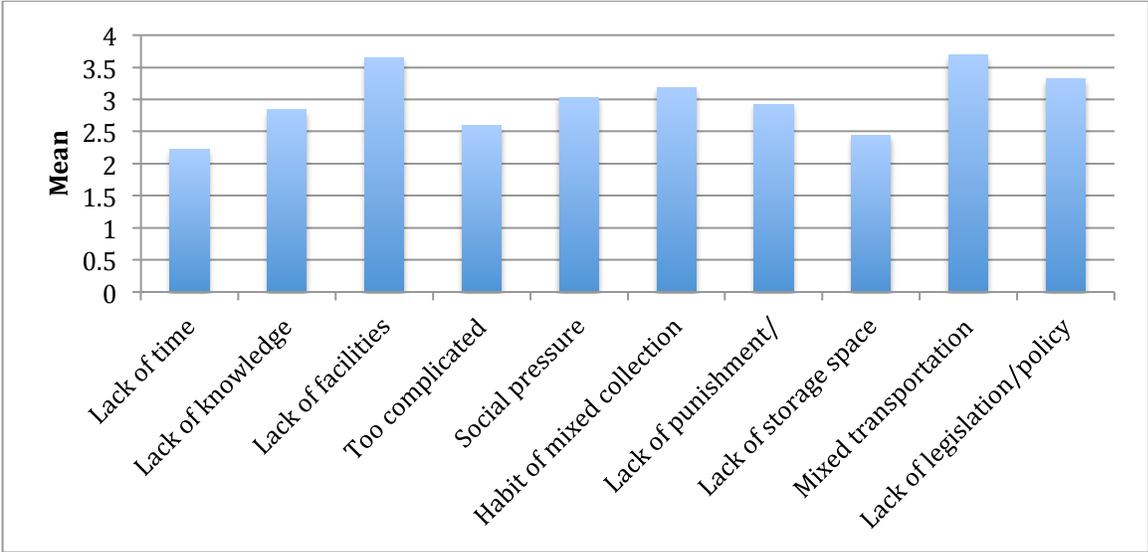
campaigns should also take into consideration the differences among population groups in order to maximize the effectiveness of the campaigns.

A comparison of the distributions among the knowledge sources between the pilot and non-pilot communities is shown in Figure 3.4. Respondents from both kinds of communities shared a nearly identical pattern of percentages for different knowledge sources. This result implies that none of the measures adopted by the pilot program for public education were successful.

### **3.3.4 Public attitudes**

The attitude to participate in the MSW source-separated collection was affected by both intrinsic factors (such as lack of time, lack of storage space, lack of knowledge, too complicated to operate, being accustomed to mixed collection, lack of punishments/rewards, and lack of legislation enforcement) and extrinsic factors (such as lack of facilities, mixed transportation after separating at source, and social pressure) (Keramitsoglou and Tsagarakis, 2013; Yang et al., 2011). A five-point ordinal scale (no, little, some, much, significant) was used to evaluate the level of impact of each factor on the respondents' attitudes. Figure 3.5 shows the mean values of the influence of 10 factors on the attitudes of respondents. A higher mean value means the corresponding factor is more important. According to Figure 3.5, "Mixed transportation after separating at source", "Lack of facility", "Lack of legislation enforcement", "Being accustomed to mixed collection", and "Social pressure" are listed as the most significant factors (all have mean values greater than 3 or, in other words, these factors have at least some impact on respondents' attitudes). These findings are consistent with those of Mstsumoto (2011) and Sukholthaman and Sharp (2016).

**Figure 3.5** The mean values of influence levels of different factors on affecting the respondents' attitudes to participate in a municipal solid waste source-separated collection program.



The significance of these influencing factors on attitudes was determined by a binary logistic regression analysis. Since most respondents were already separating valuable waste on their own initiative (only 6.5% of respondents never did any waste separation), the evaluation turns to their pro-environmental attitude (namely, attitude because of environmental conservation) to participate MSW source-separated collection. In the binary logistic regression analysis, respondents' attitudes were set as the dependent variable, and the identified 10 impact factors and demographic factors (age, gender, education level, household size and monthly income) were set to be influencing factors. The binary logistic regression model coefficients  $\beta$  are shown in the Table 3.6. Since the Hosmer-Lemeshow test with  $p = 0.488 > 0.05$  is not significant, the model fit is good (Wu, 2009).

**Table 3.6** Estimated coefficients of binary logistic model with respondents' attitudes as the dependent variable and the identified impact factors and demographic factors as independent variables.

	$\beta$
Lack of time	-0.049
Lack of knowledge	0.068
Lack of facilities	-0.097
Too complicated to operate	-0.083
Social pressure	-0.101
Being accustomed to mixed collection	-0.143
Lack of punishments/rewards	-0.229*
Lack of storage space	-0.106
Mixed transportation after separating at source	0.280**
Lack of legislation/policy enforcement	-0.004
Age	-0.167
Gender	0.374
Education level	-0.222**
Household size	-0.000
Monthly income	-0.113
Cox & Snell $R^2$ : 0.109; Nagelkerke $R^2$ : 0.151	
-2LL: 456.822	
Hosmer and Lemeshow test with $p$ in parenthesis: 7.463 (0.488)	
Overall predictive accuracy: 69.5%	
* Significant at 0.05 level	
** Significant at 0.01 level	

There are only two factors, “lack of punishment and reward” ( $\beta = -0.229, p = 0.029$ ) and “mixed transportation after separating at source” ( $\beta = 0.280, p = 0.010$ ), that have significant effects on the respondents' attitudes for participating MSW source-separated collection. The

negative sign of the coefficient with respect to “lack of punishments and reward” shows that the respondents who had positive attitudes toward participating in MSW source-separated collection, had less concern for economic incentives. This result is consistent with the definition of public attitude in this chapter, in which positive attitudes are motivated by environmental, rather than economic values. A new observation was that respondents with positive attitudes cared more about potential “mixed transportation after separating at source”. This suggests that the local authority should improve the waste transportation service. Otherwise, “mixed transportation after separating at source” may harm the enthusiasm of the people with positive attitudes and ultimately hinder them from implementing MSW source-separated collection behavior.

**Table 3.7** Kendall’s tau-b correlation coefficients between education levels and impact factors.

Impact factors	Correlation coefficient
Lack of time	-0.023
Lack of knowledge	0.070 <sup>*</sup>
Lack of facilities	0.142 <sup>**</sup>
Too complicated to operate	0.100 <sup>**</sup>
Social pressure	0.088 <sup>**</sup>
Being accustomed to mixed collection	0.106 <sup>**</sup>
Lack of punishment/rewards	0.129 <sup>**</sup>
Lack of storage space	0.120 <sup>**</sup>
Mixed transportation after separating at source	0.124 <sup>**</sup>
Lack of legislation/policy enforcement	0.111 <sup>**</sup>
* Significant at 0.05 level	
** Significant at 0.01 level	

The analyses also show that higher education levels may not always result in positive attitudes ( $\beta = -0.222, p = 0.009$ ). This finding was also observed by other researchers on waste

separation in Suzhou, China (Zhang and Wen 2014) and Kampala, Zambia (Banga, 2011). The correlations between education levels and impact factors had been further calculated, as shown in Table 3.7. Obviously, the education level has significant positive correlations with 9 out of 10 impact factors (lack of knowledge, lack of facilities, too complicated to operate, social pressure, being accustomed to mixed collection, lack of punishment/rewards, lack of storage space, mixed transportation after separating at source, and lack of legislation enforcement), and all correlations show almost equal significance. This justifies the conclusion that the respondents with higher education levels considered more factors, rather than the environmental values only, in determining their attitudes to the MSW source-separated collection.

The comparison between the pilot and non-pilot communities was also carried out by using the free samples t-test, as shown in Table 3.8. The table shows that among all the impact factors, respondents from the two kinds of communities had significant differences with respect to two of them, “lack of time” and “lack of facilities”. Compared to the non-pilot communities, respondents in pilot-communities had more concern for the time, but less concern for the facilities. This may be because more facilities have been established in the pilot communities. Although most of these facilities provided during the pilot program have been out of function, the expectation that the requirements of facilities can be met as they used to be led the respondents in the pilot communities to pay more attention to other influencing factors. The free samples t-test also shows that respondents from pilot communities exhibited a significant difference with respect to the attitude to participate in MSW source-separated collection compared to those from non-pilot communities. They were more willing to participate. This observation may imply that even though the pilot program failed, its implementation still

introduced some positive impacts on public attitude. However, this point needs further investigation.

**Table 3.8** The outputs of the t-test for the comparison of average public perception between pilot and non-pilot communities on attitude and impact factors.

	Mean (Pilot community)	Mean (Non-pilot community)	<i>p</i>
Attitude	0.67 ± 0.470	0.58 ± 0.494	0.012*
Lack of time	2.31 ± 1.340	2.05 ± 1.206	0.008*
Lack of knowledge	2.81 ± 1.399	2.92 ± 1.394	0.298
Lack of facilities	3.58 ± 1.401	3.78 ± 1.304	0.048*
Too complicated to operate	2.58 ± 1.329	2.61 ± 1.284	0.802
Community environment	3.07 ± 1.465	2.97 ± 1.426	0.381
Being accustomed to mixed collection	3.16 ± 1.428	3.24 ± 1.369	0.502
Lack of punishment/rewards	2.96 ± 1.543	2.82 ± 1.495	0.239
Lack of storage space	2.39 ± 1.306	2.55 ± 1.314	0.102
Mixed transportation after separating at source	3.67 ± 1.380	3.74 ± 1.302	0.517
Lack of legislation/policy enforcement	3.33 ± 1.472	3.33 ± 1.529	0.990
* Significant at 0.05 level			
** Significant at 0.01 level			

### 3.3.5 Willingness to pay (WTP) for waste management charges

For the accuracy of evaluation, the respondents belonging to the age category 1 (less than 19 years old) were excluded in the analysis since most of them had no income and may not reflect their actual willingness for potential payment.

Six questions were designed to evaluate the respondents' willingness to pay for waste management charges. For WTP1, WTP2, and WTP3, the response format was a 3-point scale (1: no, 2: neither yes nor no, 3: yes).

1. WTP1: The willingness to pay for special garbage bags for waste source-separated collection.
2. WTP2: Support the establishment of a new waste payment system based on the principles of “pay more for more waste discharge, pay more for mixed waste collection, and pay less for source-separated collection”.
3. If the answer to WTP2 is “yes”, which payment method is the most reasonable for waste collection charges?
4. WTP3: The willingness to pay for establishing a platform for handling separately collected household waste.
5. If the answer to WTP3 is “yes”, what is the acceptable range of payment?
6. If the answer to WTP3 is “no”, what are the reasons for refusing to make payments?

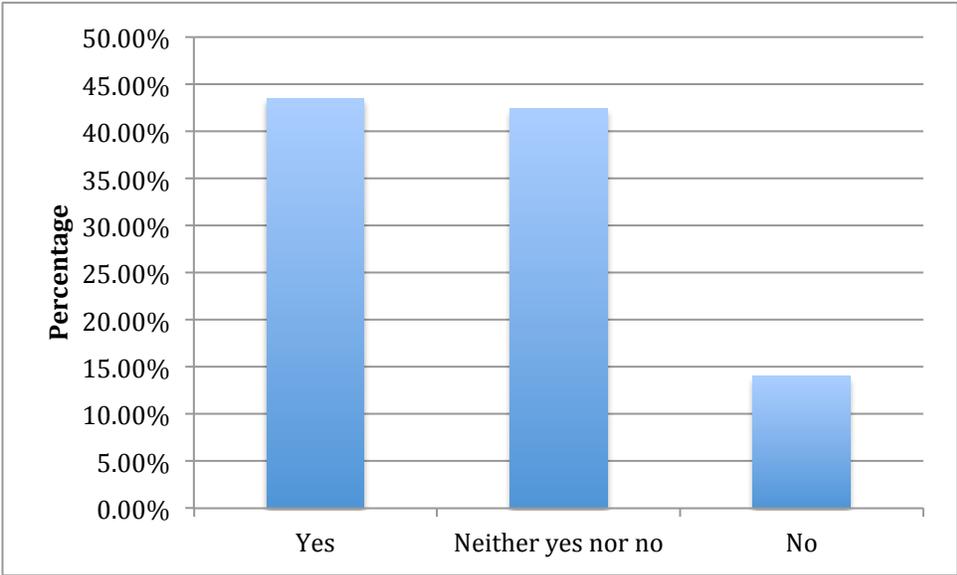
#### **3.3.5.1 Descriptive statistics**

The willingness of the respondents to pay for special garbage bags is shown in Figure 3.6, where 43.5% respondents were willing to pay, 14% refused to make payments, and 42.4% had no opinion.

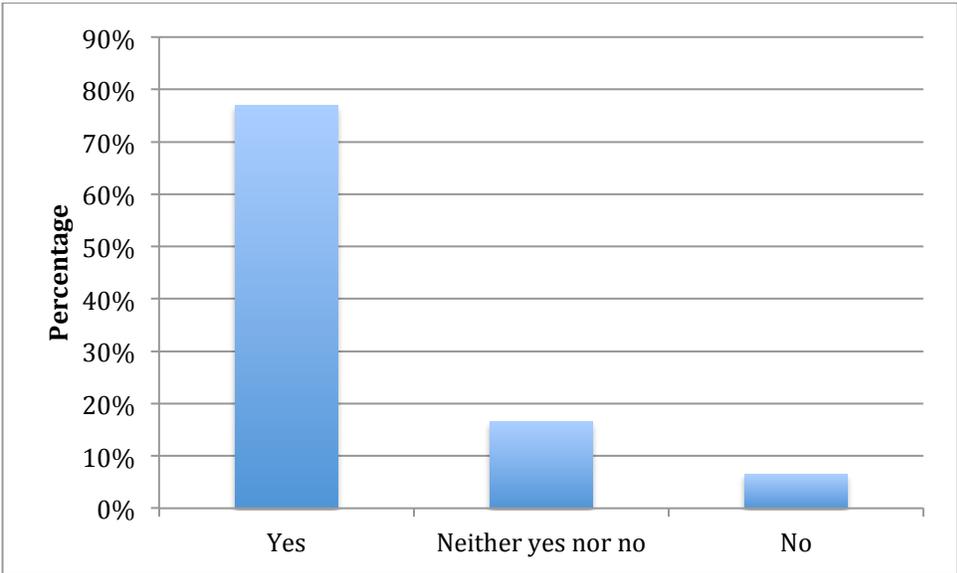
The willingness of the respondents to accept a new payment system for household waste treatment is shown in Figure 3.7. The majority of the respondents (77%) were willing to support this system. Only a very small percentage of respondents (6.5%) were opposed to this system. The high acceptance rate may result from the fact that payment for household waste collection had already been implemented in Guilin and residents had already become accustomed to paying

for household waste treatment. In addition, respondents expected that the new payment system would be beneficial to their living environment and they may have change to pay less than before if they separate the waste at source and discharge less waste.

**Figure 3.6** The percentage distribution of the respondents on willingness to pay for special garbage bags.

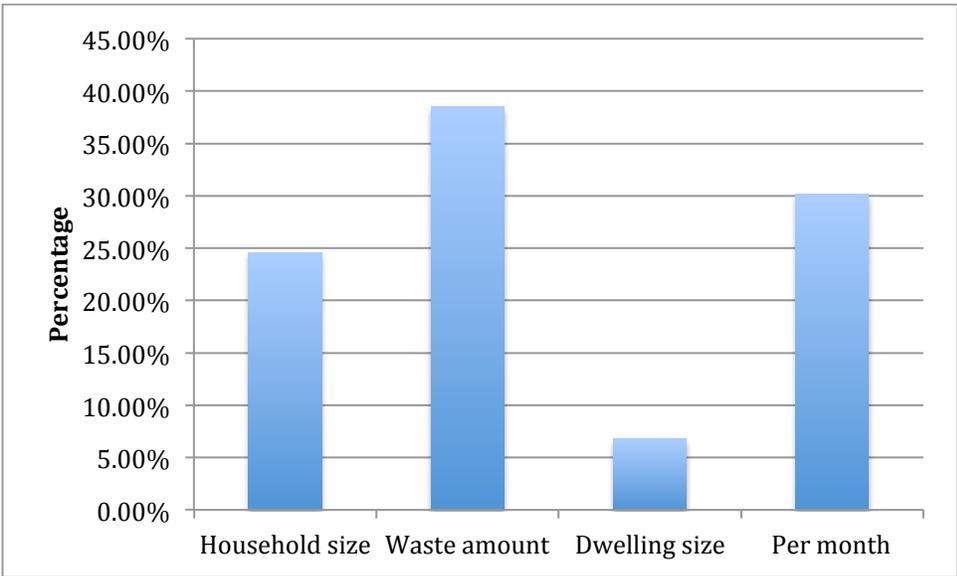


**Figure 3.7** The percentage distribution of the respondents on willingness to accept a new household waste payment system.



For the respondents who accepted the payment system, their selections of the payment methods were different, as shown in Figure 3.8. The payment system based on the amount of household waste generated was preferred most, followed by per month based and household size based methods. It is inconsistent with other works in (Batllell and Hanf, 2008; Kinnaman, 2006), where flat monthly fee was more preferred over the waste amount based method. Only 6.8% of respondents chose the payment method based on dwelling size.

**Figure 3.8** The percentage distribution of payment methods selected by the respondents.

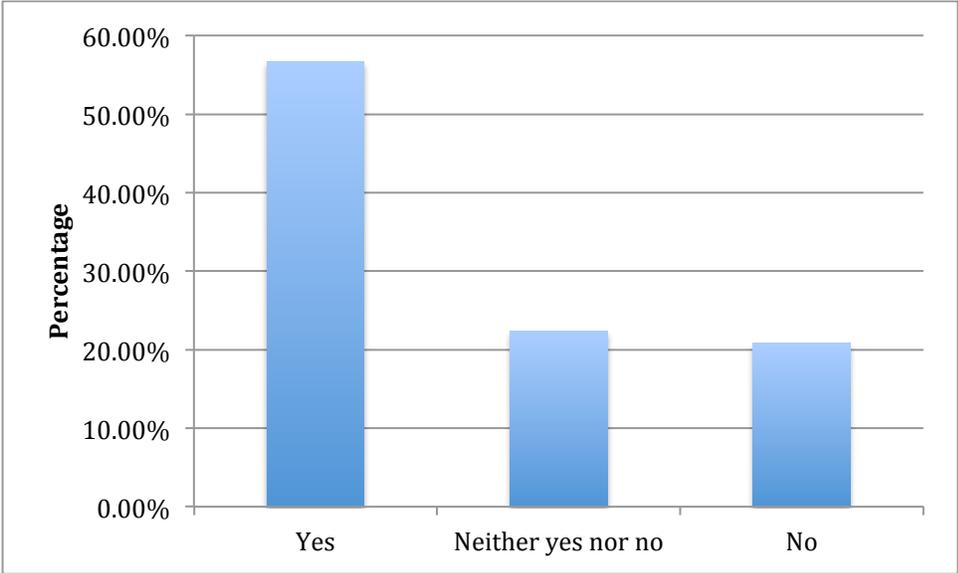


The willingness of the respondents to pay extra money for supporting the establishment of household waste recycling systems in their communities is shown in Figure 3.9. 56.7% of respondents had willingness to pay for the service, which is higher than the values for other industrializing countries, such as Iran (Babaei et al., 2015) and Sri Lanka (Vidanaarachchi et al., 2006). The trend of the respondents’ willingness to pay is similar to that shown in Figure 3.7. However, the percentage of the option “No” is much higher. This may be because it is an extra payment and a large cost was expected by respondents for building such a processing platform.

For the respondents who accept to pay for the recycling platform, most of them prefer an amount of less than 10 RMB (\$1.57 USD) per month (58.7% favor 1-5 RMB/month (\$0.16-\$0.78 USD/month) and 34.7% favor 6-10 RMB/month (\$0.94-\$1.57 USD/month)). The preference is similar to that of Guangzhou residents (Chung and Poon, 2001). For those who refuse to pay, over half of them (64.4%) thought it was the responsibility of the local government to pay for the facility, which is consistent with (Babaei et al., 2015). “unable to afford it” (20%) and “those who throw out waste should pay for it” (12.8%) were the other two major reasons for refusal.

The differences in respondents’ willingness to pay for waste management charges between the pilot and non-pilot communities in terms of WTP1, WTP2, and WTP3 were evaluated by the free samples t-test, as shown in Table 3.9. No significant difference was observed between pilot and non-pilot communities.

**Figure 3.9** The percentage of the respondents on willingness to pay for recycling platform.



**Table 3.9** The outputs of the t-test for the comparison of average public willingness to pay between pilot and non-pilot communities.

	Mean (Pilot community)	Mean (Non-pilot community)	<i>p</i>
WTP1	2.32 ± 0.700	2.25 ± 0.697	0.199
WTP2	2.73 ± 0.533	2.66 ± 0.660	0.188
WTP3	2.40 ± 0.790	2.29 ± 0.827	0.098
* Significant at 0.05 level			
** Significant at 0.01 level			

### 3.3.5.2 Influencing factors on WTP

The influencing factors on WTP were determined with a linear regression analysis. Factor analysis based on the principal component method was first used to extract a new variable, denoted as  $X_{WTP}$ , from three WTP variables (WTP1, WTP2 and WTP3). Then, in the linear regression analysis,  $X_{WTP}$  was set as the dependent variable, and age, gender, education level, and monthly income were set to be influencing factors.

**Table 3.10** Outputs of principal component analysis based on three willingness-to-pay variables.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.559	51.983	51.983	1.559	51.983	51.983
2	.780	26.004	77.987			
3	.660	22.013	100.000			
Cronbach's $\alpha = 0.523$						

The outputs of factor analysis (principal component analysis) are shown in Table 3.10, where the reliability coefficient (Cronbach's  $\alpha$ ) of three variables is 0.523, and the new extracted variable can explain 51.983% variance.

Bi-variable correlations between the extract factor,  $X_{WTP}$ , and the respondents' demographics are shown in Table 3.11. In contrast to (Chakrabarti et al., 2009), the respondents' willingness to pay has strong positive correlation with the age and gender. This may be because the older respondents experienced in person the sanitary improvement in the community in the past years so that they were more aware of the importance of effective waste management and were more willing to contribute to support such improvement. In addition, since females take more responses on waste handling than males, they demonstrate greater willingness to pay. Different from the previous works (Babaei et al., 2015), the respondents' willingness to pay had a negative correlation with the education level. This negative relation reconfirms the previous observations that higher education level does not entail a positive attitude toward participating in the MSW source-separated collection.

**Table 3.11** Kendall's tau-b correlation coefficients between the respondents' willingness to pay and their demographics.

Demographics	Correlation coefficient
Age	0.155**
Gender	0.067*
Education	-0.092**
Household size	-0.015
Monthly income	0.046
** Significant at 0.01 level	
* Significant at 0.05 level	

A linear regression model was established between  $X_{WTP}$  and demographic variables and the coefficients are shown in Table 3.12. Two factors – age and gender – significantly affect the WTP of respondents, and both of them have a positive influence.

The influencing factors on the respondents' preference regarding the payment method selection were evaluated by using multinomial logistic regression. The fixed monthly payment method, which has been implemented in reality, is used as the benchmark. Demographic factors include age, gender, education level, and monthly income. The coefficients of the multinomial logistic regression model are summarized in Table 3.13.

**Table 3.12** Linear regression model for willing-to-pay with respect to age, gender, education level, household size, and income.

Model	Standardized Coefficients	<i>T</i>	Sig.
	$\beta$		
Age	0.149**	3.268	0.001
Gender	0.113**	2.746	0.006
Education Level	-0.034	-0.754	0.451
Household Size	0.042	0.994	0.321
Income	0.078	1.848	0.065
$R^2 = 0.041$ , Adjusted $R^2 = 0.033$			
ANOVA: $F = 4.924$ , $p < 0.001$			
* Significant at 0.05 level			
** Significant at 0.01 level			

Older respondents were more likely to consider the payment method based on household size more suitable than the fixed monthly payment method. This may be because older people ordinarily live alone and can therefore pay less for waste service if the charges are based on the household size. It is not surprising that the respondents with a larger household size preferred the fixed monthly payment method to those based on household size and the amount of waste generated. In the interviews, most of these respondents made the case that larger families did not necessarily generate more waste than smaller families. In fact, as indicated in (Ojeda-Benitez et

al., 2008; Qu et al., 2009), the per capita household waste generation decreased with the increase of household size. In addition, a fixed monthly payment method may also reduce the chances that they pay more when they actually generate more waste. Respondents with higher education levels showed a less preference to the fixed monthly payment system. This suggests that respondents with higher education levels preferred a complicated but more accurate payment method.

**Table 3.13** Multinomial logistic regression model of different payment systems with respect to the fixed monthly payment method as the reference.

		$\beta$	Sig.
Household size	Intercept	-3.093	0.002
	Age	0.477**	0.000
	Gender	0.189	0.455
	Education	0.283**	0.005
	Household size	-0.159	0.090
	Income	0.003	0.984
The amount of waste generated	Intercept	-1.185	0.178
	Age	0.151	0.123
	Gender	-0.041	0.851
	Education	0.355**	0.000
	Household size	-0.178*	0.028
	Income	-0.075	0.501
Dwelling size	Intercept	-4.071	0.011
	Age	0.319	0.057
	Gender	0.014	0.971
	Education	0.407*	0.013
	Household size	-0.149	0.309
	Income	-0.068	0.732

\* Significant at 0.05 level

\*\* Significant at 0.01 level

### **3.4 Summary**

The implementation of MSW source-separated collection is a complex process and is affected by many intrinsic and extrinsic factors. As a major participant in this process, individuals with their own perceptions, awareness, and attitudes, play an important role in determining the ultimate success of MSW source-separated collection. How to encourage public participation in waste management has become a major challenge to decision makers. Some key findings and implications of this chapter are summarized as follows.

Most residents in Guilin more or less accept the current status of their living environment, although they hope for a better situation, which is consistent with other Chinese cities (Zhang and Wen, 2014). It is expected that such requests on better living conditions from residents are going to be increasing following the further development of economic and urbanization in China (Wang and Geng, 2012). Furthermore, the residents' perceptions regarding the improvement of their living conditions may motivate their further participation in more advanced, but more complicated MSW management programs. This observation re-confirms the importance of public education on public participation in solid waste source-separated collection program (De Feo and De Gisi, 2010; Read, 1999). A clear presentation of the potential benefits of any MSW source-separated collection program should be included in marketing and campaigns.

Although the roles of television, Internet, newspapers, and books in public education have been widely recognized in the literature (Moghadam et al., 2009; Shao and Wang, 2008), another more convenient way, i.e., the signs on dustbins, has been less explored by both researchers and

government. From the analysis results, the signs on dustbins are effective and cost-efficient methods for educating residents over all range of ages on MSW source-separated collection. Thus, authorities at both the local and central government levels should pay sufficient attention to the effectiveness of this education method, and make full use of it for promoting public awareness by designing more consistent, clear, and easily understandable signs.

The designed MSW source-separated collection program should include comprehensive measures to promote public participation. Such measures may include the improvement of convenience, the enhancement of facilities, the introduction of incentives, and the enhanced enforcement of laws and regulations (Chu et al., 2013; Keramitsoglou and Tsagarakis, 2013; Wang and Geng, 2012). However, when there are only limited resources available, the government should first upgrade the waste transportation services in order to avoid any mixed transportation, which is the most significant influencing factor on public attitudes. As indicated in (Zhu et al., 2009), avoiding mixed transportation requested updates on collection vehicles, collection methods, and governmental policies.

Residents in Guilin showed a high willingness to pay for advanced payment systems, which is consistent with Chu et al. (2013). Although equivocal observations have been reported in the literature on the relationship between demographic characteristics and residents' willingness to pay (Bernad-Beltran et al., 2014; Nixon and Saphores, 2007; Tonglet et al., 2004), these analyses show that older people prefer the payment method based on household size, while the big households prefer to remain at the current fixed monthly payment method. Therefore, it is challenging for the decision makers to select a suitable payment method that accommodates the preferences of the different population groups. This observation reflected the similar findings in

the literature (Afroz et al., 2009; Nixon and Saphores, 2007). In addition, the government should enhance public education on the MSW source-separated collection program through approaches that are suitable to the different population groups. This will allow residents, no matter their population group, to develop a positive attitude to the implementation of the proposed program.

Although the pilot program initiated in 2000 was not successful in Guilin, residents from the pilot communities still show some differences in terms of public perceptions and public attitudes compared to the non-pilot communities. They exhibited more expectations for improvement of their living environment and more positive attitudes toward participating in waste separation programs. The findings reconfirm the similar observation from (Li et al., 2009) that it is important to implement pilot programs for positively impacting the future implementation of MSW source-separated collection at the city level. In addition, pilot programs provide valuable data, such as waste characteristics, waste management technologies and implementation experience, can be obtained which will benefit the design of more effective MSW management systems. However, a significant challenge for the local authorities is how to achieve the continuation of the pilot program.

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# Chapter 4

## **An Analysis of Influencing Factors on Municipal Solid Waste Source-Separated Collection Behavior in China by Using the Theory of Planned Behavior**

Municipal solid waste (MSW) separation at the source has been widely accepted as a key determinant in the success of the whole MSW management process in industrializing countries, especially in China. However, achieving this target heavily depends on the participation of householders. Thus, for decision makers, a thorough understanding of major influencing factors, which ultimately determine MSW source-separated collection behavior of householders, is required. In this chapter, the Theory of Planned Behavior (TPB) is exploited to analyze how householders' attitudes, subjective norms, and perceived behavioral control affect their final behaviors. An extension to the conventional TPB framework was made by introducing a new construct of situational factor. Based on a case study in Guilin, China, the analyses derive many important findings, which further provide suggestions for development of programs and communication campaigns for MSW source-separated collection in China.

### **4.1 Introduction**

In China, MSW management has been considered as one of the key missions of the Chinese national circular economic project (Xue, et al., 2010). As the first step in the MSW management

chain, source-separated collection plays a critical role, since it determines the quality and quantity of waste flowing into the follow-up processing procedures. Although MSW source-separated collection has been put into operation in industrialized countries since the 1970s (Vergara and Tchobanoglous, 2012), its deployment in industrializing countries is still limited (Zhang et al., 2012). For example, a recent case study in Hanoi, Vietnam reported that achieving solid waste separation at the source had not yet been achieved yet despite pilot programs initiated in early 2000s (Nguyen et al., 2015).

In China, people have a tradition of recycling valuable materials, such as paper and plastic (Tai et al., 2011). However, such behavior is far from the actual requirements for recycling in MSW management. In order to promote MSW source-separated collection, in June 2000, the Ministry of Construction of China (now the Ministry of Housing and Urban and Rural Development of the People's Republic of China (MOHURD)) initiated a MSW source-separated collection pilot program in eight cities, including Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, Nanjing, Xiamen, and Guilin (MOHURD, 2000). However, as illustrated by Tai et al. (2011), most pilot programs were not successful due to a low level of public participation. Today, in most Chinese cities, the MSW is still collected in a mixed way at the source. Thus, for decision makers to ensure the successful implementation of planned programs, suitable strategies are required, which can encourage a change in public behavior in MSW source-separated collection (William and Kelly, 2003). However, designing such strategies requires an understanding of factors that have significant impacts on public behavior.

In this chapter, the Theory of Planned Behavior (TPB) (Ajzen, 1991) was employed to identify and evaluate potential influencing factors on public behaviors in MSW source-separated

collection. The analyses are based on the data collected via surveys in Guilin City, Guangxi Zhuang Autonomous Region, China. The established TPB model reveals the significant influence of respondents' attitude on the intention, and their intention and perceived behavioral control on their behavior of MSW source-separated collection. The findings of this study provide exercisable suggestions to decision makers in developing more effective education campaigns and waste source-separated collection programs.

## **4.2 Methodology**

### **4.2.1 Site selection and data collection**

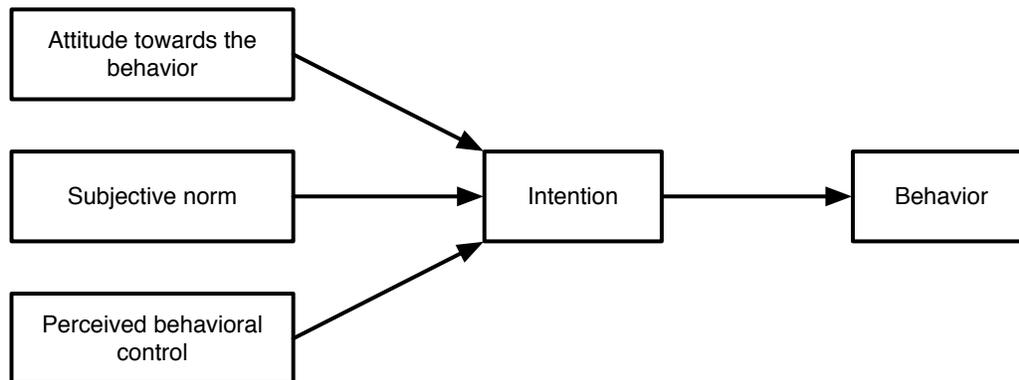
Field surveys of this study were conducted in April 2014 in urban area of Guilin city. The details of site selection and data collection please refer to Section 3.2.1 and Section 3.2.2 in Chapter 3. A total of 848 valid questionnaire responses were received. Raw data from the survey were first compiled into EXCEL spreadsheets, and then analyzed by using hierarchical multiple regression analysis and path analysis (Zar, 1999). All analyses were done by using the IBM Statistical Package for Social Sciences for MAC (SPSS, v22) and AMOS (v21).

### **4.2.2 The theory of planned behavior (TPB)**

The Theory of Planned Behavior (TPB) is a theoretical framework to explore the influence of factors on the studied behaviors (Ajzen, 1991). It has been successfully applied to diverse areas, such as leisure choice (Ajzen and Driver, 1992), driving violations (Parker et al., 1992), investment decisions (East, 1993), and dishonest actions (Beck and Ajzen, 1991). The TPB has also been applied in waste recycling (Carrus et al., 2008; Chu and Chiu, 2003; Knussen et al., 2004; Mannetti et al., 2004; Tonglet et al., 2004; Wang et al., 2011), waste source-separated collection (Ghani, et al., 2013; Zhang, et al., 2015), and waste reduction (Mota, 2015).

The TPB was developed from the earlier Theory of Reasoned Action (TRA), which assumes that people behave rationally (Ajzen and Fishbein, 1980). The TRA hypothesizes that an individual's behavior is immediately determined by his or her intention to perform or not to perform that behavior, which is in turn influenced by two factors, including attitude and subjective norm. Attitude measures the individual's belief and evaluation regarding the likely outcomes of the behavior, and subjective norm measures the individual's perception of social pressure with respect to performing the behavior.

**Figure 4.1** The framework of the Theory of Planned Behavior adapted from Ajzen (1991).



Following the work by Liska (1984), which argued the existence of other determinants, such as the lack of appropriate opportunities, skills and resources, on the performance of many kinds of behavior, the TRA was extended to the TPB, which further introduced a third variable, called perceived behavioral control (PBC). The PBC measures the individual's perception of his or her ability on the performance of the behavior. The conventional conceptual structure of the TPB is shown in Figure 4.1. The TPB suggests that in general, individuals' behavior is determined by their intentions to carry out the behavior, which is further determined by their attitude towards the behavior, their subjective norm, and their perceived behavioral control. As described by Ghani et al. (2013, p. 1277), "as a general rule, the more favorable the attitude and subjective

norm, and the greater the perceived control, the stronger should be the person's intention to perform the behavior in question. Finally, given a sufficient degree of actual control over the behavior, people are expected to carry out their intentions when the opportunity arises”.

Despite its success in investigating the determinants of various kinds of behavior, the conventional TPB framework was argued to be insufficient for explaining complex behavior, such as individuals' waste source-separated collection (Armitage and Conner, 2001), and some additional variables should be incorporated (Ajzen, 1991; Boldero, 1995; Davies et al., 2002). Following the suggestion of (Boldero, 1995; Davies et al., 2002), in this study, a new measure, called situational factor, was included in the conventional TPB model. Different from the PBC, where the respondents are directly asked about their feeling on the amount of control they may have over their behavior, situational factor represents the potential barriers to the performance of the behavior. Boldero (1995) has indicated that for analyzing the recycling behaviors, situational factors such as efforts involved, inconvenience, storage space and access to recycling schemes, should be considered. The significance of involving situational factor in the TPB framework has also been highlighted in Tonglet et al., (2004).

### **4.2.3 TPB measures**

All measures used for TPB modeling are summarized as follows.

#### **4.2.3.1 Behavior on MSW source-separated collection**

The respondents were asked whether they separate household waste, throw away garbage in accordance with the signs on the dustbins, and pay attention to the signs on the dustbins regularly. Each was scored on a 4-point scale from “never” to “often”.

#### **4.2.3.2 Intention to MSW source-separated collection**

The intention to MSW source-separated collection was measured by directly asking: “I intend to participate in MSW source-separated collection”. The response format was scaled as: 1: disagree, 2: neither disagree nor agree, 3: agree. Based on the TPB, the following hypothesis is proposed.

*Hypothesis 1 (H1):* Intention is positively related to behavior.

#### **4.2.3.3 Attitude**

The attitude was measured by asking the respondents: “I support the implementation of waste source-separated collection in my community”. The question was scaled as: 1: Disagree, 2: neither disagree nor agree, 3: agree. Based on the TPB, the following hypothesis is proposed.

*Hypothesis 2 (H2):* Attitude is positively related to intention.

#### **4.2.3.4 Subjective norm**

Subjective norm was operationalized by a question: “The level of participation in solid waste source-separated collection of the people surrounding me has an impact on my participation”. The question was scored on a 5-point scale from “significant effect” to “no effect”. The hypothesis proposed based on the TPB is

*Hypothesis 3 (H3):* Subjective norm is positively related to intention.

#### **4.2.3.5 Perceived behavioral control (PBC)**

As suggested by (Tonglet et al, 2004), the PBC was measured by evaluating the effects of three items on respondents’ activities in MSW source-separated collection: “I don’t know how to carry out the MSW source-separated collection”, “MSW source-separated collection is complicated and inconvenient”, and “There are no sufficient facilities for MSW source-separated collection”. Each was scored on a 5-point scale from “significant effect” to “no effect”. Since PBC may have

direct effects on intention and behavior (Bortoleto et al., 2012; Mahmud and Osman, 2010; Zhang et al., 2015), two hypotheses are proposed as follows.

*Hypothesis 4 (H4):* Perceived behavioral control is positively related to intention.

*Hypothesis 5 (H5):* Perceived behavioral control is positively related to behavior.

#### 4.2.3.6 Situational factor

Situational factor considered factors that may influence individuals' engagement in MSW source-separated collection. The factors under consideration included lack of time, being accustomed to mixed collection, lack of punishments/rewards, lack of storage space, mixed transportation after separating at source, and lack of legislation/policy enforcement. The influence of each factor was scored on a 5-point scale from "significant effect" to "no effect".

The hypothesis on situational factor in the TPB is

*Hypothesis 6 (H6):* Situational factor is positively related to intention.

All measurements used for the TPB modeling are summarized in Table 4.1, where Cronbach's alpha coefficients (Zar, 1999) to evaluate the internal consistency for constructs with multiple items are also included. The findings demonstrate that all measures (Cronbach's alpha >0.6) have acceptable reliability (Nguyen et al., 2015). The proposed hypotheses are summarized in Table 4.2.

**Table 4.1** List of measurements for theory of planned behavior modeling and their Cronbach's alpha coefficients for reliability analysis.

Constructs	Measurements	Cronbach's alpha
Behavior on MSW	I regularly separate household waste.	0.713
	I regularly throw away garbage in accordance with the signs	

source-separated collection	on the dustbins.	
	I regularly pay attention to the signs on the dustbins.	
Intention to MSW source-separated collection	I intend to participate MSW source-separated collection.	N/A
Attitude	I support the implementation of MSW source-separated collection in my community.	N/A
Subjective norm	The behaviors of the people around me on MSW source-separated collection have an impact on my participation.	N/A
Perceived behavioral control	I don't know how to carry out the MSW source-separated collection.	0.636
	MSW source-separated collection is complicated and inconvenient.	
	There are no sufficient facilities for MSW source-separated collection.	
Situational factor	Lack of time affects my participation in MSW source-separated collection.	0.763
	Being accustomed to mixed collection affects my participation in MSW source-separated collection.	
	Lack of punishments/rewards affects my participation in MSW source-separated collection.	
	Lack of space affects my participation in MSW source-separated collection.	
	Mixed transportation affects my participation in MSW source-separated collection.	
	Lack of legislation/policy enforcement on MSW source-	

	separated collection affects my participation in MSW source-separated collection.	
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**Table 4.2** List of proposed hypotheses for theory of planned behavior modeling.

H1	Intention is positively related to behavior.
H2	Attitude is positively related to intention.
H3	Subjective norm is positively related to intention.
H4	Perceived behavior control is positively related to intention.
H5	Situational factor is positively related to intention.
H6	Perceived behavior control is positively related to behavior

## 4.3 Analysis and results

### 4.3.1 The respondents' socio-economic characteristics

The respondents' socio-economic characteristics in terms of age, gender, education level, household size, and monthly income are shown in Table 4.3. The respondents involved in the survey were categorized in terms of their ages, with the middle group (19-65) accounting for 77.1%. The minimum age requirement (7 years old is the minimum school age in China) was set in order to ensure a full understanding of the questionnaire by the respondents. For comprehensive evaluation purposes, the survey also included very young (<19) and very old (>65) respondents. These two groups accounted for 14.9% and 8.1% of the overall respondents, respectively. There are 66% female respondents and 34% male ones. The unequal gender representation may result from the fact that female family members tend to be more involved with housework than males (Sidique et al., 2010; Wang and Geng 2012). The percentage of the respondents who held university degrees (undergraduate or graduate) was 48.1%. Up to 76.6% of respondents had a monthly income between 1000 RMB (\$157 USD) and 5000 RMB (\$784

USD). The percentages of respondents who earned monthly incomes less than 1000 RMB (\$157 USD) (7.6%) or higher than 5000 RMB (\$784 USD) (15.7%) were small.

**Table 4.3.** Descriptive statistics of the socio-economic characteristics of the 848 respondents in April 2014.

Item	Response	Percentage (%)
Age	<19	14.9
	19-24	23.0
	25-36	25.4
	37-50	17.0
	51-65	11.7
	>65	8.1
Gender	Male	34.0
	Female	66.0
Education level	Illiterate	0.6
	Elementary school	7.7
	Junior high school	10.9
	Senior high school	18.0
	Junior college	14.7
	Bachelor	33.8
	Master's and above	14.3
Household size	1	5.6
	2	16.1
	3	35.5
	4	21.6
	5	14.9
	6	4.8
	>6	1.5
Monthly Income	0-1000 RMB	7.6

	1001-3000 RMB	48.0
	3001-5000 RMB	28.6
	5001-8000 RMB	10.3
	>8000 RMB	5.4

Table 4.4 shows the bivariate correlations between the TPB constructs and the respondents' demographic variables. As expected, attitude, subjective norm, PBC, and situational factor all had positive and significant correlations with the intention to MSW separation at source and associated behaviors. Among respondents' demographic factors, education level had significantly negative correlations with the intention, which indicated that respondents with less education had stronger intention to participate the MSW source-separated collection.

**Table 4.4.** Kendall's tau-b correlation coefficients between the theory of planned behaviour constructs and the respondents' demographics.

	1	2	3	4	5	6	7	8	9	10	11
1. A	1	-0.021	0.041	0.045	0.134*	0.153*	0.052	0.115*	0.006	0.002	-0.037
					*	*		*			
2. SN	-	1	0.331*	0.434*	0.102*	0.109*	0.012	-0.042	-	0.027	0.047
			*	*	*	*			0.088*		
									*		
3. PBC	-	-	1	0.371*	0.120*	0.223*	0.005	-0.002	-	0.043	-0.003
				*	*	*			0.121*		
									*		
4. SF	-	-	-	1	0.104*	0.106*	0.026	-	-	0.027	0.033
					*	*		0.075*	0.138*		
									*		
5. I	-	-	-	-	1	0.260*	-0.020	0.042	-	0.058	-0.029
						*			0.087*		
									*		
6. B	-	-	-	-	-	1	0.059*	0.071*	-0.033	0.083*	-0.018

										*	
7. Age	-	-	-	-	-	-	1	0.014	0.070*	-	0.032
										0.209*	
										*	
8. G	-	-	-	-	-	-	-	1	0.035	-0.030	-0.058
9. E									1	-0.047	0.161*
											*
10. HS	-	-	-	-	-	-	-	-	-	1	-0.022
11. MI	-	-	-	-	-	-	-	-	-	-	1
Notes: A: attitude, SN: subjective norm, PBC: perceived behavioral control, SF: situational factors, I: intention, B: behavior, G: gender, E: education level, HS: household size, MI: monthly income ** $p < 0.01$ * $p < 0.05$											

The influence of TPB constructs and respondents' demographic variables on the intention to MSW separation at source was evaluated through hierarchical multiple regression analysis, where the intention was set as the dependent variable. The regression outputs are shown in Table 4.5, where the standardized regression weight ( $\beta$ ) represented the relative contribution of each predictor in explaining the variance to the intention. Specifically, at the first step, demographic variables were entered. These variables explained 2.3% of the variance of intentions with ( $F_{change}(5,397) = 2.886, p = 0.014$ ). The constructs in the conventional TPB model (attitudes, subjective norm, and PBC) were entered in the second step, which collectively explained an additional 4.2% of the variance in the intention with significant  $F_{change}(3,394) = 5.993, (p = 0.001)$ . In the third step, the additional TPB construct (situational factor) was added to the regression equation, which resulted in minor increase on  $R^2$  (0.3%) with ( $F_{change}(1,393) = 1.078,$

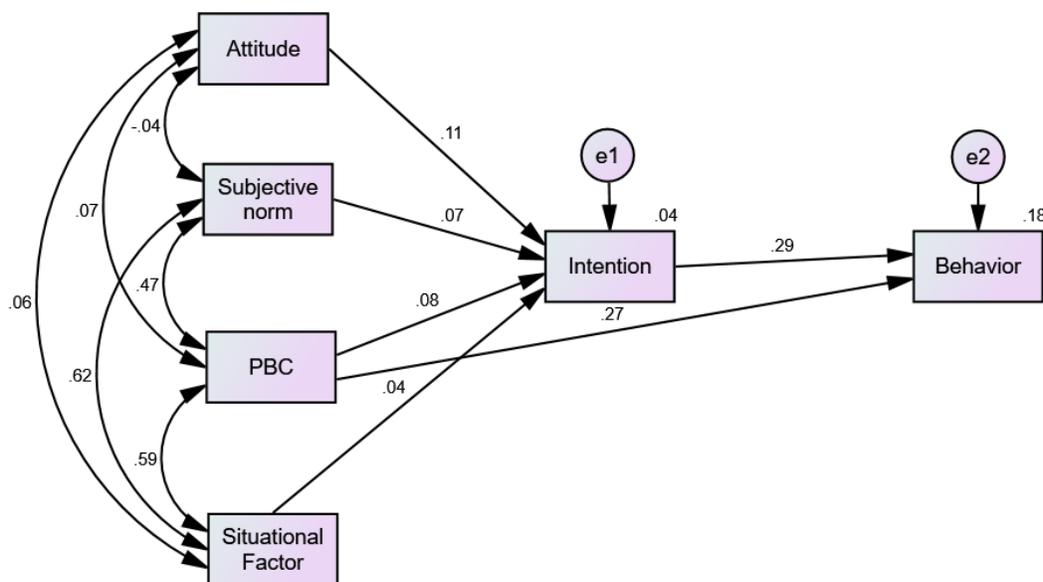
$p = 0.3$ ). In steps 2 and 3, both education level and attitude were significant in predicting the intention, while subjective norm was significant on step 2, but lost significance when situational factor was added to the equation. In summary, those with stronger intention to MSW source-separated collection were less educated and had more positive attitude.

**Table 4.5.** Hierarchical multiple regression analysis of intentions to municipal solid waste source-separated collection.

	$\beta$	$R^2$ change	$F$ change
Step 1			
Age	-0.064	0.023*	2.886
Gender	0.086		
Education level	-0.154**		
Household size	0.006		
Monthly income	-0.026		
Step 2			
Age	-0.078	0.042**	5.993
Gender	0.075		
Education level	-0.133**		
Household size	-0.011		
Monthly income	-0.031		
Attitude	0.124*		
Subjective norm	0.115*		
PBC	0.075		
Step 3			
Age	-0.081	0.003	1.078
Gender	0.083		
Education level	-0.128*		
Household size	-0.011		

Monthly income	-0.034		
Attitude	0.120*		
Subjective norm	0.089		
PBC	0.051		
Situational factors	0.068		
Notes: $R^2 = 0.08$			
** $p < 0.01$			
* $p < 0.05$			

**Figure 4.2.** Path analysis of theory of planned behavior model for behaviors of municipal solid waste source-separated collection.



The path analysis for the hypothesized TPB model (based on the hypotheses in Table 4.2) was shown in Figure 4.2 by using IBM SPSS AMOS 21. By considering the conventional cut-off criteria and the model complexity (Hu and Bentler, 1999), the built TPB model resulted in a modest fit of the data with  $\chi^2 = 23.705$ ,  $\chi^2 = 25.719$ ,  $p < 0.001$ , comparative fit index (CFI) = 0.98, and root mean square error of approximation (RMSEA) = 0.09.

The standardized regression weights ( $\beta$ ) of path analysis were summarized in Table 4.6. For the prediction of behavior on MSW separation at source, 18% of the variance was explained. Specifically, intention (standardized effect = 0.286) and PBC (standard effect = 0.27), both had significant independent effects on the behavior. While for the intention, attitude (standard effect = 0.113), but not subjective norm, PBC and situational factors, had significant direct effect. The results supported hypotheses H1, H2 and H6, while rejecting hypotheses H3, H4 and H5.

**Table 4.6** Standardized regression weights of path analysis.

			$\beta$	$p$
Intention	<---	Attitude	0.113**	<0.001
Intention	<---	Subjective norms	0.073	0.098
Intention	<---	PBC	0.077	0.07
Intention	<---	Situational factors	0.039	0.414
Behaviors	<---	Intention	0.286**	<0.001
Behaviors	<---	PBC	0.270**	<0.001
** $p < 0.01$				
* $p < 0.05$				

## 4.4 Discussion

In this study, the Theory of Planned Behavior (TPB) was used as the framework to analyze respondents' behaviors to MSW source-separated collection in Guilin, China. Besides constructs in conventional TPB model (including attitude, subjective norm, and perceived behavioral control), a new variable (situational factor) was added as the model extension. The findings from this study have several implications for the development and implementation of policies and programs in order to promote the public participation in MSW source-separation collection.

The analysis results showed that the extended TPB model could explain 8% of the variance in the intention when demographic variables have been controlled. Among all TPB constructs, attitude played a most significant role in the prediction of intention. This finding is consistent with previous studies (Knussen et al., 2004; Pakpour et al., 2014) that without positive views on the behavior and its potential outcomes, it is difficult for householders to engage in MSW source-separated collection. This finding suggests that in the goal of promoting households' intention/behavior in MSW source-separated collection, emphasis should be put on strategies, which reinforce residents who have a more positive attitude, and on the other hand, change those with a negative attitude. This suggestion is more important in Guilin, the study area, where public participation in MSW source-separated collection were at a relatively low level (Tai et al., 2011). Moreover, the path analyses showed that the standardized total effect of attitude to behavior was only 0.032, which was much smaller than that of PBC (0.292). It reconfirms the fact that individuals with positive attitude may not necessarily mean that they will engage in the associated behavior (Tonglet et al., 2004).

Environmental education has been widely accepted as an effective way in promoting public attitude (De Feo and De Gisi, 2010). Therefore, for decision makers, it is important to design effective advertising campaigns and marketing programs to foster individual's attitude. The designed campaigns should emphasize not only positive perception and attitude to MSW separation at source, but also the moral correctness of performing such behaviors (Ghani et al., 2013). As indicated in the previous studies (Ma et al., 2016), signs on dustbins are effective and cost-efficient methods for educating residents in Guilin on MSW separation at source. Thus, it is recommended that this relatively under-estimated measure be used by authorities for promoting public awareness through designing more consistent, clear, and easily understandable signs.

Besides attitude, education level was another significant predictor of intention to MSW source-separated collection. The finding that education level had negative relationship with intention was also been observed by other researchers on waste source-separated collection in Suzhou, China (Zhang and Wen 2014) and in Kampala, Zambia (Banga, 2011). This may be because the respondents with a higher education level may consider more than the environmental values in determining their intention to the MSW source-separated collection. This finding was further reconfirmed by the significant correlation (negative) between the education level and subjective norm, PBC, and situational factor, as shown in Table 4.3. Thus, improving public acceptability and convenience should be considered in the designing of source-separated collection programs.

Neither PBC nor situational factor was significant in the regression with respect to the intention. This finding was consistent with those in Tonglet et al. (2004) and Ghani et al. (2013). It is suggested that for Guilin residents, the issue of control and the situational factor were not major issues for their intention to MSW separation at source. As observed by Knussen et al. (2004) and Tonglet et al. (2004), PBC and situational factor may be more relevant in situations where the available resources (such as facilities) for waste behavior were poor. In addition, both PBC and intention had significant effects on the respondents' behavior. Furthermore, similar to the observations by Terry et al., (1999) and Armitage and Conner, (2001), subjective norm was not a significant predictor to the intention of waste separation at source. It may be because waste source-separated collection has not been sufficiently established in Guilin to provide strong norms so that the respondents did not think they were under significant social pressure for their waste separation behaviors. However, the significant correlations between subjective norm, PBC and situational factor implied that access to the factors that make MSW separation at source

easier had impacts on residents' behavior. Thus, it is requested that convenience issues have to be considered in designing MSW source-separated collection programs.

The variances of both intention and behavior explained were relatively small compared to those in the literature (Knussen et al., 2004; Rhodes et al., 2015; Tonglet et al., 2004). It may be because i) the measurements of TPB constructs deserve further consideration. Since the measurements used for TPB modeling in this study were extracted from a larger questionnaire, some of them did not follow the conventional settings, which may cause bias in representing the corresponding model constructs; ii) the low percentage of explained variance implied the importance of adopting additional constructs in the conventional TPB model, which had also been revealed by others (Boldero, 1995; Davies et al., 2002; Davis et al., 2006; Ghani et al., 2004; Tonglet et al., 2004). For example, habit, knowledge, moral norms, past experience, recycling outcomes, recycling consequences, attitudes to waste minimization, and concern for the environment have been found to be effective in improve the capacity of the TPB model in explaining the variance of the intention for recycling (Davis et al., 2006; Tonglet et al., 2004). Applying alternatives to the TPB, such as the conceptual framework proposed by Barr (2008, 2007), may also be considered (Pakpour et al., 2014).

There are some other limitations on this study. First, self-report rather than direct observation was used for measuring respondents' behavior, which may introduce bias (Barr et al., 2001; Rhodes et al., 2015), although correlation has been observed between actual and self-reported behaviors (Barr et al., 2001; Gamba and Oskamp, 1994). Therefore, follow-up validation of the findings based on observed behavior may be necessary. Second, the findings of this study were

based on the data from one urban area in China. Thus, the generality of the findings to other regions may be limited.

## **4.5 Summary**

In this chapter, an extended TPB framework was established with the constructs of attitude, subjective norm, perceived behavioral control, and situational factor. The TPB framework predicted certain variance of behavior to MSW source-separated collection. The behavior was explained by intention and PBC, while intention was further explained by attitude and PBC. Both subjective norm and situational factor had insignificant effects in the TPB. In addition, people with higher education level had lower intention to MSW source-separated collection. The findings suggest that fostering public attitude via effective environmental education and improving perceived control may be important to promote public participation in MSW source-separated collection. Follow-up measurements with consideration of observed behaviors and other constructs will be done in the future works.

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# Chapter 5

## **An Evaluation of the Social Dimensions in Public Participation in Rural Domestic Waste Source-Separated Collection in China**

In this chapter, RDW source-separated collection is evaluated within a social dimensions framework, specifically in terms of public perception, awareness, attitude, and willingness to pay for RDW management. A case study was conducted in rural area of Guilin, Guangxi Zhuang Autonomous Region, China. Important finding from the analyses include i) the rural residents maintained a high rate of recycling, but in a spontaneous manner; ii) the rural residents paid more attention to issues that were closely related to their daily lives, but less attention to those at the general level; iii) public awareness of RDW source-separated collection was low and different age groups showed significantly different preferences regarding the sources of knowledge acquirement. Among potential information sources, village committees played a very important role for knowledge dissemination; iv) for the respondents' pro-environmental attitudes, the influencing factor of "lack legislation/policy" was considered to be significant; v) mandatory charges for waste collection and disposal had a high rate of acceptance among rural residents; and vi) high monthly incomes had a positive correlation with public pro-environmental attitudes and public willingness to pay for extra charges induced by RDW management. These observations imply both short-term and long-term measures for decision makers.

## 5.1 Introduction

China has experienced a high rate of economic growth and change of lifestyle in both urban and rural areas (Liu and Huang, 2014). Such economic development and alteration in lifestyles have induced significant changes in rural domestic waste (RDW) in terms of both quantity and composition. For example, in 2011, RDW generation was more than 200 million tons, which exceeded the total generation of municipal solid waste (MSW) from 660 cities in China (He, 2012). It is also widely accepted that the generation of RDW will continue to increase in the future (Huang et al., 2013). Additionally, the composition of RDW is becoming more complex, due to the increasing consumption of packaged and processed goods, and is similar to MSW in urban areas (Han et al., 2015; Zeng et al., 2015).

Although many studies have been devoted to MSW management (Ma and Hipel, 2016), domestic waste management in rural areas of China has not been given sufficient attention because of the scattered living conditions in these areas, the relatively low residence density, and the historically simple waste composition (traditionally, most of waste was composted as fertilizer or used to feed livestock (Liu and Huang, 2014)). Furthermore, poor infrastructure construction and an imperfect legislation system caused the sanitary disposal rate of RDW to be very low (5.2% in 2006) and most of RDW was randomly dumped along the riverbanks or around farms (Lu and Wang, 2008; Zeng et al., 2015). Such practices have caused severe degradation of the aquatic system and ecological environment, and have introduced harmful effects on rural residents' health and lives (Liu et al., 2008; Mosier et al., 2002; Wang et al., 2009; Zhang et al., 2006). For example, leachate from RDW may contaminate soil and ground water, while burning waste may cause air pollution (Ye and Qin, 2008). In 2007, it was reported

that more than 50% of villages in China were polluted mainly by RDW (Tang and Zuo, 2008). Further considering the fact that around 50% of the Chinese population live in rural areas, which accounts for more than 90% of mainland China (National Bureau of Statistics of China, 2011), establishing sustainable RDW management systems is extremely urgent.

Similar to MSW management, waste separation at the source is considered as a necessary treatment method for RDW. For example, He (2012) indicated that RDW in China consists of easily-degradable waste (accounting for 50% of the overall RDW), ash and slag (10-20%), and recyclable materials (10%). Thus, through composting easily-degradable waste, on-site landfilling ash and slag, and recycling, over 70% of RDW can be reduced at the source, so as to significantly decrease the management costs (up to 33%) (He, 2012).

RDW management has attracted attention from researchers. Most of the work reported in the literature has focused on analyzing RDW characteristics (generation and composition), and disposal techniques and methods (Abduli et al., 2008; Apostol and Mihai, 2012; Dolezalova et al., 2013; Gowda et al., 1995; Han et al., 2015; Huang et al., 2013; Lal et al., 2007; Li et al., 2011; Wang et al., 2011; Wei et al., 2007; Wu et al., 2006; Wu et al., 2014; Yao et al., 2009; Ye and Qin, 2008). However, to the best of my knowledge, little research has focused on investigating the role of villagers and influencing factors on their participation, especially from social dimensions. In the paper by Chung and Poon (2001), a case study in one village in Guangdong Province (a coastal province) in China was carried out to evaluate public opinion on RDW separation. The analyses focused on villagers' perception of RDW collection and payment, and the New Environmental Paradigm (NEP). How to motivate public participation for the good of society and how to maintain an effective market for recyclables were identified as the major

implications for policymaking. In addition, although there is some research investigating public participation in MSW management (Jin et al., 2006; Ma et al., 2016; Tai et al., 2011; Zhang et al., 2010), because of the distinctions between urban and rural areas in terms of economics, living patterns, and education levels, simply shifting the observations from MSW management to RDW management is not sensible and may cause mistakes in decision-making.

In order to fill the gap in the existing literature, the attitudes of rural residents regarding participation in RDW source-separated collection in China were evaluated. The analyses are based on the data collected from a field survey of seven villages in Guilin, Guangxi Zhuang Autonomous Region, China, and are carried out in terms of public perception, public awareness, public attitude, and willingness to pay for the waste management charges. The data analyses show a significant difference in rural residents' attitude to RDW source-separated collection in comparison with their urban counterparts, and reveal important implications for promoting informed decision making in RDW management. This research results in better insights on public participation in RDW source-separated collection in rural areas of China, and provides useful guidelines for the government for designing more effective and efficient policies and programs for addressing sustainable RDW management.

## **5.2 Methodology**

This study consists of field surveys executed in July 2014 in rural areas of Guilin, Guangxi Zhuang Autonomous Region, P. R. China. The geographic location of Guilin, as shown in Figure 5.1, is longitude 109°36'50"- 111°29'30" and latitude 24°15'23"- 26°23'30". The total area of Guilin is 27,809 km<sup>2</sup>, with a rural area of 25,042 km<sup>2</sup> (Guilin People's Government, 2014).

**Figure 5.1** The geographic location of the selected rural area in Guilin, Guangxi, China.



The sampling procedure follows Babbie's (1989) multistage sampling approach. First, two counties of Guilin were selected. To more accurately reflect the status of RDW management in these areas, one county (Lingui) with an established landfill and one neighboring county (Lingchuan) without such a facility were selected. After that, based on consultation with the county government staff, the second stage of sampling was performed. In the first county, two villages with relatively good sanitary conditions, two average villages, and one representative village with all residents being minorities (Yao minority) were selected. A total of 170 residents participated the survey. In the second county (the village size is larger than the first county), one village with relatively good sanitary conditions and one with average conditions were selected. A total of 145 residents participated in the survey. In each village, all households were visited and interviewed through questionnaires. For the cases where no one answered the door, a second try

was done to find residents in the farmland or via a second visit at a later time. All the testing samples were excluded from the data analyses. In most studied villages, public dustbins have been provided for domestic waste collection.

In total, 253 households from 7 villages were interviewed and 312 valid responses were collected. All respondents were required to be older than 7 years old (the minimum school age in China) in order to ensure the participants were able to understand the questionnaire and provide responses. Raw data from the survey was first compiled in EXCEL spreadsheets, and then analyzed using the Statistical Package for Social Sciences for MAC (SPSS, v22). Statistical analysis tools, such as principal component method for factor reduction, linear and multinomial logistic regression for evaluating relationship between independent and dependent variables, were used (Hosmer and Lemeshow, 2000; Zar, 1999).

The questionnaire incorporated both Likert-scaled, single choice, and multiple-choice questions. It consisted of four major themes. The first theme was on the demographic characteristics of respondents. The second theme was related to the data about public perception on the villages' living conditions, and domestic waste collection facilities and services. The third theme was on public attitudes toward RDW source-separated collection. The fourth theme was connected to public awareness of RDW source-separated collection.

### **5.3 Results and discussion**

Data collected from the field survey were analyzed to evaluate the villagers' participation in RDW source-separated collection. Demographics of respondents were first summarized, followed by statistical analysis in terms of public perception, awareness, attitude, and willingness to pay.

### **5.3.1 Demographics of respondents**

For the purpose of analysis, all respondents were categorized into six categories in terms of the age:  $\leq 18$ ; 19 to 24; 25 to 36; 37 to 50; 51 to 65;  $>65$  years old. The distributions of respondents in all categories are 19.9%, 2.6%, 17.3%, 18.9%, 22.4%, and 18.9%, respectively. The relatively low percentage of young adults reflects the common situation in rural areas of China, where most young adults emigrate to urban cities to find jobs, while most children and elderly people remain at their home villages (Han et al., 2015). Therefore, children and elderly people are major contributors to the daily RDW generation and potential source-separated collection. The education levels of respondents were relatively low. The majority (82.9%) had education levels at only the elementary school or junior/senior high school level with 14.5% considered illiterate. Only a few (1.0%) had postgraduate degrees. Of the illiterate respondents 86.6% were older than 50. Most households had a monthly per capita income of less than ¥3,000 RMB (\$470 USD). The average surveyed household size was 4.10 people and there was no obvious bias in the gender of respondents (there are 47.1% male and 52.9% female respondents). Farming (54.5%) and out-migration for work (22.3%) constitute the top two major livelihood sources of respondents.

### **5.3.2 Public perception**

Public perception reflected the perception of respondents at both a village level and a more general level. At the village level, respondents were asked to evaluate the sanitary condition of their living village (4 scales from very clean to poor), the frequency of careless waste littering (3 scales from often to never), the satisfaction of the number of dustbins (3 scales from satisfied to unsatisfied), the satisfaction of the locations of dustbins (3 scales from satisfied to dissatisfied), and whether the waste collection follows a schedule (3 scales from satisfied to dissatisfied). At a

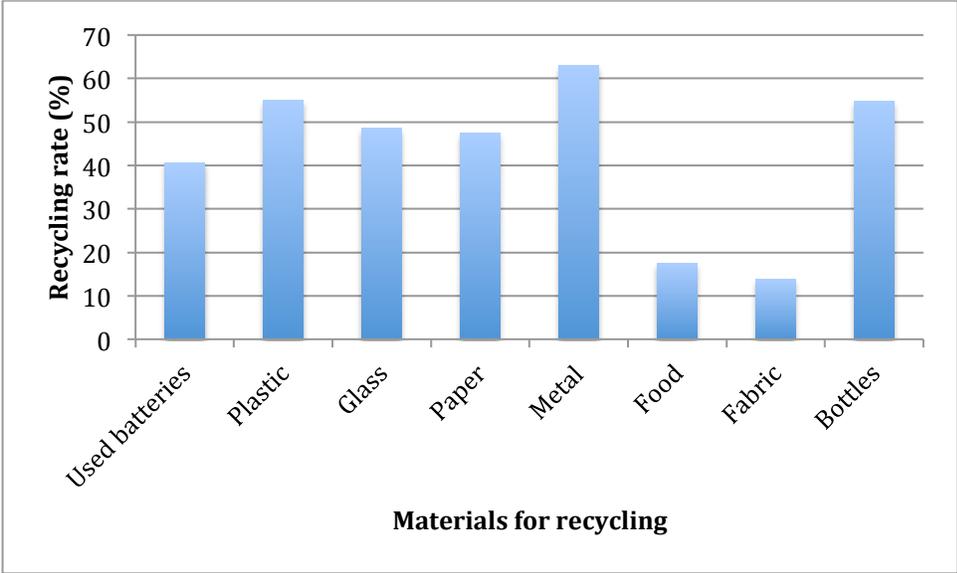
more general level, respondents were asked whether they were satisfied on the status of legislation/policy on solid waste source-separated collection, enforcement of the legislation, professionalism, media, non-governmental organizations (NGOs), public awareness of waste source-separated collection, and public awareness of environmental conservation. All these questions are based on a 5-scale score from strongly dissatisfied to strongly satisfied.

With economic development in the rural areas of China, villagers perceive their living conditions and circumstances to be improved. In the survey, only 4.5% respondents thought the neatness of their living areas was poor, while 45% of them thought it was acceptable, but they put forward requests on further improvement. Careless waste littering only happened occasionally (14.0%). With respect to the satisfactory condition of public dustbins at the 3-scale levels (“1: satisfied”, “2: fair”, and “3: dissatisfied”), both the numbers and the locations of these public facilities were ranked as “fair” with mean values (in the form of “mean value  $\pm$  standard deviation”) of  $1.90 \pm 0.789$  and  $1.73 \pm 0.761$ , respectively.

Most respondents have had some degree of participation in RDW separation and recycling at the household level, although most of such wastes are valuable to sell. Only 0.3% of the respondents never did any waste separation, which is consistent with the similar popularity of rural household recycling in Guangzhou Province (Chung and Poon, 2001). However, by considering the relatively low public awareness of RDW source-separated collection as shown in the next section, it is reasonable to assume that most of these recycling activities were spontaneous, rather than environment oriented. As shown in Figure 5.2, metals are the most popular waste being separately collected (by 63.0% of respondents), followed by plastic (55.1%), bottles (54.8%), glass (48.5%), paper (47.5) and used batteries (40.6%). Only 17.5% of the respondents separated

food waste. Liu and Huang (2014) stated that the low rate of food waste recycling may result from the low percentage of poultry farming at homes.

**Figure 5.2** Recycling rates of different materials in rural domestic waste.



**Table 5.1** Mean values of public perceptions at the general level.

	Mean
Regulation/Policy on waste source-separated collection	2.94±0.858
Enforcement of legislation	2.56±0.874
Professionalism	3.03±0.787
Media	2.75±0.84
Non-governmental organizations (NGOs)	2.67±0.815
Public awareness of waste source-separated collection	2.44±0.885
Public awareness of environmental conservation	2.63±0.767

People living in rural areas paid less attention to waste management issues at a more general level. In the survey, the respondents were asked about their perception of legislation/policy on waste source-separated collection, enforcement of legislation, professionalism, media, non-governmental organizations (NGOs), public awareness of waste source-separated collection, and

public awareness of environmental conservation. There are 35.7%, 45.2%, 20.5%, 32.9%, 45.7%, 23.5%, and 15.9% of respondents reporting “no idea” for these 7 questions, respectively. This situation may be a result of the low educational level of the respondents and the low efforts invested in pro-environmental education. For the rest of respondents, the mean values of their perceptions based on a 4-level scale from “1: strongly dissatisfied” to “4: strongly satisfied” are shown in Table 5.1. Respondents felt more or less dissatisfied with respect to public awareness on waste source-separated collection and enforcement (both of them had mean values around 2.5).

### **5.3.3 Public awareness of RDW source-separated collection**

Public awareness of RDW source-separated collection was evaluated by asking respondents to select sources they used to acquire knowledge on RDW source-separated collection. A total of 12 options were provided, consisting of television, radio, newspapers/magazines/books, internet, posters, pamphlets, friends/family members, village committees, signs on dustbins, campaigns, schools, and never heard.

It is a general perception that adequate public awareness is necessary for the success of waste source-separated collection programs (De Feo and De Gisi, 2010; Read, 1999). However, in this survey, among all respondents, 27.5% of them have never been educated or heard about waste source-separated collection. A further analysis as shown in Table 5.2 indicates that 75% of those who have not been educated were older people with ages of over 50, and account for 44.3% and 55.2% of respondents in the age categories of 51-65 and >64, respectively. More importantly, 17.3% and 17.5% of young to middle-age respondents from the age categories of 3 and 4,

respectively, also were not educated on waste source-separated collection. This clearly reflects insufficiency in relevant education in the rural areas of China.

**Table 5.2** The percentage distribution of respondents without knowledge of rural domestic waste source-separated collection with respect to different age categories.

	Age Category					
	≤18	19-24	25-36	37-50	51-65	>65
Percentage of respondents without knowledge of RDW source-separated collection	3.3%	0.0%	17.3%	17.5%	44.3%	55.2%

**Figure 5.3** Percentage distribution of respondents’ selections of different knowledge sources for acquiring information on rural domestic waste source-separated collection.

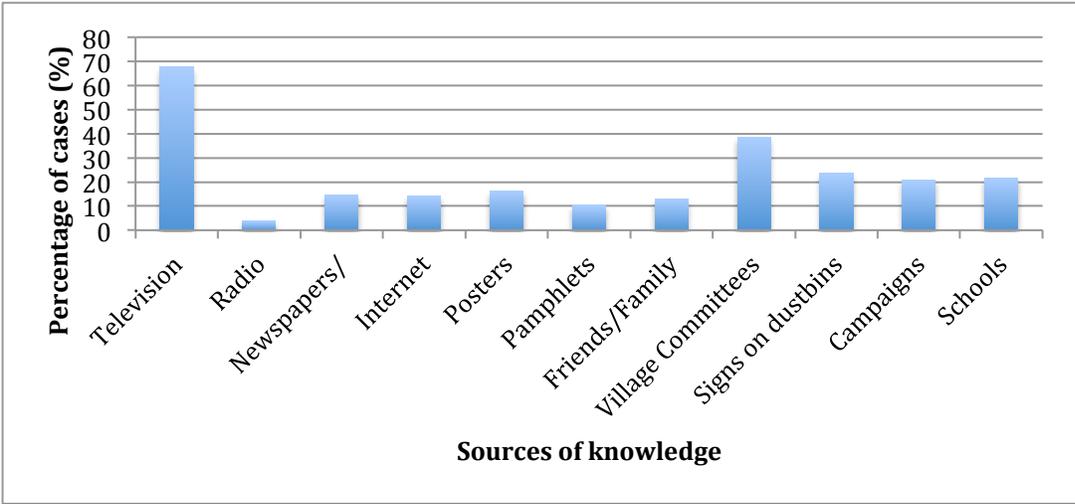


Figure 5.3 displays the distribution of knowledge sources used by the respondents to acquire the information on RDW source-separated collection. Television, village committees, signs on the dustbins, schools, and campaigns are ranked as the top five sources in order of importance, from which the respondents acquired knowledge of waste source-separated collection. The high ranking of village committees reflects their important role in RDW education for rural residents

in China. During the field survey, it was informed frequently that most information dissemination, especially on governmental policies, relied on these village committees.

**Table 5.3** Top three information sources for different age groups. The numbers shown in parentheses indicate the percentages in each age group who made the associated selection.

Age	≤18	19-24	25-36	37-50	51-65	>65
Information sources	School (63.8%)	Television (85%)	Television (79.1%)	Television (64.3%)	Village Committees (64.9%)	Television (76.9%)
	Television (62.1%)	Newspapers, Magazines, Books; Internet; Campaign (57.1%)	Signs on Dustbins (23.3%)	Village Committees (57.1%)	Television (56.8%)	Village Committees (65.4%)
	Signs on Dustbins (39.7%)	Schools (42.9%)	Internet (20.9%)	Signs on Dustbins (19%)	Campaigns (21.6%)	Campaigns (26.9%)

Respondents from different age categories showed different preferences regarding sources for knowledge acquirement. More specifically, the top three sources in each age category are summarized in Table 5.3. Television is a common source, which is common to all age categories. For respondents of school ages, school education becomes the major knowledge source. For respondents having middle and older ages, the role of village committees in their awareness about waste source-separated collection becomes more significant. By considering the fact that

these respondents are major family members who handle daily household waste, the importance of village committees is further highlighted. Although Internet service has been widely provided in all selected areas under this survey, its popularity in environmental education was only observed among respondents with ages of 25 to 36 years old. Similar to urban residences (Ma et al., 2016), having signs on dustbins is also preferred by the rural respondents as one of the major knowledge sources. However, the follow-up analyses showed that 38.7% of respondents reflected that the signs on dustbins in their villages were “vague”, “disappeared”, or “missing”. Thus, the government should pay more attention to designing more consistent, clearer and more easily understandable dustbin signs.

#### **5.3.4 Public attitude toward RDW source-separated collection**

Public participation in waste source-separated collection can be affected by many influencing factors, both intrinsic and external (Keramitsoglou and Tsagarakis, 2013; Yang et al., 2011). Because of the lack of research in the literature related to RDW source-separated collection, 10 influencing factors, which have been widely accepted as the major factors influencing urban residents’ activities in MSW separation at source (Ma et al., 2016), were considered. They are lack of time, lack of knowledge, lack of facilities, too complicated and inconvenient to operate, social pressure, being accustomed to mixed collection, lack of punishments/rewards, lack of storage space, mixed transportation after separating at source, and lack of legislation enforcement (Ma et al., 2016). The effects of each factor were evaluated on a 5-level ordinal scale from “1: no” to “5: significant”.

The mean for each influencing factor was calculated and the calculation results were represented in the form of mean value  $\pm$  standard deviation, as shown in Table 5.4. On average, only one

factor, “lack of facilities,” has a mean value larger than 3 ( $3.10 \pm 1.411$ ), which means that the factor had an effect on the respondents’ participation, while all other factors introduced only limited influence. This observation is consistent with those on MSW separation in the literature (Nixon and Saphores, 2007; Zhang et al., 2012), and indicated that both urban and rural residents share a common opinion on providing sufficient facilities to bring about the success of solid waste management. Although almost all the villages that were included in the survey have been provided dustbins at the public levels, the numbers and the locations of these facilities are still not sufficient, which greatly limited the public participation in RDW source-separated collection in these areas. When taking into account the scattering of living patterns and limited financial support in the rural areas of China, it is expected that this situation may be generally the case.

Since none of the evaluated factors was significant, further analyses should be conducted in order to identify other factors, which may affect the participation of rural residents.

**Table 5.4** Mean values of influencing levels of different factors on the respondents' activities in rural domestic waste source-separated collection.

	Mean
Lack of time	$2.01 \pm 1.251$
Lack of knowledge	$2.64 \pm 1.299$
Lack of facilities	$3.10 \pm 1.411$
Too complicated to operate	$2.25 \pm 1.292$
Social pressure	$2.48 \pm 1.384$
Being accustomed to mixed collection	$2.86 \pm 1.403$
Lack of punishments/rewards	$2.42 \pm 1.411$
Lack of storage space	$1.86 \pm 1.182$
Mixed transportation after separating at source	$2.70 \pm 1.324$
Lack of legislation enforcement	$2.57 \pm 1.501$

**Table 5.5** Kendall’s tau-b correlation coefficients of the respondents’ pro-environmental attitude with impact factors and demographics.

Impact factors	Correlation coefficient
Lack of time	-0.062
Lack of knowledge	-0.188**
Lack of facilities	-0.070
Too complicated to operate	-0.139*
Social pressure	-0.047
Being accustomed to mixed collection	-0.142*
Lack of punishments/rewards	-0.166**
Lack of storage space	-0.105
Mixed transportation after separating at source	-0.226**
Lack of legislation enforcement	-0.147*
Age	-0.158**
Gender	0.095
Education	0.009
Household size	-0.025
Monthly income	0.188**
* Significant at 0.05 level	
** Significant at 0.01 level	

Since almost all respondents (99.7%) voluntarily engaged in waste separation to some extent, the evaluation turns to their pro-environmental attitude (namely, attitude because of environmental conservation) to participate in RDW source-separated collection with respect to all listed impact factors and demographics through correlations and binary logistic regression, as shown in Tables 5.5 and 5.6, respectively. It is found that the respondents’ pro-environmental attitudes are negatively correlated with all impact factors (Table 5.5), among which “lack of knowledge,” “too complicated to operate,” “being accustomed to mixed collection,” “lack of

punishment/rewards,” “mixed transportation after separating at source,” and “lack of legislation enforcement” are significant. In addition, the respondents’ pro-environmental attitude is negatively correlated with age, but positively correlated with monthly income. This may be because i) there is low public awareness among older people due to the high percentage of illiteracy, and ii) high monthly incomes make the respondents feel less burdened in meeting their basic needs, allowing them to pay more attention to their living conditions and environment. This observation is inconsistent with that from (Chung and Poon, 2001), where in rural area of Guangdong Province, the family income had a negative correlation with the household recycling rate. This inconsistency is in line with the widely accepted notion that there is no one-size-fits-all solution for RDW management in China (Zeng et al., 2015).

The binary logistic regression analysis in Table 5.6 further indicates that “lack of legislation/policy” ( $\beta = -0.627, p = 0.005$ ) and “monthly income” ( $\beta = 0.986, p = 0.001$ ) are two of the most significant factors influencing the respondents’ pro-environmental attitude. In fact, among the respondents who did not have a positive pro-environmental attitude to waste source-separated collection, 77% of them indicated that they would participate in mandatory programs if there were regulations or policies enforced by the government. This observation conflicts with that in Chung and Poon (2001), where in Guangdong Province, voluntary programs were more welcomed in the rural areas.

**Table 5.6** Binary logistic regression coefficients ( $\beta$ ) of the respondents' pro-environmental attitude with impact factors and demographics.

Impact factors	$\beta$	S.E.	Odds ratio
Lack of time	-0.024	0.221	0.976

Lack of knowledge	-0.445*	0.218	0.641
Lack of facilities	-0.007	0.179	0.993
Too complicated to operate	0.041	0.272	1.041
Social pressure	0.343	0.223	1.410
Being accustomed to mixed collection	-0.335	0.207	0.716
Lack of punishments/rewards	0.011	0.216	1.011
Lack of storage space	0.500*	0.250	1.649
Mixed transportation after separating at source	-0.393*	0.185	0.675
Lack of legislation enforcement	-0.627**	0.223	0.534
Age	0.012	0.154	1.012
Gender	0.613	0.492	1.846
Education	0.052	0.243	1.053
Household size	-0.123	0.138	0.884
Income	0.986**	0.303	2.681
Constant	0.679	1.766	1.971
-2LL: 144.786; $\chi^2 = 49.038$ **			
Cox & Snell $R^2$ : 0.296; Nagelkerke $R^2$ : 0.394;			
Hosmer and Lemeshow $\chi^2$ with $p$ value in parenthesis: 12.462 (0.132);			
Overall predictive accuracy: 76.4%			
* Significant at 0.05 level			
** Significant at 0.01 level			

### 5.3.5 Willingness to pay for RDW management charges

For accuracy of evaluation, the respondents belonging to the age category 1 (less than 19 years old) were excluded in the analysis since most of them had no income by themselves and hence their responses may not reflect their actual willingness for potential payment.

To evaluate the respondents' willingness to pay for RDW management charges, three questions were asked, each of which was scored on a 3-point scale of: 1: No, 2: neither yes nor no, 3: Yes.

These three questions are:

1. I support the establishment of a new charging system based on the principle of “pay more for more waste discharge, pay more for mixed waste, and pay less for separated waste”.
2. Do you accept to pay for establishing a platform for handling separately collected household waste?
3. I am willing to pay for special garbage bags used for waste source-separated collection.

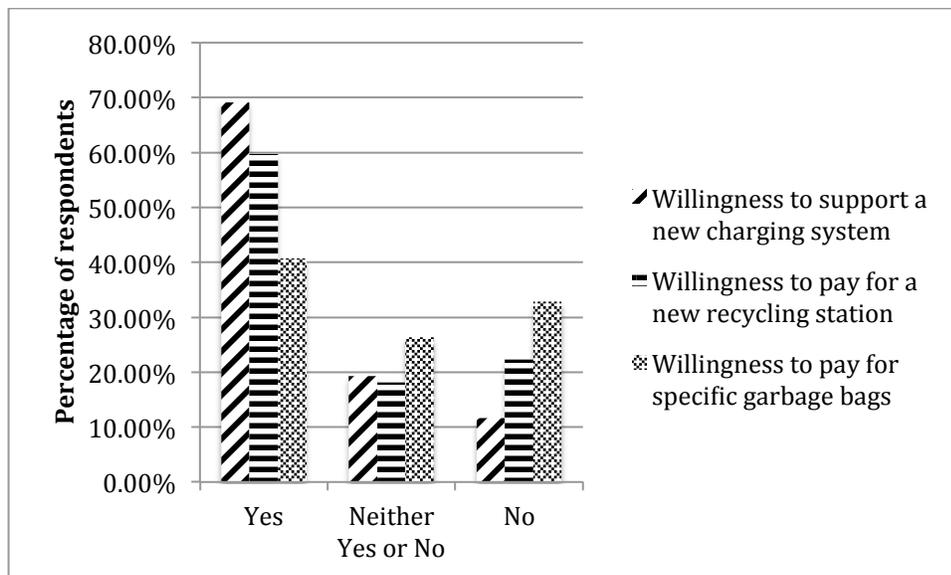
In the selected areas, some villages have set up a flat rate payment system (¥5.00 RMB or \$0.78 USD per month) for waste collection. A full 69.1% of the respondents supported the establishment of a new payment system based on the principle of “pay more for more waste discharge, pay more for mixed waste, and pay less for separated waste”. Only 11.6% of the respondents refused to accept this new payment system.

Most of the respondents (59.7%) supported the establishment of new waste recycling stations, even though they would need to pay extra money for that, and 94.2% of them could afford less than ¥10.00 RMB (\$1.57 USD) per month. There were 22.3% of the respondents who refused the payment, and 73.7% of them thought it is the responsibility of the government. However, if special garbage bags are requested for waste separation, only 40.7% of the respondents are supportive and 32.9% against.

Figure 5.4 shows the comparison of respondents' willingness to support a new payment system, pay for a new recycling station, and use special garbage bags. A clear trend of decreasing rate of support and increasing rate against can be observed, which reflects the rural people's willingness to pay for potential waste management charges as follows:

- The high support rate for the new payment system for waste collection may result from the fact that there already exists a payment system and no extra payment is expected.
- The relatively high support rate for establishing new waste recycling stations was considered as the action needed by government so that the payment was considered to be mandatory.
- If the extra payment involves individual behaviors, such as buying special garbage bags, the extra financial pressure became more important in rural people’s decision because of their relatively low monthly incomes.

**Figure 5.4** The comparison of respondents' willingness to pay for charges from rural domestic waste management.



In order to evaluate the respondents’ attitude toward paying for extra charges induced from RDW management, the principal component analysis method was first applied to extract a variable from three factors, “support of implementing new payment systems”, “extra charges for establishing a new recycling station” and “extra charges for buying specific garbage bags for waste separation,” as shown in Table 5.7. Cronbach’s  $\alpha = 0.543$  indicates that there is sufficient consistency among the three factors. After factor reduction, the new variable can explain 52.35%

of the variance. Note that the larger the extracted factor is, the higher the respondents are willing to pay.

**Table 5.7** Factor extraction by principle component analysis on the respondents' attitude to pay for extra charges induced from rural domestic waste management.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative Percentage	Total	Percentage of Variance	Cumulative Percentage
1	1.571	52.350	52.350	1.571	52.350	52.350
2	0.782	26.071	78.421			
3	0.647	21.579	100.000			
Cronbach's $\alpha$ =0.543						

Bivariate correlations between the extract factor and the respondents' demographics are shown in Table 5.8. It can be observed that the respondents' willingness to pay has a strong positive correlation with income. The higher the income, the greater the support from the respondents.

**Table 5.8** Kendall's tau-b correlation coefficients between the respondents' willingness to pay and their demographics.

Demographics	Correlation coefficient
Age	-0.053
Gender	-0.027
Education	0.024
Household size	0.028
Monthly income	0.119*
Significant at 0.05 level	
** Significant at 0.01 level	

By further considering the methods for the new payment system, 49.5% of the respondents preferred to keep the existing flat rate payment method, followed by household sized based

(27.2%) and waste weight based (22.3%) methods. Few respondents (1%) preferred to be charged based on the size of living space. The relationship between the payment method selection and the respondents' demographics is evaluated by using multinomial logistic regression, as shown in Table 5.9. The existing flat rate payment method is selected as the benchmark. The table shows that the respondents with larger household sizes preferred the existing flat rate payment method, rather than those based on either household size or the amount of waste generation. Such selection preference is intuitive since for the households with larger sizes, the flat rate can better protect them from paying for higher rates even if the actual amount of waste is positively proportional to the household sizes.

**Table 5.9** Multinomial logistic regression model coefficients (B) on respondents' preference in selecting payment systems.

		B	Sig.	Exp (B)
Household size	Intercept	0.278	0.874	
	Age	0.228	0.279	1.256
	Gender	-0.544	0.211	0.580
	Education	0.002	0.993	1.002
	Household size	-0.430**	0.001	0.651
	Income	0.320	0.249	1.377
The amount of waste generated	Intercept	-0.184	0.920	
	Age	0.188	0.384	1.207
	Gender	-0.410	0.360	0.664
	Education	0.259	0.277	1.296
	Household size	-0.396**	0.005	0.673
	Income	0.035	0.905	1.036

-2 Log Likelihood: 280.929; $\chi^2$ : 27.102**; $p = 0.003$
Pearson $\chi^2$ : 248.714 ( $p = 0.37$ ); Deviance $\chi^2$ : 251.522( $p = 0.324$ )
Cox and Snell $R^2$ : 0.149; Nagelkerke $R^2$ : 0.171
% correctly predicted: 54.8%
* Significant at 0.05 level
** Significant at 0.01 level

## 5.4 Summary and policy implications

With economic development and urbanization, RDW management has been facing ever increasing per capita waste generation, complexity in waste composition, and shortages in facilities (Chung and Poon, 2001; Nie and Dong, 1998). Today, RDW management has become as important and urgent as MSW management. For RDW management, although the importance of implementing waste separation and recycling at the source has been widely recognized, promoting the participation of villagers is challenged by social and economic factors, which further hampers the success of operating sustainable RDW management in rural areas of China.

As indicated by this study, public awareness of rural residents on RDW separation is low. Since such awareness is a significant factor influencing public pro-environmental attitudes, educating village residents should be an important concern by the decision makers. Such education should include knowledge not only on waste source-separated collection itself, but also on social wellbeing. Because of the particular age distribution of populations in the rural areas, education on RDW source-separated collection should focus on younger and older people, who stay in their home villages most of the time throughout the year and are major waste generators and disposers. However, the low educational level, even illiteracy, of rural residents significantly limits the effects of some traditional education methods, especially for those having complicated contents

(such as newspapers and pamphlets). Thus, the knowledge dissemination in rural areas should apply graphical formats more often. In addition, television programs and signs on dustbins should be widely applied as major educational media.

This study confirmed a previous observation (Han et al., 2015) that rural residents care more about environmental issues closely related (mostly visible) to their daily lives, while paying less attention to those at a more general level. Therefore, on one hand, for the RDW management education of rural residents, highlighting the benefits of successful RDW management on improving their living conditions is the most effective means of promoting their participation in waste source-separated collection in the short term. In the long run, promoting pro-environmental education is also necessary.

At the grassroots level, the village committees play a very important role in RDW management. Besides being the main source of knowledge to rural residents, they are fundamental administrative entities taking charge of most domestic waste collection and disposal (Zeng et al., 2015). Thus, it is important for the central government to strengthen the functionality of village committees in sustainable waste management by providing more support in policy, finance, and technology.

Villagers' economic status is identified in the analyses as being an important factor influencing their attitude toward participating in RDW source-separated collection. Therefore, introducing some economic incentives in RDW separation and recycling programs should be considered by decision makers (Han et al., 2015). In addition, since the villagers are more willing to follow regulations or policies enforced by the government, a mandatory RDW source-separated

collection program may currently be more effective than a voluntary one. However, it is the duty of the government to enact laws or policies and provide sufficient support for their enforcement.

The significant differences between urban and rural residents in terms of lifestyle, consumption patterns, and residence environment results in major differences in their attitude to waste management. An example is their opinion on the potential barriers to their participation in waste source-separated collection. The most commonly accepted influencing factors for urban residents are not viewed as problems by rural residents. Thus, specific policies which can address the uniqueness of waste management in rural areas are needed.

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# Chapter 6

## Conclusions and Future Work

### 6.1 Conclusions

In this thesis, a systematic literature review was first used to determine the social dimensions of MSW management, which consist of vulnerability, public participation, attitude and behavior, and policy. A relatively comprehensive list of publications on the related peer-reviewed literature published between 1980 and 2014 was compiled. After that, the factors that have impacts on public participation in municipal solid waste (MSW) and rural domestic waste (RDW) source-separated collection in China were identified and evaluated through social survey, statistical analyses, and the extended Theory of Planned Behavior (TPB) framework with the constructs of attitude, subjective norm, perceived behavioral control, and situational factor. The thesis provides a comprehensive understanding of the social dimensions of source-separated collection in both MSW and RDW management and puts forward suggestions for promoting solid waste management. The major conclusions of this thesis are as follows.

1. The social dimensions of MSW management have been studied by researchers around the world. However, these efforts are far from sufficient.
  - Potential risks from MSW to vulnerable populations mainly focus on health, economic/wage inequity, environmental injustice, and inequity in service provisioning.

Among them, health risks to children are investigated most. Further research on other types of risks is suggested.

- Improving the governmental functions and administrative structures should be emphasized so that the public education, the involvement of the informal sector, and the collaboration between the private and public sectors could be efficiently promoted.
- The effectiveness of regulations and incentives is limited by many implementation issues and is dependent on locations. Therefore, designing policies to fit the local situations is a key research issue.
- Integrated management should become the new trend in MSW management to achieve the goal of sustainable development. The analysis methods adopted in MSW management should be carefully selected so that more reasonable observations and conclusions can be derived by balancing the tradeoffs between long-term and short-term, as well as local and global.

2. Public participation in both MSW and RDW source-separated collection and the implementation of MSW source-separated collection in China are affected by many factors.

- As major participants in this process, individuals with their own perceptions, awareness, and attitudes, play an important role in determining the ultimate success of MSW source-separated collection. How to encourage public participation in waste management has become a key challenge to local authorities.
- Public education on citizen participation in solid waste source-separated collection programs is very important. Specifically,
  - i) The education should include knowledge not only on waste source-separated collection itself, but also about social wellbeing. For urban residents, it is suggested

that fostering a responsible public attitude via effective environmental education and improving perceived control may be important to promote public participation. For rural residents, highlighting the benefits of successful RDW management on improving rural residents' living conditions is the most effective approach to promote their participation in waste source-separated collection in the short term. In the long run, promoting pro-environmental education becomes necessary;

- ii) The government should enhance public education through different approaches that are suitable to different population groups. For example, in rural areas, education on RDW source-separated collection should focus on younger and older people, who stay in their home villages most of the time throughout the year and are major waste generators and disposers. In addition, the low educational level of rural residents limits the effects of some traditional education methods, such as newspapers and pamphlets. Hence, knowledge dissemination through graphical formats in rural areas should be utilized more often.
  - iii) Posting signs on dustbins are effective and cost-efficient methods for educating residents on both MSW source-separated collection and RDW source-separated collection. Designing more consistent, clear, and easily understandable signs is the key to promote public awareness.
  - iv) In rural areas, the role of village committees in knowledge dissemination should be strengthened.
- There are differences between urban and rural residents in terms of lifestyle, consumption patterns, and residence environment, which result in differences in their attitudes to waste management. Specifically, there is a significant difference about the opinion on the potential

barriers to participation in waste source-separated collection between rural residents and urban residents.

- To promote public participation, solid waste source-separated collection program should include comprehensive measures such as the improvement of convenience, the enhancement of facilities, the introduction of incentives, and the enhanced enforcement of laws and regulations. In urban areas, the waste transportation services (collection vehicles, collection methods, and governmental policies) should be upgraded with a higher priority in order to avoid any mixed transportation. In rural areas, introducing some economic incentives and improving the enforcement of laws and regulations in RDW separation and recycling programs should be first considered.
- Residents from the pilot communities show some differences in terms of public perceptions and public attitudes compared to the non-pilot communities. Specifically, they exhibited more expectations for improvement of their living environment and more positive attitudes toward participating in waste separation programs. Thus, it is important to implement pilot programs for positively impacting the future implementation of MSW source-separated collection at the city level. How to achieve the continuation of the pilot program is the big challenge for the local authorities.

## **6.2 Future work**

### **6.2.1 Evaluate the effectiveness of existing laws and regulations on source-separated collection of MSW in China, as well as seeing how they have changed over the last 50 years and might evolve in the future.**

Legislation on separated-collection of MSW management in China went through three stages

(Yu, 2010). Stage 1. 1980s – 1990s: In this stage, some laws and regulations on separated-collection in China first appeared in the legislation system. In 1989, “Environmental Protection Law of the People’s Republic of China” was promulgated as the basic law for environmental conservation. In 1992, “Regulations of the State Council on the Administration of City Appearance and Environmental Sanitation the Procedures” were proposed as the first systematic regulations on MSW management including separated-collection. The subsequent “Regulations of the State Council on the Administration of City Appearance and Environmental Sanitation” and “The Law of the Peoples' Republic of China on Prevention and Control of Environmental Pollution by Solid Waste” added more details on the separated-collection and were adopted in 1996 (The State Council of PRC, 2016). Stage 2: In 2000, under the “Notification of Pilot Cities for MSW Separated-Collection” from the Ministry of Construction, eight cities, (i.e., Beijing, Shanghai, Guangzhou, Nanjing, Shenzhen, Hangzhou, Xiamen, and Guilin), were chosen as the pilot cities to explore the MSW source-separated collection system. Subsequently, “local governments of each pilot city have issued their own regulations as a measure to promote the MSW management project implementation” (Tai, et al., 2011, p. 1673). Stage 3. 2007 to Present: In this stage, one regulation and one law were issued that will greatly facilitate further progress of implementing separated-collection systems in China. They were amended as the “Administrative Measures for Urban Living Garbage” under the Ministry of Construction in 2007 and as the “Circular Economy Promotion Law of the People's Republic of China” under the Standing Committee of the National People's Congress in 2008. Regarding the latter, the concept of “circular economy” was first introduced, and “reducing, reusing, and recycling” first set as the guideline for the future development of MSW management in China (Yu, 2010).

However, the development of laws and legislation faces a range of barriers and challenges. For

example, in China, the wording of most existing legislation is too general, without explicitly specifying any rewards or punishments. This in turn reduces the operability of local laws and regulations (Wang and Zhang, 2011). There is confusion between law enforcement agencies and law-abiding citizens. Thus, the sanitation departments in China play dual roles as both law enforcement and law-abiding citizens (Yu, 2010). There is no complete and independent solid waste pollution prevention legislation for rural areas. Most existing relevant regulations are subsidiaries of some other environmental laws.

Future work should investigate legislative initiatives (in terms of legislative systems, legislative processes, and legislative principles) and legislative enforcement (with respect to legal relationships, practice, and legal measures) in China. The goal is to identify any existing problems in the current legislative systems, such as inadequate systems structure and techniques, imperfect responsibility systems, inadequate public participation, and so on.

In addition, the legislation on MSW between China and other industrialized countries should be compared. The objective of this study would be to propose suggestions and guidelines for further improving the related legislative systems in China. This comparison should focus on the enforcement capability and law implementation efficiency, and use quantitative methods, such as multiple-criteria decision analysis (MCDA) (Chankong and Haimmes, 1983). These quantitative outcomes will be supplemented by the qualitative data that arise from semi-directed interviews with people who are involved in and knowledgeable of MSW in China.

### **6.2.2 Evaluate the education and campaign program on source-separated collection of MSW and RDW in China, as well as improve and design effective education and campaign program.**

There is no doubt that the success of any MSW management system is highly dependent on whether participants are sufficiently knowledgeable about how and when to use it. This highlights the importance of public education throughout MSW management. In practice, such public education should make use of different media including local press and radio communication, leaflets delivered to households, public consultation meetings and personal contact with individual householders, and now the Internet and new social media (Martin et al., 2006). However, the effectiveness of each medium varies significantly. For example, although advertising in the local press and distributing pamphlets may be the cheapest and simplest ways of educating the public, they are in fact fare the worst in performance. Many studies show that more complicated and face-to-face communications, such as door-to-door campaigns, roadshows, the Internet, questionnaires and focus groups, are more efficient in promoting public knowledge and further improving stakeholder participation (Mee et al., 2004; Perrin and Barton, 2001; Read, 1999). Moreover, education initiatives also prove to be important in apprising the public about the necessity for, and the benefits from, the acceptance of a wider responsibility towards waste disposal (Martin et al., 2006).

The objective of the future work is to evaluate the education and campaign program on source-separated collection of MSW and RDW in China, and propose suggestions for improvement. Specifically, the future work will focus on

- Designing more consistent, clear, and easily understandable signs for placing on dustbins.

- Designing education and campaign programs for rural residents. Specific attention should be given to those who have low education levels.
- Exploring the implementation of efficient source-separated education programs in schools by carrying out the comparisons between China and other countries.

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