HOUSEHOLD PARTICIPATION IN SOLID WASTE MANAGEMENT TOWARDS CIRCULAR ECONOMY: A CASE STUDY OF HAIDIAN DISTRICT, BEIJING, CHINA

MASTER THESIS

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Abstract

The consumption of natural resources, the generation of solid waste, waste water streams and air pollution emissions are all increasing along with rapid economic development. To stop this unsustainable trend, China has incorporated the concept of circular economy into its national development strategy and endeavored to complete the circular transition.

Solid waste is one of the important aside components generated along the value chain (from raw material extraction for the manufacturing phase till post-consumption management) of any product. Being of enormous quantity, having potential hazards and yet unemployed value, solid waste represents a great opportunity for circular economy which aims to recover resources as much as possible. On the other hand, households are the main actors of society whose daily behaviors have significant power to influence the value chain of products from the consumption perspective. Under this scenario, this study is conducted to investigate how participation of household in the solid waste management can contribute to the transition towards circular economy through a case study of Haidian district, in Beijing, China.

To answer this question, the reported impacts of household participation in the solid waste management towards circular economy, the current situation of household participation in solid waste management in Haidian district, and the challenges of enabling participation of household in solid waste management are identified and analysed in this research. Ultimately, recommendations to enable participation of households in solid waste management are generated.

Key words: circular economy; household participation; solid waste; recovery rate

Chapter 1 Introduction

In this section, the research background is introduced. It begins with the global background of solid waste management and zooms on China' s domestic background. Subsequently, problems about enabling the participation of households in Beijing in the solid waste management are identified and illustrated on the premise of the background. Finally, research objectives are established.

1.1 Background

Whether in the developed or developing countries, solid waste management (SWM) faces environmental, economic and societal issues at any societal activity, business, tourism, health, safety, just to mention few of them. In fact, it has been reported that 7 to 10 billion tons of urban wastes are generated annually, which include municipal solid waste (MSW), commercial and industrial waste, construction and demolition waste (United Nations Environment Programs, 2015). Among them, the amount of municipal solid waste is 2 billion tons and this number increases annually due to population growth, rapid urbanization and economic development (United Nations Environment Programs, 2015). According to predictions of the United Nations, the waste generation in cities with lower income will be doubled within two decades. Meanwhile, with the development of global solid waste management systems, the waste of 2 billion people who currently do not have access to collection and transportation services of solid waste is expected to be brought into the solid waste management systems. All these trends lead to a growing pressure to the solid waste treatment. In that case, it is urgent to improve solid waste management systems and develop strategies to bring wastes under control.

The rational of the solid waste management systems consists of preventing the upstream of waste management and its management in the downstream of discarded wastes. To enable this entire stream, it is suitable to convert traditional linear streams, "take-make-discard", to circular patterns. According to the concepts from Ellen MacArthur Foundation (2013), the aim of circular economy (CE) is to keep all components within the value chain throughout the time in

closed loops. The CE principles in the field of solid waste management, are generally understood in the actions of "prevent, reduce, reuse and recycle".

As the largest waste generator worldwide, China generated 18.68 million tons municipal solid waste in 2016 (Ministry of Environmental Protection of the People's Republic of China, 2017). To pursue sustainable development, China launched the Circular Economy Promotion Law of the People's Republic of China in 2009, which says "to improve the efficiency of resource utilization to protecting the environment and achieving sustainable development" (Law info China, 2008). Abided by this law, local governments proposed relevant policies as well to minimize the amount of solid waste and increase the recovery rate.

Haidian district is the second largest district of the Chinese capital city, Beijing, with 3.6 million inhabitants, whose production of solid waste in 2016 was 1.03 million tons (Beijing Municipal Bureau of Statistics, 2017). Although the resource recovery rate (including incineration and biochemistry transformation, among others) increased from 30% in 2013 to 60% in 2016, the current and future solid waste situation demands urgent attention (The State Council of The People's Republic of China, 2017). In 2017, the work plan on promoting segregation of MSW in Haidian district was launched to target reduction, resource recovery of non-hazardous MSW.

As the starting point of the solid waste management, separation process is groundwork followed by reuse and recycling process that aims at reducing the volume of solid waste. However, separation process is barely realized in Beijing's communities despite the existence of relevant facilities, such as trash bins for different types of waste, and enforcement policies.

In this research, a case study of Balizhuang community in Haidian district of Beijing, China will be analyzed. The participation of households in solid waste management in this area will be investigated and the challenges of enabling the participation of households in solid waste management in this area will be identified. Ultimately, the methods to enable household participation in order to achieve high recovery rate and transit toward circular economy will be proposed.

1.2 Problem Statement

Mixed MSW have little value (International Solid Waste Association, 2018). But if the individual materials are separated, it is more feasible and profitable to recover their potential value. Hence, separation operations at the solid waste generation sources will directly reduce the amount of MSW to be disposed of or incinerated.

Currently, the household municipal solid waste (HMSW) is mandatory to be segregated into two categories: "organic", and "others". But it has being reported that most of the households dump all wastes into the 'Others' bins or they use the 'Organic bins as the 'Others' bins (China Economic Net, 2013). As a result, the total amount of HMSW is vast which pressures the waste management sectors in the downstream. Besides, in Beijing even throughout all China, "recyclable" wastes are collected by informal sectors rather than households themselves or waste management companies. The informal sectors merely segregate the wastes which are profitable for them, such as plastic bottles, cardboards and so on. Other "recyclable" wastes are disposed to landfills or incinerators.

According to Yu's (2017) research, there are mainly three methods of MSW disposal in Beijing by 2015: incineration (40%), landfill (30%), and biochemistry transformation (30%). By 2020 the percentage of incineration will reach 70%. Organic waste makes up a main fraction in HMSW in Haidian district of Beijing, roughly 60% of total amount of HMSW. But most of the organic waste is mixed with other types of discharged materials. In that case, the efficiency level of the incineration plants is relatively low due to the high water content in the organic waste portion.

For all the above explained reasons, this project is dedicated to conduct a research on participation of households in Beijing in the solid waste management. After understanding of the current situation and its challenges, some recommendations will be formulated to enable the participation of households in Beijing in the solid waste management and to contribute to the transition towards circular economy.

1.3 Research Objective

The foremost objective of this study is to investigate participation of households

in solid waste management in a circular economy perspective and provide recommendations to enable participation of household in SWM.

To support the main objective, the following sub objectives are:

1. To identify some of the best practices regarding household participation in solid waste management towards circular economy.
2. To identify the current situation of household participation in solid waste management in Haidian district in Beijing.
3. To assess the challenges of increasing participation of households in solid waste management in Haidian district in Beijing.
4. To formulate the recommendations that enable participation of households in solid waste management in Haidian district in Beijing.

1.4 Research Question

To achieve foremost research objective proposed in 1.3, the linkage between participation of household in SWM and circular economy should be found at first, and then by investigating the current situation of household' s participation in SWM, recommendations to enable transition to circular economy are formulated. In this way, the main research question is

How does participation of households in solid waste management contribute to the transit towards circular economy?

To answer this question progressively, sub-research questions are:

1. What is the linkage between household participation in solid waste management and circular economy?
2. What is the current situation of household participation in solid waste management in Balizhuang community of Haidian district of BeiJing?
3. What are the challenges of enabling participation of households in solid waste management in Balizhuang community of Haidian district of BeiJing?
4. How can the Balizhuang community of Haidian district of Beijing enable the participation of households in solid waste management in Haidian district?

1.5 Research Outline

In this research, by analyzing relevant existing literatures, their achievements and shortcomings were revealed. Then, on the premise of that, the methodology of

this research was presented. After that, in the Findings and Discussions, the first three research questions were going to be solved. Ultimately, in the last section, Conclusion and Recommendation, the fourth question was answered.

Chapter 2 Literature Review

In this chapter, relevant key concepts are introduced and descriptive information about the circumstances of municipal solid waste management in China is presented as well.

2.1 Solid Waste Management

Waste is defined as a combination of both solid and liquid waste which is considered unwanted and useless with the exception of waste water (Sasikumar & Krishna, 2009). Solid waste is generated from any activity associated to commercial, mining, industrial and agricultural operations and from households. Solid waste management incorporates the whole process of treating solid waste, which refers to "collection, transportation, processing, recycling or disposal" (Tsai, 2007). The negative impacts of improper solid waste management include: climate change, contamination, and risk to health and safety issues (United Nations Environment Programs, 2015).

According to the US Environmental Protection Agency (2008), normally municipal solid waste is managed by local municipalities, and the major disposal methods include incineration, burying, compost, and recycling. Based on Sasikumar & Krishna's research (2009), generally, the types of municipal solid waste are paper & cardboard, food waste, plastics, textiles, rubber & leather, aluminum cans, metals, glass, inert material and hazardous wastes (batteries, chemicals, pesticides, etcetera). With the development of manufacturing technologies, the characteristics of municipal solid wastes have changed over time. Wastes become more difficult to be degraded due to the increasing amount of plastics, glass, electronic equipment and become more hazardous to human health and natural surroundings, owing to chemicals, infectious waste and radioactive substances. Meanwhile, as a result of increasing population

growth, rapid urbanization and economic development, the quantity of MSW keeps increasing as well, at the consumption phase of those products.

Traditionally, municipal solid waste management (MSWM) covers waste generation, sorting, collection, transportation, recovery/treatment and finally disposal (Sasikumar & Krishna, 2009). In the light of the changes of characteristics and quantity of municipal solid waste (MSW), it is essential to integrate sustainability into MSWM. A widespread principle named "waste management hierarchy" (Figure 1) which is an adaptation of the Lansink's ladder (Lansink, 2012) provides a general priority for MSWM (Chandrappa & Das, 2012). This principle gives priority to prevention, minimization, and recovery rather than to landfill and controlled disposal. "Moving waste management up through this hierarchy" has been a widely accepted rule by most developed countries when policies are framed. In addition, 3Rs principle (reduction, recycling and reuse) has been applied globally for decades. In developing Asian countries, 3Rs principle not only provides a general direction to develop policies but also is used as indicator to measure policy implementation.

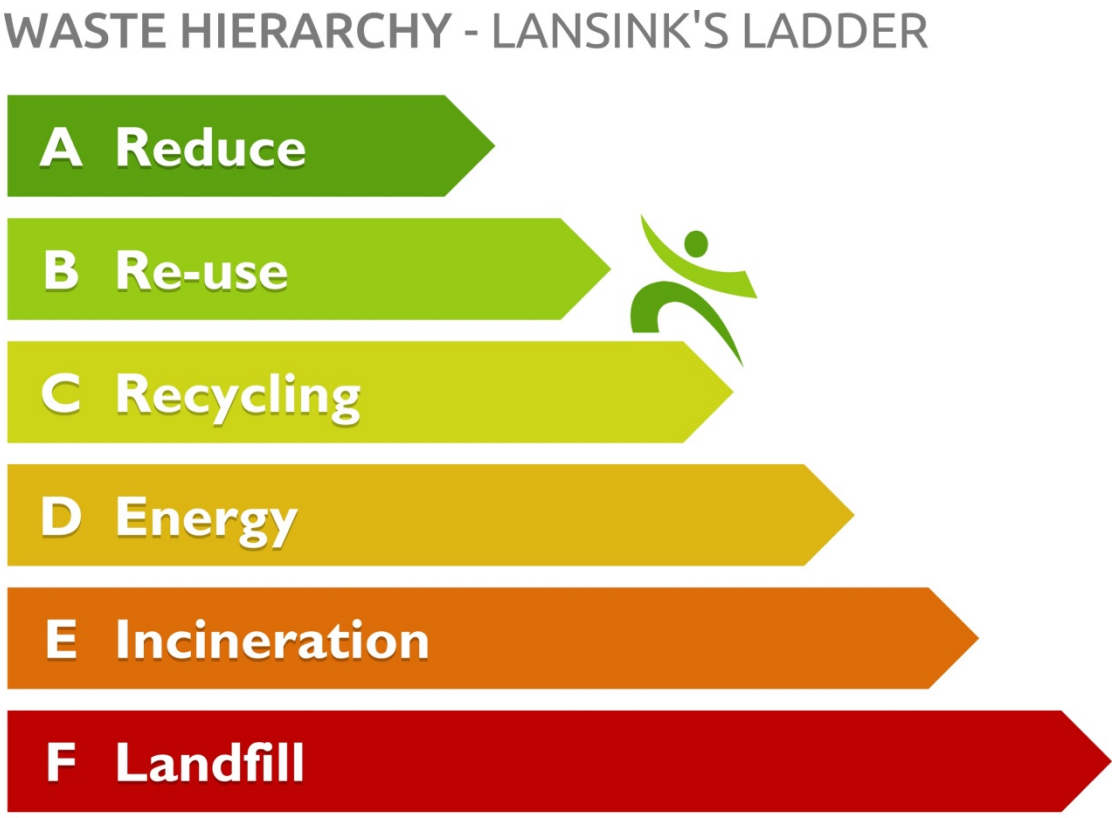

Figure 1 Waste management hierarchy. (Recycling.com, 2012)

2.2 Circular Economy

The traditional economic linear model, "take-make-dispose", is based on exploitation of real resources. Sectors along this line seem to take little consideration of its negative environmental and societal impacts (Ellen MacArthur Foundation, 2015). Unnecessary resource losses are in every process. To halt the trend of exhausting natural resources and to shift to a sustainable development, the concept of circular economy emerged. Many scholars have put efforts on bringing a clear definition (Zhaoxue et al., 2013; Yuan et al., 2006; Geng et al., 2008). But it was Ellen MacArthur Foundation (2015) who came across with a, so far, well-accepted definition which is here quoted: "circular economy aims to rely on renewable energy, minimize the use of toxic chemicals and eradicate waste through careful design". As a circular system, both biological and technical nutrients are restorative by design, those are showed in Figure 2

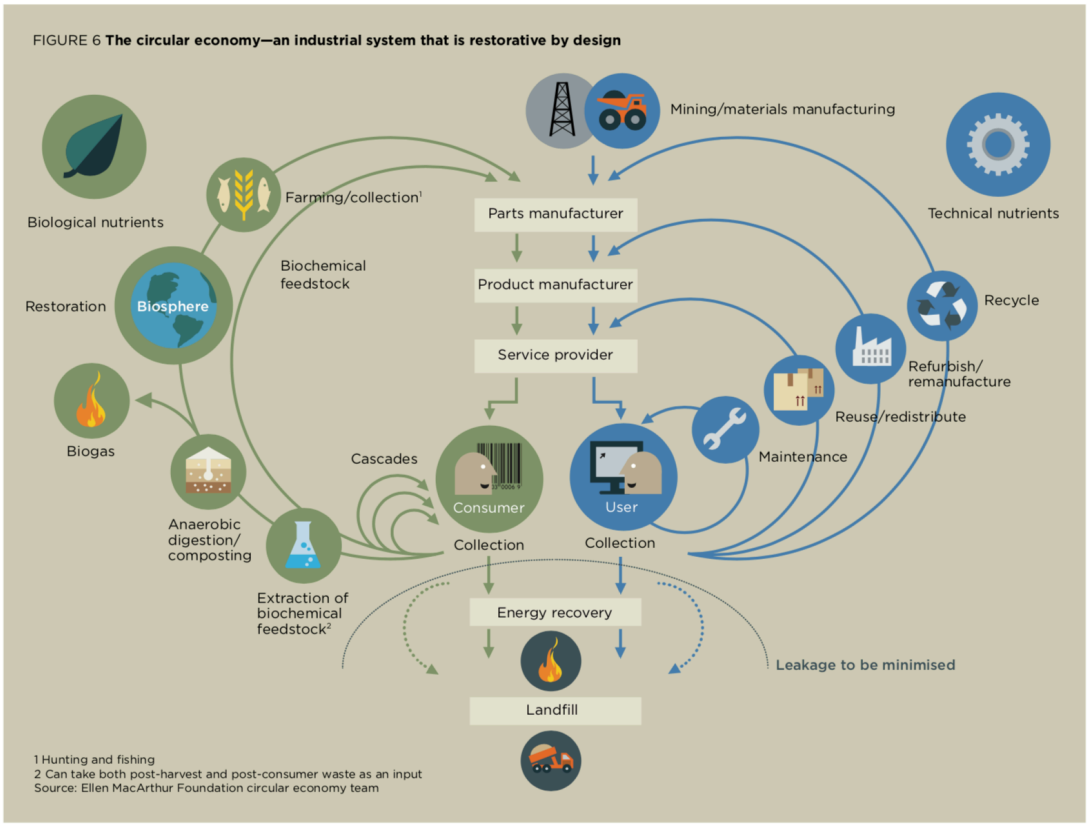

Figure 2 The circular economy system. (Ellen McArthur Foundation, 2013)

There are four primitive principles that circular economy provides to guide the transformation from linear to circular economy (Ellen MacArthur Foundation, 2013). Those are here described as follows:

- First, tighter circles generate larger savings. The tighter circles mean more raw materials are substituted since the potential economic value of reused and recycled waste.
- Second, keep the materials, products and elements in use longer. The longer time of usage will reduce the cost of raw materials.
- Third, cascaded utilization across different types of products; the same as previous "tighter circles" principle, the core of this principle is also reuse, but the reuse is not restricted in the same sort of product. For instance, the clothing is able to be transformed as a material for fiberfill for furniture production.
- Fourth, enable the inputs and designs to be easier-to-segregate. Presently, most post-consumption materials are mixed together, which causes difficulties to reuse and recycle. The products improved from the cradle will in reverse boost the efficiency and escalate the production scale.

The concept of circular economy has been integrated into solid waste management for sustainable development. Shift from "waste management" to "resource management" has been proposed in many policy initiatives to prevent waste and enable resource efficiency (United Nations Environment Programs, 2015). In a project called "Energy from Waste" in Sweden, an eco-cycle model is implemented with the recovery of 98% of the wastes and less than 2% of the wastes going to the landfill (United Nations Environment Programs, 2015). The applied methods incorporate source separation, reuse, material recycling and incineration. Figure 3 shows the streamline model.

Figure 3 The Eco-cycle approach. (Sysav, 2015)

UNEP suggested in 2015 that there are two main aspects to transit current solid waste management toward circular economy, one is waste prevention and the other is feedback loops. Waste prevention means using less amount of materials, which include designing products with less waste generation across its life cycle and maximizing reuse. Feedback loop means maximizing recycling and enabling the recovery rate. To facilitate both aspects, it is vital to improve the quality and concentration of collected wastes. Moreover, by waste segregation, these waste materials will keep clean and can be reintegrated to any of the value chain stages from which it came from or be integrated to the value chain of other product/sector. In CE terms, the discharged material can close the loop at lower costs and in higher efficiency. Normally the MSW contains dry recyclables and biowaste. Biowaste will contaminate the dry recyclables when they mix. Although downstream-sorting-plants may separate the dry recyclables again, typically its quality is much worse than the quality of those materials which were already separated at the collection points (International Solid Waste Association, 2018).

2.3 Household participation in solid waste management

To achieve the transition of the current MSWM toward circular economy, not

only municipality should take the responsibility for the transition but also other sectors, such as households, communities, private enterprises, that are also obligated to collaborate.

Households, as the main generators and the start point of the MSWM chain, play an important role in contributing to the downstream management sectors and at the same time, are the main hamper to the MSWM implementation. Generally, there are two benefits that can be generated by participation of households in the MWM, which are: (i) reduction of waste volume and; (ii) increasing the recovery rate (Akil & Ho 2014). In developed countries, the private enterprises mostly take charge of providing households with designated sorting trash bins and they also collect wastes periodically. During these procedures, households may participate in the sorting out of their own wastes. In Asian developed countries like Singapore and Republic of Korea, residents have high willingness of sorting out their daily waste. In fact, this results in high recovery rates, e.g. in Singapore it is over 70% and over 90% in the Republic of Korea (Mehri, 2017).

However, in the developing countries, the circumstances are utterly different. In the low-income countries, no controlled disposal facilities exist, and residents even openly burn their waste (The World Bank, 2017). In these countries, the MSW is usually managed by municipalities or state-owned companies, instead of private companies. The operation fee is unaffordable for governments in these low-income countries, which sometimes accounts between 20 to 50% of the total municipal budgets (The World Bank, 2017). Different from the situation when households participate in recycling through formal recycling sectors, residents or informal sectors (mainly scavengers) separate biowaste for feeding animals, and plastic bottles, cardboards and metals for making profit by selling them in developing countries (Rotich, et al., 2006). Although there is still an immense gap between developed countries and developing countries in participation of households in SWM, a vast of efforts have been made by local governments and plethora research projects have been conducted to improve this situation in the developing world (Oberlin, 2011).

In Myanmar, an initiative was proposed by the Bagan municipality, but because of household' s unclear understanding, lack of legitimate support and neglect of local residents' voices, this initiative failed at the end (Minn, Srisontisuk &

Laohasiriwong, 2010). In Malaysia, policies on waste minimization and initiatives of recycling programs have been carried out by governmental authorities for many years, but the participation of local residents qualifies still at a low level (Malik & Manaf, 2015). A large number of policy instruments have been adopted in many developing countries, but due to a lack of auditing provisions, their implementation and enforcement have not been as expected (United Nations Environment Program, 2017).

To assess the main factors influencing the participation of households in MSWM, research and case studies have been done. In Malaysia, households merely separate paper and textiles, which indicates they have some level of willingness of participation in the HSWM. But their participation is limited due to their low level of recycling knowledge (Akil & Ho, 2014). In Indonesia, a pilot program named *Waste Bank Management* was carried out to boost participation of households. Similar to Malaysia, the willingness and motivation existed in Indonesia but residents did not have comprehensive knowledge to demonstrate "correct" sorting behaviors. Moreover, activities of the local communities facilitated participation of the households in municipal waste management and positively influenced the participating behavior of residents (Maryati et al., 2018). In Myanmar, to increase the participation of households, all parties involved should develop comprehensive knowledge and have strong motivation (Minn, Srisontisuk & Laohasiriwong, 2010). According to Global Methane Initiative (2012), the low willingness to keep public spaces clean is also a participation problem in The United Republic of Tanzania and other developing countries.

2.4 Situation of municipal solid management in China

In 2016, 188.51 million tons of MSW were generated in 214 large and medium-sized cities of China, 2.91 million tons more than in 2015. If the MSW in rural area was included, the total amount would surpass 400 million (Ministry of Environmental Protection of the People's Republic of China, 2017). The treatment methods and their proportion of China's MSW in 2012 are illustrated in Figure 4.

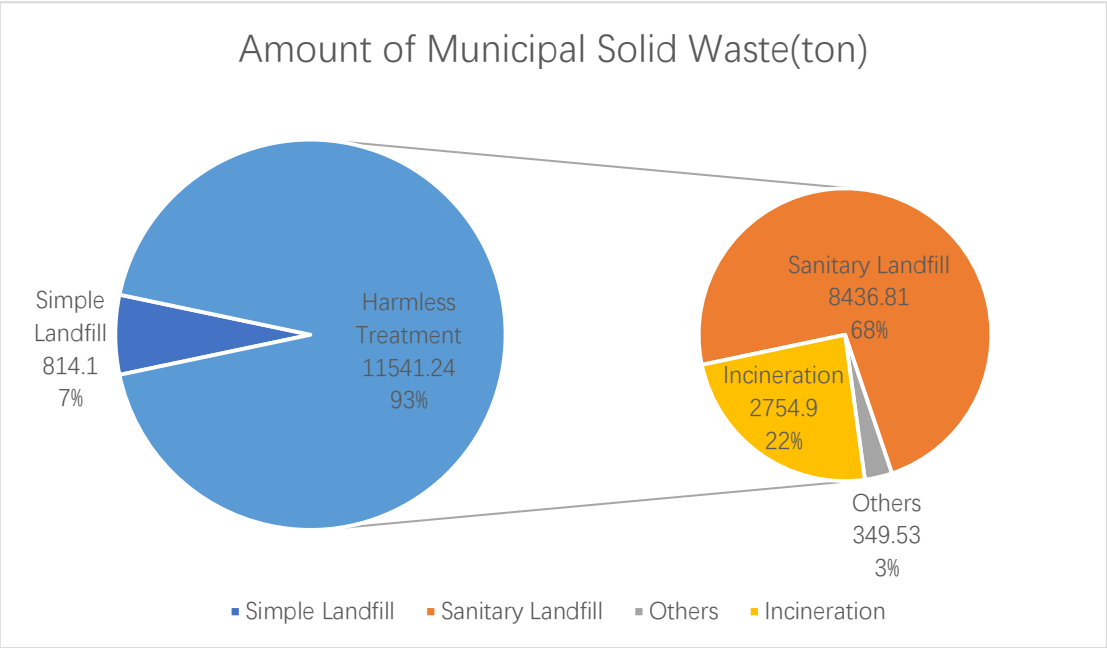

Figure 4 Treatment Methods and Their Proportion of China' s MSW in 2012. Source: China City (Statistical Yearbook, 2013)

According to the National Academy of Development and Strategy of Renmin University of China (2015), in recent years, the MSW in China has changed in the following four aspects:

- Between 2006 and 2012, the average coverage rate of collection of MSW rose from 64.16% to 65.85% nationwide (this figure in urban area was 93.43% in 2012);
- The average rate of harmless treatment increased from 80.54% to 93.43%;
- The disposal volume of MSW per capita fluctuated around 1.15 kg/(p*d);
- From 2009 to 2013, the recycling rate of paper and cardboard grew from 43.9% to 44.51%.

These figures implied that the general situation of MSW did not ameliorated substantially, in spite of the central governments' efforts who have published principles, strengthened the implementation and invested in solid waste treatment infrastructure. Table 1 shows several examples of policy instruments.

Table 1 Examples of China' s Policy Instruments about MSW. (National Academy of Development and Strategy of Renmin University of China, 2015)

CATEGORY	NAME	YEAR
Law	Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste	1995
Law	Circular Economy Promotion Law of the People's Republic of China	2009
Document	Notice of the State Council on Issuing the Circular Economy Development Strategy and Near-Term Action Plan	2013
Document	Notice of the State Council on Strengthening the Recycling and Utilization of Renewable Resources	2011
Document	Notice on Further Strengthening the Incineration Treatment of Municipal Solid Waste	2016
Document	The State Council approved the Ministry of Housing and Urban-Rural Development and other departments About Notification of further strengthening of disposing municipal solid waste	2014
Standard	The Pollution Control Standard for MSW Landfills	2008
Standard	Pollution Control Standard for Municipal Solid Waste Incineration	2014

In China' s 13th Five Year Plan (2016-2020), Circular Economy was set as a national development strategy. Meanwhile, in light of the publishing of the Circular Economy Promotion Law of the People's Republic of China in 2009, MSWM was required to adjust to a circular mode. More specifically, SWM contributes to transit towards circular economy in three major perspectives, which are reduction, harmless treatment and resource recovery based on the principles of circular economy. According to National Academy of Development and Strategy of RUC (2015), the elaborations of these three perspectives are:

1. Reduction：through sorting the waste at the headstream (family or office), the quantity of delivering MSW is reduced. The recyclable part feeds into the recycling or reuse system; organic waste is reused as animal feed or compost after dehydration; other waste is disposed by landfill or incineration.
2. Harmless treatment：all MSW are collected, airtight-transported and disposed after meeting the national criteria of discharging waste water and air.
3. Resource recovery: after sorting at the headstream, the recyclable waste

(paper, plastic, rubbery, metal, glass etc.) is reused. By repair, refurbish and remanufacture, the recyclable waste becomes valuable again.

As participation of households in SWM is a starting point and vital sector of MSWM, most of local governments have implemented policy instruments to enable it and some relevant studies have been conducted.

In 2015, 26 cities were chosen as pilot demonstration cities for MSW sorting program, which required that the coverage rate of waste separation facilities reached 90%, the quantity of delivering MSW reduced by 6% (compared with the figure in 2014) and the recovery rate of MSW arrived at 60% by 2020 in these cities (China Daily, 2015). These cities have published or amended the implemented measures to resonate this official decision. For instance, "Jiangsu Province Domestic Waste Classification System Implementation Measures" was published in 2017, in which two pilot cities, Nanjing and Suzhou, were involved (People.cn, 2017). In addition, some governments chose experimental districts to lead the implementation within these pilot cities like Tianjin (Sina, 2017).

Hua and Zong (2014) conducted surveys in Suzhou of China and found that the waste sorting pilot programs in Suzhou facilitated the participation of households in SWM and the main factors that influenced their behaviors were in direct proportion to resident's age, the availability of sorting facilities and relevant guiding policies. Zhuang et al. (2008) proved the existence of relationship between the waste sorting behavior and residents' knowledge by conducting questionnaires. Yu (2017) found that gender, age, incentive policies, income, knowledge about recycling system and the number of categories all influenced the sorting behaviors of respondents by collecting data in the eight pilot demonstration cities. Liu & Zhang made surveys in 100 households in Xi'an and also identified that in spite of having motivation to sorting the wastes, only few residents in Xi'an actually did that. The main restrictive factors were lack of accessibility of facilities, comprehensive knowledge about waste classification and lack of monitoring regulations. As the capital city of China, Beijing was chosen as one of the pilot demonstration cities.

"Suggestions Concerning Accelerating the Classification of Domestic Wastes" was published by The General Office of the Beijing Municipal People's Government in October of 2017 to pursue the 2020's goal. There have been a

few studies about the participation of household in SWM in this widely extended area. Lei et al. (2011) found that for students and office workers the sense of honor[1] was also an important factor to boost the sorting operation of wastes. Yalin and Mitsuyasu discovered that for young and middle-aged residents, the rewards for separating waste are not a determinant and for this group the municipal service and instructions were more effective. But due to the dynamic circumstances of Beijing, it is possible that some of the results of previous research are no longer valid at present. In addition, most of previous researches set the whole Beijing as research boundary so that their researches have lack of accuracy. In Beijing, different districts have various situations (residents' age composition, number of waste separation facilities, waste collection methods etc.), which are supposed to be investigated individually instead of being confused with each other. Therefore, with the purpose to make the research more accurate and persuasive, this thesis mainly focuses on one of the hundreds of Beijing' s neighborhoods as a show-case that represents similar neighborhoods.

In this research, a local community named Balizhuang is chosen as the research unit. Balizhuang is located in Haidian District (the western of Beijing) with a population of 127,900 and a surface of 6.51 km^2 (Haidian District Balizhuang School District Introduction, 2016)

Chapter 3 Research Design

Based on the research objectives mentioned in chapter 1, this chapter is dedicated to describe the research methods applied in this project.

3.1 Research Framework

Research framework is the bridge linking the research objectives with the research questions and it is also a schematic presentation of the research objectives (Carol, 2017). The following steps outline the research framework.

[1] If students or office workers have waste preparation behavior, they will be considered to have better manners and be more in compliance with regulations than their classmates or colleagues. As a result, they will feel honored.

Step 1: Characterizing briefly the objective of the research project.

The foremost objective of this study is to investigate participation of households in solid waste management in a circular economy perspective and provide recommendations to enable participation of household in SWM.

Step 2: Determining the research object.

The research object of this research is solid waste management in Balizhuang community of Haidian district of Beijing at the household level.

Step 3: Establishing the nature of research perspective.

In this research, to achieve the research objective, the critical factors concerning the participation of households in SWM in target area and their function on transiting current MSWM is investigated. So, the conceptual model of this research is based on the causal relationship between these factors and their effects. Thus, this research is a problem-analyzing research.

Step 4: Determining the sources of the research perspective

The conceptual model is established based on the scientific literature. The involved key concepts and the theoretical framework are shown in the Table 2.

Table 2 Sources of the research perspective. (Yang Chen, 2018)

Key concepts	Theoretical framework
Municipal Solid Waste	Theory on solid waste management
3Rs Principle	Theory on sustainable development
Participation of Household in SWM	Theory on solid waste management
Waste Management Hierarchy	Theory on waste management hierarchy
Circular Economy	Theory on circular economy

Step 5: Making a schematic presentation of the research framework

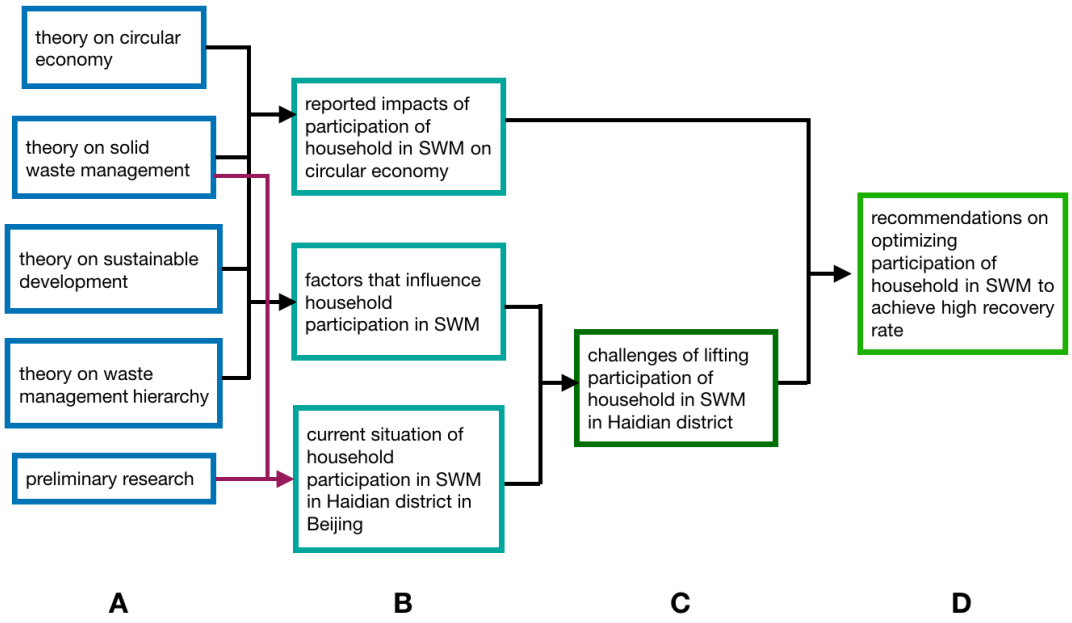

Figure 5 A Schematic Presentation of Research Framework. (Yang Chen, 2018)

Step 6: Formulating the research framework in the form of arguments according to the following 4 steps.

1. Conduct a study of existing theories and preliminary research.
2. Identify the reported impacts of participation of households in SWM on circular economy and the current situation of household participation in Balizhuang community of Haidian district of Beijing and the factors that influence the household participation behaviors.
3. Analyze the current situation and effective factors to identify the challenges to ameliorate the present situation.
4. Confront the challenges and reported impacts of participation of households in SWM for circular economy to formulate the recommendations on achieving high recovery rate.

Step 7: Checking whether there is any necessity to make changes for the model. Changes are not required in this research.

3.2 Defining Concepts

Perceiving accurate concepts is the groundwork for conducting an academic research and answering the research questions. Thus, the major concepts involved in this research are presented here.

Waste: a combination of both solid and liquid which is considered unwanted and useless but except waste water (Sasikumar & Krishna, 2009). It is produced from commercial, mining, industrial and agricultural operations and from household.

Solid waste management: the whole process of treating solid waste, which refers to "collection, transportation, processing, recycling, treatment or disposal" (Tsai, 2007).

Circular economy: a system in which by closing the material and energy loops, the input resources and waste are minimized and the value of the material are kept in the loop (Ellen MacArthur Foundation, 2015).

3Rs principle: a principle calls for an increase in the ratio of recyclable materials, reusing of raw materials and manufacturing wastes and reduction in resources and energy used (Hari Srinivas, 2015).

3.3 Research Strategy

This research conducts a case study to pursue the research objective and answer research questions. The collected data and the focus of the research area will compass only one region. The profundity and reliability are both strengthened by this strategy.

3.3.1 Research Unit

The research unit of this research is a community called Balizhuang in the Haidian district of Beijing, China where participation of households in SWM is analyzed.

3.3.2 Selection of Research Unit

In this research, the informants who provide information about others and the respondents who provide information about themselves are selected as follows:

Households: both informants and respondents

They provide the relevant data and information about their own backgrounds and the situation of waste separation in their own family. At the same time, they also supply the information about their neighborhood.

In this research, the number of samples is calculated based on the formula:

$n = N / (1+N.e^2)$

n= number of samples

N= total population

e= error margin (5%)

3.3.3 Research boundary

To achieve the research objective within the restricted time, a research boundary is served to delineate the domain of a research. For this research, the research boundary is as follow:

The number of questionnaires will be determined by the time limitation and be extended as far as possible. Moreover, the background of samples will be as various as possible.

The territory boundary is set basically in Balizhuang community in the Haidian district of Beijing, and the surveys will be distributed to at least fulfill the minimum number calculated in 3.4.2 and as broadly as possible in the area.

3.4 Research Material and Accessing Method

Desk research: Academic literature, official reports, journal articles and other relevant sources were examined to provide inspiration, basic concepts, and evidence about the key aspects of this research. The digital library of the University of Twente and Google scholar were used and most of the sources reported were accessible.

Questionnaire (survey): Questionnaires were dispensed around the communities of the Haidian district of Beijing to collect information and data about local residents.

Observation: Observation was taken around the communities to complement the information and data about local residents.

The Table 3 shows the data and information required for the research and their accessing methods.

Table 3 Data and information required for the research and their accessing methods. (Yang Chen,2018)

Research Question	Data/Information Required to Answer the Question	Sources of Data	Accessing Data
What are the reported impacts of household participation in solid waste management towards circular economy?	Existing information, data and evidence about household participation in other area and their effects; relevant theories.	Secondary data: Literature, Documents	Content Analysis and Search Method
What is the current situation of household participation in solid waste management in Haidian district of BeiJing?	Conditions of relevant facilities; Existing policy instruments; source and level of relevant knowledge; behaviors of household.	Primary data: Individual households , Reality (objective situation) Secondary data: Literature	Questionnaire and individual interviews; Observation and field trip; Content Analysis and Search Method
What are the challenges of enabling participation of household in solid waste management in Haidian district of BeiJing?	Relevant indicators to evaluate current situation; data analyze methods;	Primary data: Individual households Reality (objective situation) Secondary data: Literature	Questionnaire and individual interviews; Observation and field trip; Content Analysis and Search Method
How does the Haidian district of Beijing enabling participation of household in SWM to achieve high recovery rates?	Good examples of other regions including other cities in China and oversea cities; evaluation of collected data and information	Secondary data: Documents, Literature	Content Analysis and Search Method

3.5 Data Analysis

Through data analysis, the required data and information are transformed into the answer of the specific sub-research question that are present and described in the findings section.

3.5.1 Method of Data Analysis

In social sciences, there are two categories of methods, qualitative methods and quantitative methods. The methods used to analyze the data and information are shown in Table 4.

Table 4 Data and Method of Data Analysis. (Yang Chen, 2018)

Data/Information Required to Answer the Question	**Method of Analysis**
Existing information, data and evidence about household participation in other area and their effects; relevant theories.	Qualitative: analysis of the impacts, either positive or negative to circular economy
Conditions of relevant facilities; Existing policy instruments; source and level of relevant knowledge; behaviors of household.	Qualitative：analyzing the facilities' conditions, identifying the policy instruments, the level of knowledge, whether the residents separate waste; Quantitative: identifying the numbers and popularity of facilities
Relevant indicators to evaluate current situation; data analyze methods;	Qualitative: analyzing how the correlative factors restrict household participation Quantitative: calculate Correlation Coefficient between factors and the household behaviors
Good examples of other regions including other cities in China and oversea cities; evaluation of collected data and information	Qualitative: analyzing challenges and generate recommendations referring to the experience other successful regions

3.5.2 Validation of Data Analysis

Desk research: This method is applied at the start point of this research. To answer the research questions and ensure the reliability of the information, academic literature, regional organizations, and government official websites were the main sources for the research. Only the literature published in the last 5 years are eligible to be referred to ensure the information is not outdated.

The questionnaires (survey) were disseminated randomly in order to avoid any type of bias in the data collection process. Hence the survey was randomly distributed trying to cover all possible categories in terms of gender, education level, income level, the level of knowledge about household participation in waste management, etcetera. In addition to this, the number of questionnaires was extended as much as it was possible. In this way, the data of these surveys can represent the whole area.

3.5.3 Analytical Framework

Figure 6 shows the Analytical Framework of this research.

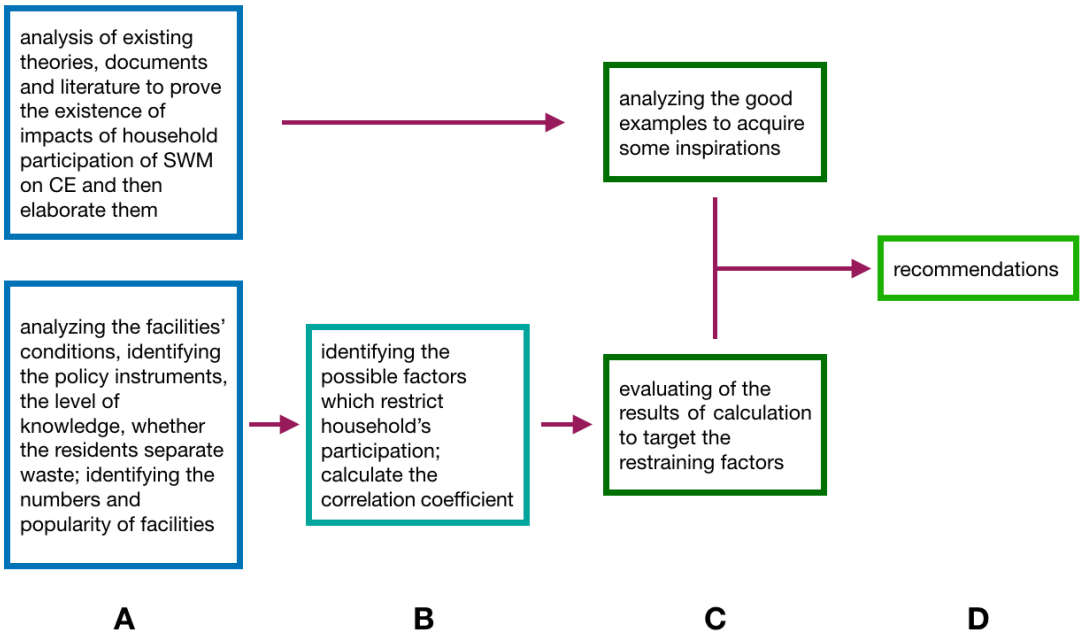

Figure 6 Analytical Framework of the research. (Yang Chen, 2018)

The data analysis was conducted with the following steps:

Step A: By analyzing existing theories, documents and literature, the linkage between household participation in SWM and circular economy was identified.

After that, current situation of SWM is identified by investigating residents' willingness, current HSWM service and the level of police implementation.

Step B: suggest the possible factors which may restrict household' s participation; then the correlation coefficient by Spearman' s correlation was calculated.

Step C: based on the results of the calculations, the restraining factors are targeted. Also, referring to the answer to the second research question, the challenges of enabling participation of household in SWM was identified. In addition, good examples of other regions where the participation of households in SWM is advanced, are analyzed briefly to acquire a vision. In this step, the third question was answered.

Step D: this was the final step, in which some recommendations were generated to enable the participation of households in SWM. Furthermore, due to the interrelationship between circular economy and the participation of households in SWM, the high recovery rate was also estimated. In this step, the fourth sub-question was responded.

Ethical Statement

The independence and impartiality, integrity and quality of this research are assured as much as possible; all the respondents of the surveys did it totally voluntarily after being well-informed about its nature, method and purpose for this research; full respect was given to their anonymity as well.

Chapter 4 Findings

This chapter presents and describes the cause-effect relationship between HSWM and circular economy through the analysis of existing literature. Meanwhile, current situations of household participations in SWM in target areas are analyzed by questionnaires, individual interviews and observations.

4.1 Impacts of household participation in solid waste management towards circular economy

4.1.1 Circular Economy

As mentioned in Chapter 2, the concept of circular economy, as proposed by Ellen MacArthur Foundation, aims to replace traditional resource-intensive Linear Economy. The main point of circular economy is to keep the materials throughout in their value loop and elude exhaust of nonrenewable energy as much as possible by enabling the mode of the current linear economy.

To bridge the two overarching concepts of this research, household solid waste management (HSWM) and circular economy (CE), together, it is necessary to further elaborate on the principles of circular economy (Ellen MacArthur Foundation, 2013). According to Ellen MacArthur Foundation (2013), the theory of circular economy is based on three principles, which are:

1. Nature capital: Renewable energy or better-performing resources should be prioritized and all the nutrients in the value chain should be preserved in the flow.
2. Resource yield: by maintenance, refurbishing and reusing, the duration of all the components in the value chain is prolonged, thereby their utilization also is enabled.
3. Negative externalities such as contamination of water, air and land and hazardous emission and outflow should be eliminated at the designing stage.

As these three aspects cover the main idea of circular economy, how HSWM can facilitate the transition of circular economy is demonstrated in these three aspects respectively in 4.1.3 to associate circular economy with HSWM

4.1.2 Municipal Solid Waste Management

On the other hand, with the principal objective of protection of the public health and the environment, municipal solid waste management could be summarized as the sum of operations pursuing for reliable collection, controlled disposal and resource recovery (United Nations Environment Programs, 2015). Controlled dumping and collection are the groundwork for further waste treatment including (incineration, landfill, recycling, etc.), which is delivered by public or private companies, communities or informal sectors (such as scavengers). After preliminary segregation, MSW is transferred to designated sites or waste treatment plants. Controlled disposal effectively avoids generating health and environmental problems. Otherwise water, soil and air would become

contaminated, and also recyclable resources would mix with non-recyclables materials. According to National Academy of Development and Strategy of RUC (2015), MSWM in China mainly includes waste reduction, harmless treatment and resource recovery.

As mentioned in Chapter 2, MSW takes sustainability into account. The term of waste management is in some contexts refreshed and transformed into one of resource management. By adopting this term, the managerial operations of discharged materials go beyond the traditional landfill, incineration and export to developing countries. In addition, there have been several existing concepts about sustainable waste management such a Waste Management Hierarchy and 3Rs, Waste Prevention, Waste Minimization and Waste Recovery.

4.1.3 Linkage(s) between Circular Economy and Municipal Solid Waste Management

There are several elements overlapping between these two concepts.

Negative externalities are in principle able to be eliminated by reliable collection and controlled disposal. If not, toxic gas emission is caused by open-burning of MSW, which exacerbates air quality; hazardous substance infiltrates the soil, ground water source and flow into surface water source; virus and bacteria propagate faster in uncontrolled dumpsite.

As one of the predicted benefits of CE, it has been reported that more natural capital can be generated by resource recovery (Ellen MacArthur Foundation, 2013). For instance, organic waste, 50%-70% of MSW in developing countries, is able to release methane and the solid component be reused as organic fertilizer (United Nations Environment Programs, 2015). Paper, plastics, textile and electronics are recycled and reused as secondary industrial materials both after being segregated and recovered.

The duration of all components in the value chain becomes extended and the value circles become longer due to controlled disposal. In some developed countries such as Japan and Singapore, the cost of MSWM service is depending on the amounts of wastes and residents are obliged to pay extra fee for disposing large household appliances and furniture. As a result, residents are

more prone to choosing to reuse, refurbish and maintain them rather than disposing them of.

With higher waste collection coverage and resource recovery rate, more value loops can be created by including the reuse of wastes, both within its inherent system and another system. Therefore, the relationships among each component can be expected to be tighter and more diverse (Ellen MacArthur Foundation, 2013). In conclusion, sustainable MSWM can contribute to shift to Circular Economy

More specifically, when it comes to household level of the MSW, there are mainly two ways to promote MSW: one is by reducing the quantity of their waste, the other is by segregating the solid waste (National Academy of Development and Strategy of RUC, 2015).

Reducing the amount of solid waste means less substance becomes exhausted, more can be reused, higher recovery rate can be observed, and the working load for waste management companies or organizations lessens as well.

Waste segregation means separating various types of household wastes at the beginning, when it is being generated post consumption. By waste segregation, recyclable resources such as cardboard, paper and textiles are kept dry and clean and not contaminated by other waste like organic waste, which is the premise of subsequent recovery. In addition, if organic waste is mixed with other waste, it not only misses opportunities to reutilize the organic matters to generate energy and fertilizer, but also downgrades the efficiency level of incineration plants due to its high water-content and contaminates recyclable resources.

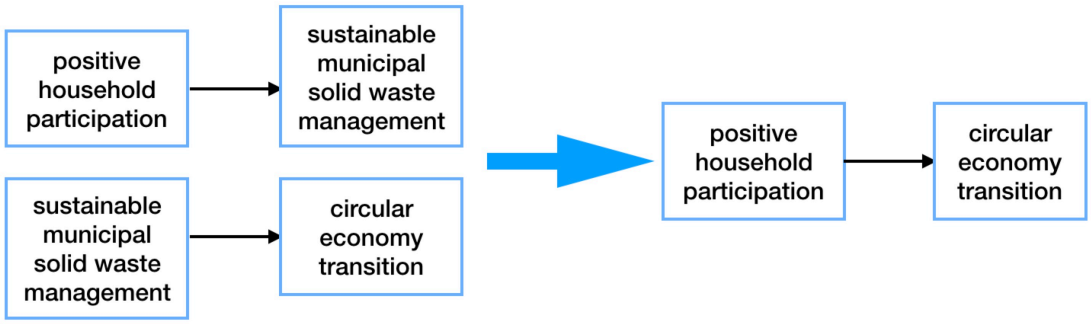

Figure 7 Flowchart of household participation in SWM and Circular Economy. (Yang Chen, 2018)

Based on the here above reasons, it is possible to assume that positive household participation in solid waste management can contribute to the circular

economy transition, so finding the solution to enabling household participation in MSWM may accelerate the circular economy conversion (Elison, 2017 & Danny, 2016).

4.2 Current situation of household participation in solid waste management in Balizhuang community

As part of this research a survey (text can be seen in appendix 1), was conducted in Balizhuang community to investigate the current situation of household participation in SWM. Based on the population of Balizhuang community, 127,900 in 2016, 402 questionnaires were disseminated, which is a bit bigger than the minimum number (398.75) calculated under the basis of the formula: $n = N / (1+N.e^2)$. This formula is described in section 3.

4.2.1 Characteristics of the surveyed Households in Balizhuang Community

Name of Category	Result (number of registrations)
Gender	Male=189(47%), Female=213(53%)
Age	18~25=72(17.91%), 26~35=103(25.62%), 36~45=69(17.16%), 46~55=49(12.19%) Over56=109(27.11%)
Education Level	High school or less=168(42%), Bachelor=188(46.8%), Master or more=46(11.4%)
Income Level[2]	5000RMB[3] or less=79(19.7%), 5000~10000RMB=268(66.67%), 10000~20000RMB=48(11.94%), 20000 or more=7(1.74%)
Ever Visited a Solid treatment plant	Yes=9(2.24%) No=393(97.76%)

Table 5 Characteristics of the surveyed Household sample in Balizhuang Community. (Yang Chen, 2018)

The basic background of the sample is described in Table 5, which is obtained by summarizing the results of the first 5 questions of the survey. As all the respondents were randomly selected, the characteristics of this sample is

[2] The average annual income in Beijing is 57230 RMB in 2017 (4769RMB monthly).
[3] 100RMB=12.58Euro in 2018. 7

statistically representative of the Balizhuang community households' with 5% of possibility of error according to the formula in the section 3.4.2.

Among all the respondents, there was a gender balance among the respondents: males 47% and females 53%. And the age of respondents covers a wide range, but the biggest two age groups were 26~35 and over 56. In relation to the educational level, there are 47% of respondents holding bachelor degrees and 11% of master degrees, and most of samples of 'high school or less' group are senior people. Even further 66.7% of respondents have incomes from 5000~10000 and 98% of all respondents have not visited a solid waste treatment plant yet.

4.2.2 The Current household participation in SWM

The actual situation of household participation in SWM is investigated by survey and direct observations.

In the survey, Question 13, 'In the real life, when you throw away garbage, which trash bins do you use for these following listed wastes?', listed 17 types of waste (shown in Table6). When answering this question, the respondents marked the trash bin they used for each type of waste respectively and their score of this question is equal to how many types of waste they marked correctly. Therefore, the score of Question13 can express the segregation behavior of respondent, which was equal to the amount of listed waste that they disposed correctly.

	Organic solid waste	Others
Old clothes		
Fruit peels		
Broken bowls		
Light Bulbs		
Dust		
Old toys		
Toilet paper		
Expired food		

Newspaper		
Flowers		
Bread		
Shampoo bottle		
Cardboard		
Wine bottle		
Plastic bags		
Eggshell		
Leftovers		

Table 6 the 17 Types of Waste in Question 7 and 13. (Yang Chen, 2018)

After processing the data from surveys, the tendency of the responds was plotted and can be seen in figure 8.

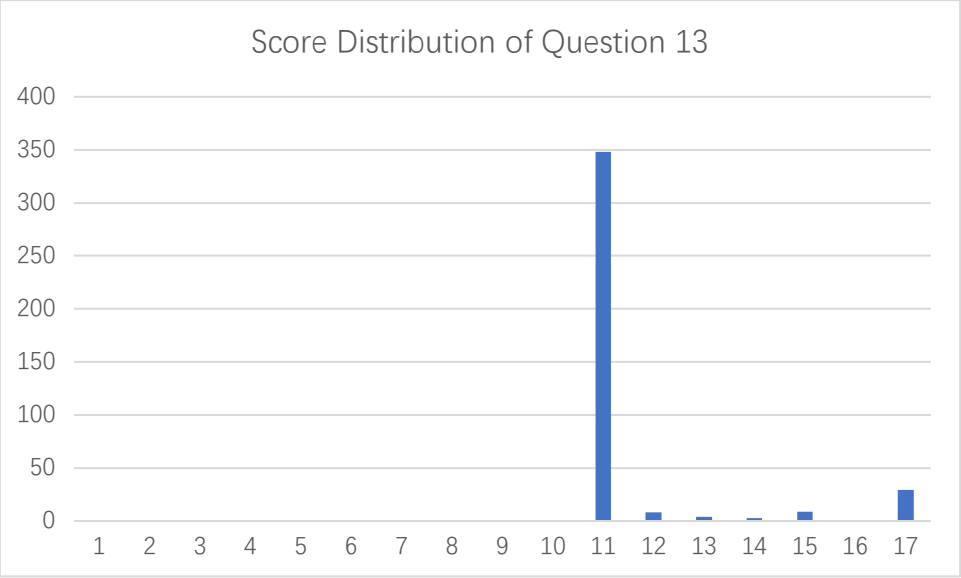

Figure 8 Number of respondents with each Score of Actual Segregation Behavior. (Yang Chen, 2018)

There are no respondents falling into score range 0 to 10, and Score 11 is the most dominant, 348 respondents out of 402 acquiring this score. The explanation of this phenomenon is: amid all the listed 17 daily necessities, there are 11 types of 'Others' waste so if the respondents do not separate the trash at all and dump all of them into 'Others', they would score 11. In other words, scoring 11 means the respondents do not have segregation behavior.

There are 54 respondents that obtained a score not less than 12, having waste segregation behaviors, and among them, 53.70% got full scores, separating all their organic waste. Hence, it is assumed that once households use waste segregation in practice, most of them perform a relatively high segregation rate. When respondents were asked about separation of the organic waste, one respondent said that he carries the organic waste to the dumpsite in the ordinary plastic bags and then separates the plastic bag from the organic waste; another respondent said that he collects organic waste in biodegradable bags; the rest 52 respondents admitted that they used non-biodegradable bags. This means only 1 out of 402 respondents have correct waste segregation behavior, 53 out of 402 respondents having waste segregation behavior yet with "incorrect" methods. Besides the survey, onsite observations were also taken into account to validate above reported results as much as possible. Three-time observations were done respectively from 7:00 to 8:00, 13:00 to 14:00 and 18:00~19:00 in the Balizhuang community at one of the dump sites. During the onsite observation period, only one of 27 residents dumped the organic waste in the 'organic' bin and 7 residents separated cardboards, plastic bottles and paper out of other waste, placing them near to the trash bins though, this was not actually requested. On the contrary, there was one resident dumping the mixed waste into the 'Organic' bin, which indicates that some residents misuse the 'Organic' trash bins as 'Others' bins.

4.2.3 Public perception and attitude of participation in solid waste management

Public perception and attitude were tested by the question 6 in the survey which was formulated as follows: 'Have you ever considered to participate in separating household solid waste?' This question indicates the respondents' willingness to participate in waste segregation; Question 7 'Which categories do you think the following listed wastes belong to?' The idea of this question is to assess the respondents' knowledge about solid waste separation by simulating segregation of 17 daily household wastes (shown in Table6), and their score of this question is equal to how many types of waste they marked correctly

Public Awareness and Willingness toward Participation in Solid Waste Management

Among all the respondents, there were 193 of 402(48%) answering that they have considered to segregate their household solid waste, signifying that half of residents lack the awareness. A awareness to participate in SWM is one of the groundworks to reduce the quantity and improve the recovery rate, it is crucial to excogitate methods to raise the awareness of the rest. Moreover, respondents aged over 56 took up 46% of perceptible respondents, being the largest part, which demonstrates that older people are more prone to separate their waste. This result is also coincident with the conclusion of previous studies (Akil & Ho 2014). And this kind of obvious divergence did not appear in other characteristics.

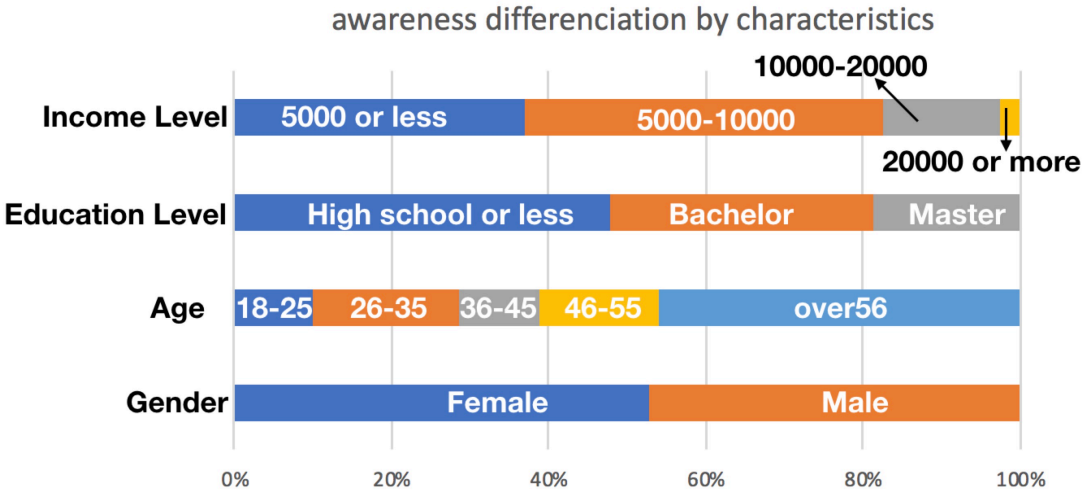

Figure 9 Respondents with awareness categorized by their characteristics. (Yang Chen, 2018)

Even though, 193 respondents expressed their willingness to separate HSW, only 54 actually have segregation behavior. Therefore, finding the reasons why people do not separate organic waste in spite of possession of the awareness and then spurring them to implement is as essential as raising the willingness of separating HSW.

Public Knowledge of Segregating Solid Waste

In Question 7, respondents' knowledge of separating solid waste is embodied by how many daily necessities they categorized correctly. The full score is 17 and the lowest score is 5.

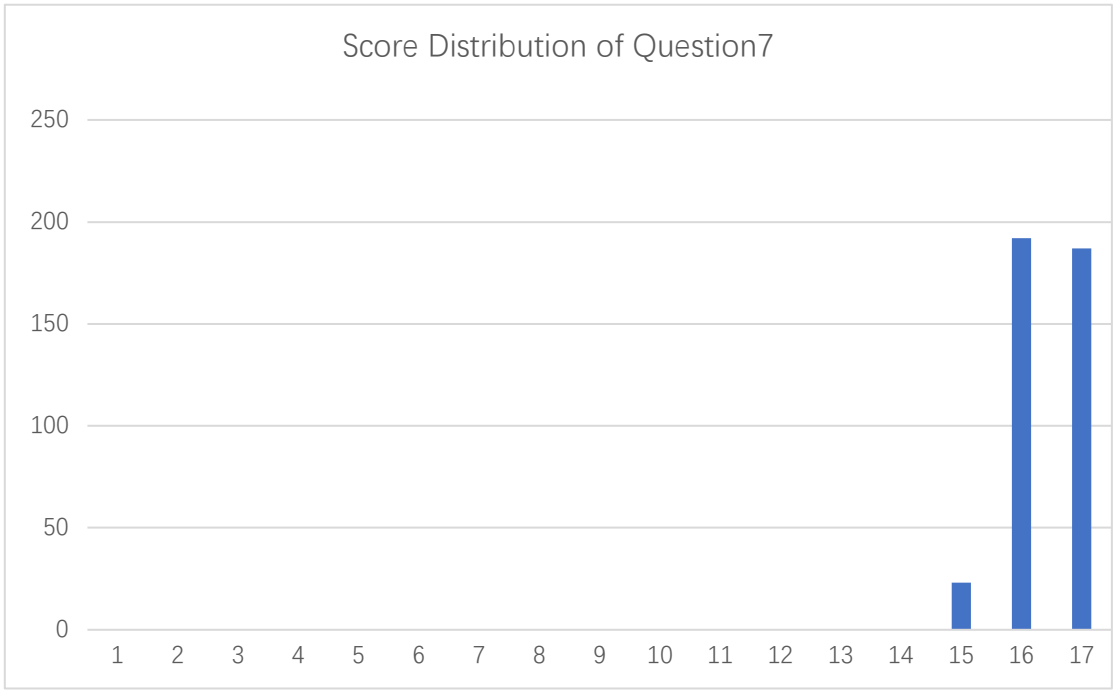

Figure 10 Number of respondents with each score. (Yang Chen, 2018)

The average score of all the respondents is 16.41 with correct rate of 80.85%, which indicates the level of respondents' knowledge about the type of their waste is relatively satisfying. In addition, 387 respondents of 402 knew that the green bin is for 'Organic' and the black one is for 'Others', understanding the current meaning of each color of trash bins.

However, when it comes to how to separate the organic waste, 2 of 402 respondents claimed they knew organic waste was supposed to be kept in biodegradable bags. It signifies that most of respondents do not have sufficient knowledge of correct separating methods.

4.2.4 Degree of Satisfaction of Household Solid Waste Service

The degree of satisfaction of household solid waste service and current criteria of waste separation also have the possibility to influence the behavior of households participating in solid waste management. Thereby, in the survey, there are four questions to investigate them (shown in Table7).

No.	Question
8	Please score the degree of satisfaction of current criteria of solid waste separation

10	Please score the degree of satisfaction of relevant facilities of solid waste separation
11	Please score the degree of satisfaction of collection service of solid waste separation
12	Please score the degree of satisfaction of public education of solid waste separation

Table 7 Questions of Investigating the Degree of Satisfaction. (Yang Chen, 2018)

Satisfaction of current criteria

Since 2017, household solid waste has been requested to separate into two categories: Organic Waste and Others, aiming at accomplishing separation of dry and wet (organic) wastes (Beijing Municipal Commission of City Management, 2017). Also, compared with the previous regulation (2012), this amendment intends to simplify household solid waste segregation activities and enable or increase the separation rate. The previous regulation requests residents separating HSW into three categories: Recyclables, Organic Waste and Organics (SohuNews, 2017).

As the result shows, the average score is 3.35 of 5. Although this score seems to satisfy over half of respondents, if the survey is deeper analyzed, we can find the fact that 73.97% of respondents who scored higher than 3 are who do not have awareness to segregate this household waste. What' s more, 72.45% of aware respondents are not content with current criteria giving scores 3 or less. As for the reasons for dissatisfaction, respondents say the current classification is so rough that they have to mix recyclable waste with others because there is no designated bin for the recyclables, and under this circumstance, the recyclables such as cardboard cannot be kept clean.

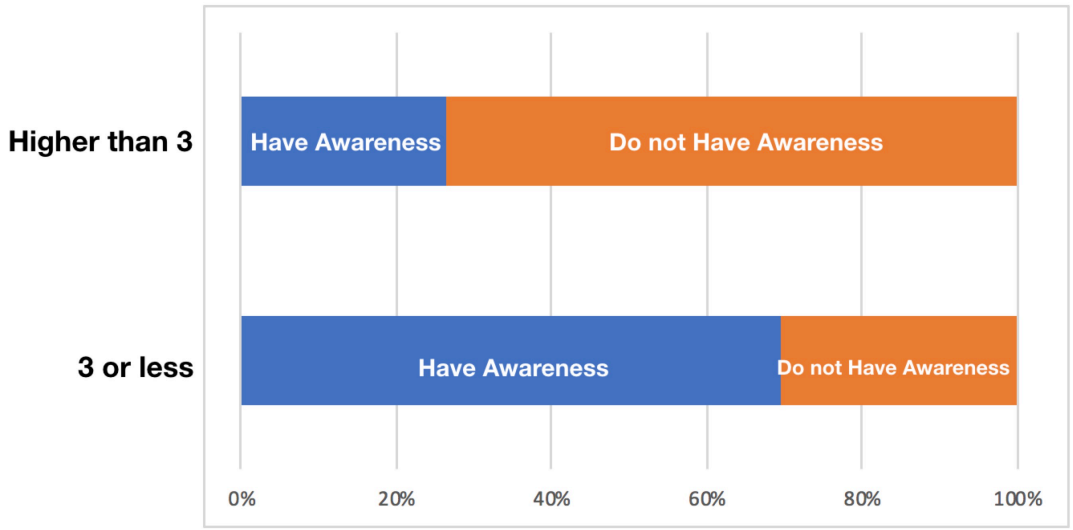

Figure 11 Bar chart of the score of satisfaction of current criteria (Yang Chen, 2018)

Satisfaction of Relevant Facilities

Along with the criteria amending, the original one 'others' bin, one 'recyclable' bin and one 'organic waste' bin have been replaced by two 'others' bin and one 'organic waste' bin in Bailizhuang community and most Beijing's communities. Below is a picture of the dumpsite of household solid waste in Balizhuang community.

Figure 12 A dumpsite in Balizhuang community. (Yang Chen, 2018)

The average score of satisfaction of relevant facilities is 2.70 of 5, which means most of respondents are dissatisfied with the facility. The reasons include: the number of the bins are not enough; the facility and the dumpsite are not organized; there is no 'recyclable' bin, nowhere to dispose recyclable waste. It can be observed from the Figure 10 that in spite of absence of 'recyclable' bin, some respondents still separate recyclables such as cardboards aside.

Satisfaction of collection service

In Balizhuang community, household solid waste is collected 4 times a day, respectively at 7:00~8:00, 11:00~12:00, 13:00~14:00 and 19:00~20:00. The waste collection service is provided by the waste management company and charged per household annually. Figure 13 and Figure 14 show the collection tricycles which transport the waste to transfer station.

Figure 13 Waste Collection Tricycle (1). (Yang Chen, 2018)

Figure 14 Waste Collection Tricycle. (Yang Chen, 2018)

The extra bag at the back of the tricycle in the Figure 14 is used for collecting

recyclables privately, mainly plastic bottles and cardboards which benefit the collectors. But 'Others' and 'Organic Waste' are mixed together in the tricycle again when being collected.

The average score of satisfaction of collection service is 3.25 of 5. The provided service fulfills the basic need of Balizhuang' s households by transporting the trash away following the fixed timetable, otherwise residents would face a trash pile. But there are still reasons for dissatisfaction which can be summarized as follow : ①the collection service is not frequent enough; ②the collecting methods are not in compliance with the waste separation rules; ③the collection facilities and management are outdated. Figure15 shows the aware and unaware respondents' reasons for dissatisfaction of collection service respectively. It is found that there are significant differences among the reasons given these two groups. Reason① is the dominant reason for dissatisfaction for the unaware people. But for aware people, reason ② is the most prevalent one. As a result, it is rational to presume that incorrect collection methods are one of the constraints.

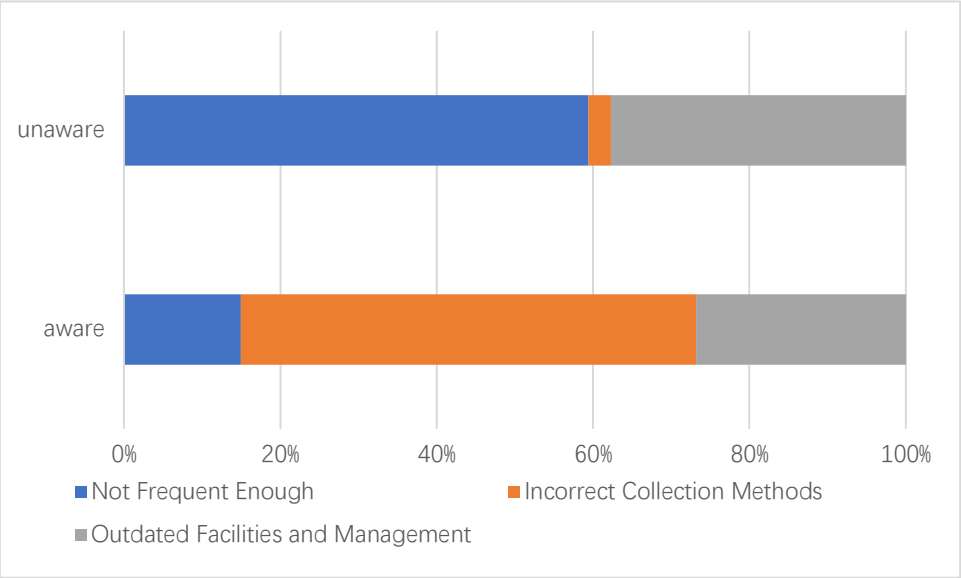

Figure 15 Percentage of Each Reason for Dissatisfaction of Collection Service. (Yang Chen, 2018)

Satisfaction of Public Education of Solid Waste Separation

The main approach to provide information about Solid Waste Separation for residents in Balizhuang community includes: signs near the trash bins, Government' s education propaganda, Internet, Newspaper, School Education,

Communication with other residents and Television. The percentage of each approach is demonstrated in Figure 16. Except 'Signs near to the trash bins', taking up 44%, other approaches are all insufficiently invested or received.

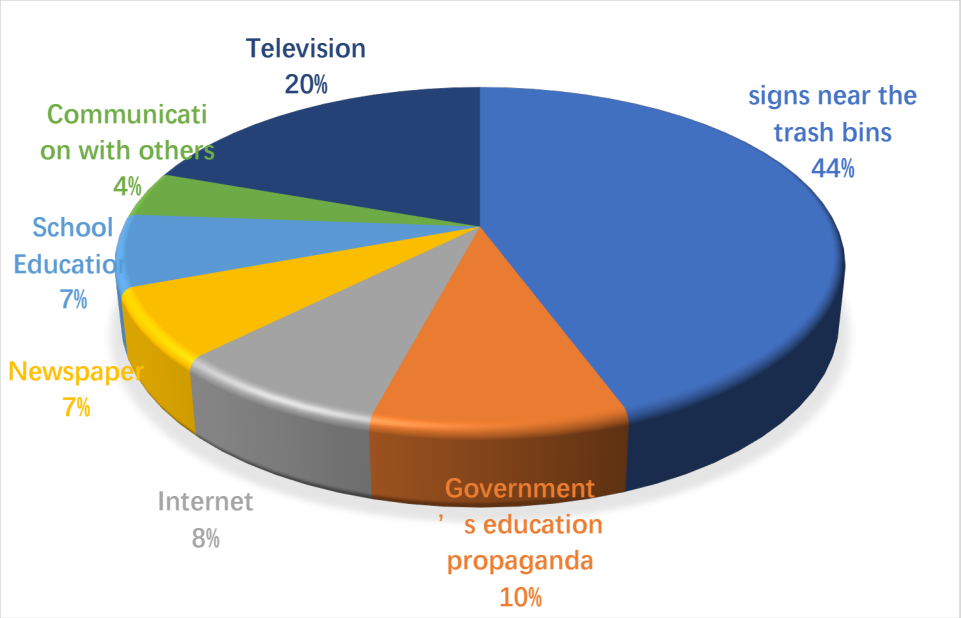

Figure 16 Pie Chart of Approaches to Public Education of Waste Segregation. (Yang Chen, 2018)

The average score of the satisfaction of public education is 2.70 of 5, and this score also indicates that most of the public are willing and expecting more information about waste segregation.

4.2.5 Summary of This Section

In this chapter, by surveys application and observations, the current situation of household participation in solid waste management in Balizhuang community was analyzed.

To explore the challenge of enabling participation of households in solid waste management in Balizhuang community, the public willingness toward participating in SWM, the public knowledge of SWM, the degree of satisfaction of household waste management service including current criteria, relevant facilities, collection service and the public education were investigated. The findings can be summarized as follows:

1. The participation of household in SWM needs urgent improvement, since only 1 out of 402 respondents have the "correct" waste segregation behavior and

53 out of 402 respondents having waste segregation behavior yet with false methods.

2. Although 193 out of 402(48%) respondents have willingness to participate in SWM, only 54 of 193(27.97%) actually did it. Hence, the willingness is essential to be raised and at the same time, finding what prevents the aware respondents to participate is crucial as well.

3. Most respondents are able to distinguish the type of the waste and the type of trash bins, but only 2 out of 402 know the correct way to separate waste.

4. 72.45% of the respondents who have willingness of participation are not satisfied with current criteria, for the reason that current criteria are so rough that recyclables cannot be recycled effectively.

5. The degree of satisfaction from relevant facilities is low as well, acquiring a score 2.70 of 5. Complaints about no 'recyclable' bin and unorganized dumpsite are lodged.

6. In the aspect of collection service, aware respondents complain that the collecting methods are incorrect because 'Organic Waste' and 'Others' are mixed again during the collection in spite they have already separated at home. In addition, outdated collection facilities and management are also unsatisfied points.

7. Public education of SWM is insufficient as well. 'Signs near the trash bins' is the most popular approach, 44% of respondents acquire information about waste separation there, and the rate of other approaches is no more than 20%.

In Table 8 data summarization of the survey is presented.

Question	Result
Have you ever considered to participate in separating your solid waste?	Yes=193(48.01%) No=209(51.99%)
Which categories do you think the following listed wastes belong to?	Score1~4=0(0%), 5~8=11(2.74%), 9~12=56(13.93%), 13~17=335(83.33%)
the degree of satisfaction of current criteria of solid waste separation	Score: 1=19(4.72%), 2=46(11.44%), 3=141(35.07%), 4=167(41.54%), 5=29(7.21%)
the degree of satisfaction of relevant facilities of solid waste?	Score: 1=87(21.64%), 2=111(27.61%), 3=89(22.14%), 4=65(16.17%), 5=50(12.44%)

the degree of satisfaction of collection service of solid waste?	Score: 1=39(9.7%), 2=47(11.69%), 3=161(40.05%), 4=86(21.39%), 5=69(17.16%)
the degree of satisfaction of public education of solid waste separation	Score: 1=25(6.22%), 2=158(39.3%), 3=161(40.05%), 4=30(7.46%), 5=28(6.97%)

Table 8 The Questions and Results of Questionnaires. (Yang Chen, 2018)

Chapter 5 Discussion

Challenges of enabling participation of households in solid waste management in Balizhuang community

From section 4.2, it can be concluded that the number of households' participation in SWM and the quality of their participation are still relatively low in Balizhuang community. In this section, the challenges of enabling participation of households in solid waste management are discussed. According to the results of the survey, 'the participation of households in solid waste management in Balizhuang community' pyramid is shown in Figure 17. The number of respondents of each group decreases and the degree of their participation increases from bottom to the top. In the following contexts, challenges will be discussed bottom-up stepwise, based on this pyramid.

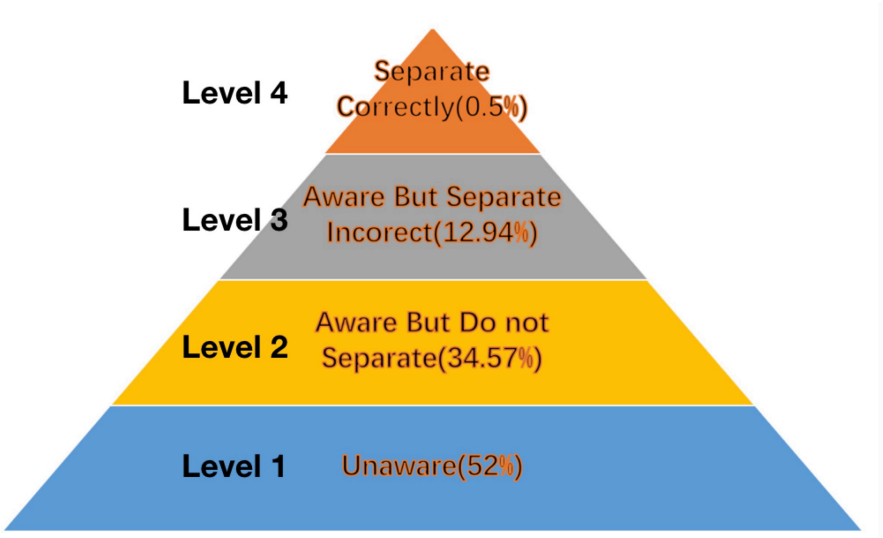

Figure 17 Household Solid Waste Management Pyramid (1). (Yang Chen, 2018)

5.1 Unawareness due to Starting Late

As the findings show, only 48% of respondents have considered to participate in the HSWM, i.e, roughly half of residents in Balizhuang community do not have the awareness to take part in HSWM, the waste separation and reduction.

One of the reasons for the unawareness is that compared with developed countries, China is a late starter for HSWM, so the perception and habit of waste separation have not been developed yet. For instance, Japan, Sweden, Germany and US have started household solid waste separation since last century, lasting over one generation (Cnenergy.org, 2016). Under this circumstance, the older generation teaches the younger by personal examples as well as practical actions. However, Beijing, the capital city just started to popularize separation of the recyclables and non-recyclables for SWM in 2000 and was picked up as one of the pilot cities for household solid waste segregation in 2015 (People.cn, 2017). Therefore, part of residents' perception of participation in HSWM still remains in disposing the waste at designated dumpsites by self-discipline. Indeed, as 4.2.3 shows, senior citizens are more aware than the younger, but most of these old people as part of informal collectors merely separate valuable recyclables for surplus income, which are not in coincidence with current criteria of household solid waste separation.

5.2 Deficient Publicity

Deficient Publicity is a challenge for both residents in Level1 and Level3. For Level1, residents are lack of awareness for this sake. And for Level3, owing to deficient publicity, residents do not have sufficient knowledge to separate correctly. In the following context, the discussion is done in these two aspects.

5.2.1 Unawareness Due to Deficient Publicity

Even though there are instructions and information shown near the dumpsite and in some public areas, still the lack of awareness is observed. In comparison, the relatively more effective approach of popularizing separation of waste is the empirical communication, including communication with family members and staff of governments and NGOs. But, as mentioned above, most of older generation does not have awareness, either. If children can be equipped with awareness of waste separation in schools, they will convey this to their family members. Under this circumstance, the awareness also can be raised from

bottom-up, and children and their parents can both achieve waste separation by mutual supervision. However, currently few schools educate the indispensability of waste sorting, less schools have relevant facilities to nurture this and teachers do not steer students to sort trash neither. Meanwhile, employee education also plays a crucial role in raising awareness and developing habits of waste separation. In workplace, employees are more prone to be engaged owing to the bind of companies' rules and colleagues' mutual supervision. But only a few seem to take part in it. On the other hand, no government staff and volunteers were seen in Balizhuang community. So the limited approach to popularizing waste segregation in Balizhuang community affects the awareness of people to separate the waste. As a result, the lack of dissemination of information and instructions is another challenge.

5.2.2 Insufficient Knowledge Due to Deficient Publicity

In Level 3, there are 12.94% of respondents did separate but in an incorrect manner. The main barrier for these people is the lack of abstract knowledge in waste separation. Separating incorrectly for residents in Level 3 includes the misunderstanding of the concept of organic waste and the wrong container they use for carrying organic waste.

Compared with 'recyclables', 'organic waste' is a relatively new concept for residents. In the past 60 years, people, especially the old, have got used to consider recyclables as valuable and non-recyclables as invaluable, and they do not understand the impact of separating organic waste as they consider organic waste is invaluable and unharmful. Therefore, these aware people pay less attention to organic waste than recyclables. As discussed in 5.2, in spite of the cancellation of 'recyclable' bin, residents still focus on how to cope with recyclable waste, instead why 'organic waste' bins remain and whether they did correctly with organic waste. So, we can say organic waste has not aroused enough attention of residents yet. And the reason for the indifference to organic waste is deficient publicity. It is obligatory for government to disseminate the relevant information to ensure public have been informed, including the how to separate correctly and effectively. Once residents in Level 3 are equipped with sufficient knowledge about the correct manner to sort organic waste, they will

readily upgrade to Level 4, separating correctly.

5.3 Low Level of Implementation and Enforcement

For residents in Level1, low level of implementation and enforcement are is one of the barriers to raise their awareness to separate waste. and for residents in Level2, low level of implementation and enforcement are also the reasons for dissatisfaction of current criteria and waste management service, which leads the aware residents being unwilling to actually segregate the waste.

5.3.1 Unawareness Due to Low Level of Implementation and Enforcement

In spite of the issue of 'Beijing Municipal Solid Waste Management Regulations' in 2010, the level of its enforcement is low(The standing committee of Beijing Municipal People' s congress, 2017). One of the main reasons for ineffective enforcement is that the regulation is not strict enough and the division of the power is not detailed enough so that in spite of the issue of regulation by superior authority, the government offices at lower levels do not raise concern and transfer obligations to each other. In Balizhuang community even throughout Beijing, after the issue of the waste separation regulation, few local authorities, waste management service companies, property management companies and households did carry it out due to the lack of on-site supervision of superior authorities.

Unlike to Beijing, Shanghai, another metropolis in China, where the city hall empowers local neighborhood committees to take responsibility to speed up the work of waste separation, and the superior authority in Shanghai also examines the results periodically(Shanghai.Gov.cn, 2018).

5.3.2 Dissatisfaction Due to Low Level of Implementation and Enforcement

No staffs from government and waste management companies disseminate the information about waste sorting regulation. Some residents do not understand what the advantages of current criteria compared with the old ones are, how the sorted waste is treated and why the 'recyclables' bins are canceled. Thereby, their dissatisfaction and misunderstanding about criteria cannot be resolved.

On the other hand, waste management companies do not procure or update relevant waste collecting facilities by self-discipline, so the tricycles still collect

and transfer all the waste together, and the number of 'others' bins cannot meet the demand, resulting in residents misusing 'organic' bins as 'others' bins.

When it comes to enforcement, no indications of enforcement were observed. No enforcement division means none supervise the behavior of residents, collectors and waste treatment companies. However, guide and supervision is necessary for households in the beginning phase to develop and standardize their waste sorting behavior and remind them of separating. For waste collectors, without supervision and regulatory bind, it is not uncommon to find them lack of taking shortcut to finish work, collecting all waste at one time (mixing the organic waste and 'others' waste). Due to lack of enforcement, waste treatment companies do not administrate the collectors strictly and not update the relevant facilities (trash bins, collecting vehicles, processing treatment plants et al.) timely.

5.4 Lack of Incentive and Penalty

Currently, what Beijing's government implements most is appealing, but solely appealing will not inject impetus to residents' willingness of waste separation. It is financial and statutable incentives and penalty that raises households' awareness and willingness more effectively. However, in Bailizhuang community, no respondents claimed them ever heard it and during the observation, no relevant facilities existed.

Incentives have been in practice among Chinese cities such as Shanghai, Wuhan, Yangzhou and so on. In some communities of these cities, every time residents dispose their organic waste in correct bins, they will earn some credits which can be a redemption of some daily necessities afterward. Penalty for waste separation has also been activated in some developed countries for decades, such as Hong Kong and Japan (South China Morning Post, 2017; mydrivers.com, 2016).

Penalty and incentive are both economical regulation strategies. One of the reasons why penalty is effective is that penalty associates waste sorting with inviolability, being a kind of harsher hint than appealing for unaware residents. The behaviors in the regulations are highlighted as correct. By the same reason, incentive or subsidy can guide residents' behavior to some extents. Without

them, currently waste separation is left with self-discipline, losing two effective triggers.

At the same time, Penalty for level 2, the aware residents, is more like a deterrent to make them adhere to the regulation or a conciliation that punishes the unaware and eliminates the dissatisfaction of the nuisance to public waste infrastructure.

5.5 Fixed Waste Management Fee

According to the investigation, in Balizhuang community, households pay €3.76 annually for household solid waste transportation and €0.376 monthly for household solid waste management, and this charging rate has not been adjusted since 1999. Additionally, this charging method is fixed so it will not fluctuate with the amount, separation method and the type of waste

The fluctuated waste management fee has been adopted in many cities, such as Hong Kong, Seoul, New York (South China Morning Post, 2017; Research Office Legislative Council Secretariat, 2017 & Abrashkin, 2015). Residents in these cities are obligated to buy designated plastic bags for their household waste, which is actually a mandatory quantity-based charging scheme on HSW.

The non-differential charging method results in residents not paying attention to the quantity and the disposal method. Waste producers do not need to pay extra money for more garbage, thereby even aware residents easily abandon waste sorting.Conversely, if charged by quantity, households would be more prone to reduce the amount of their HSW; if charged by the disposal method, households would tend to be conscious of what is correct or government-recommended method is.

On the other hand, waste management fee is one of the main sources of income for waste management companies. But because of current charging method, waste management companies can hardly make margins to fulfill the cost for updating waste sorting facilities, to pay its staff for more frequent collection service or employ more staff, to update the monitoring system to avoid mixed collection which also can be regarded as a challenge for residents in Balizhuang community.

5.6 Summary of Chapter 5

In chapter 5, challenges of enabling participation of households in solid waste management were discussed based on Household Solid Waste Management Pyramid showed in Figure 17. On the whole, the most restrictive challenge for each level to upgrade to its upper level is various: From level 1 to 2, it is awareness that distinguishes these two groups; From level 2 to 3, the satisfaction of current criteria, waste management service restrict the aware residents putting their perception of separation HSW in practice; From level 3 to 4, due to the incomprehensive knowledge of HSWM, aware residents segregate their HSW in a false manner.

To be more concrete, in each section, the triggers of challenges are discussed respectively (see Figure 18). Triggers for Level 1 are starting late, deficient publicity, low level of implementation and enforcement, lack of incentive and penalty, and fixed waste management fee; triggers for Level 2 are low level of implementation and enforcement, fixed waste management fee and lack of incentive and penalty; the trigger for Level 3 is deficient publicity. In addition, the triggers for each level decrease progressively and overlap. As a result, triggers can be summed up as starting late, deficient publicity, low level of implementation and enforcement, lack of incentive and penalty, and fixed waste management fee.

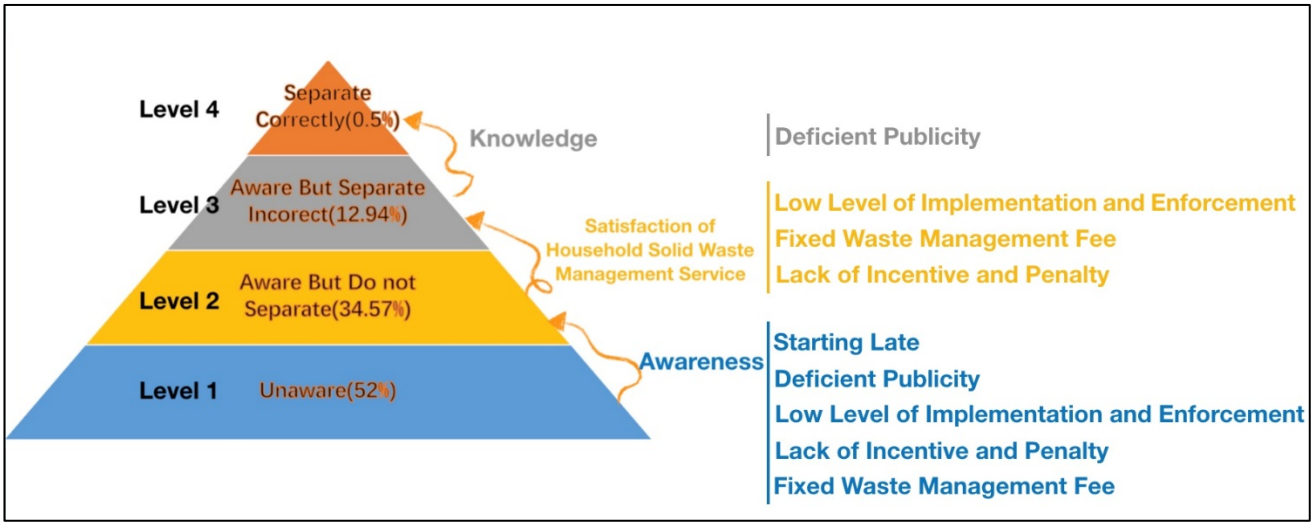

Figure 18 Household Solid Waste Management Pyramid (2). (Yang Chen, 2018)

Chapter 6 Conclusion and Recommendation

In this chapter, first the conclusions of findings and discussion are made and then recommendations for enabling participation of households in solid waste management are proposed based on the challenges identified in chapter 5.

6.1 Conclusion

During the research, desk research, surveys and observations were carried on to answer the research questions. By desk research, the linkage(s) between household participation in SWM and circular economy has been proven in chapter 4. That is positive household participation in SWM can contribute to circular economy transition. Positive household participation embodies as reduction of the amount of HSW and the segregation of HSW. Not only less raw material is going to be consumed before the stage of waste generation, but also the efficiency of waste recovery is lifted at the phase of waste management. In this way, all the materials are circulated in the value chain as possible and more value is developed. Therefore, current linear economy can transfer to a circular mode progressively.

Through the survey and direct observations in Balizhuang community, the current situation of household participation in SWM was identified. First, over half of the residents in Balizhuang community do not have the awareness to participation in SWM. They never considered to sort the waste. Second, almost one of third of the residents do have the awareness, however, they are not willing to participate. Their reasons can be summarized as dissatisfaction with waste management service and current criteria of waste separation principle. Third, although there are a few residents do actually separate household waste, few of them did it in a correct manner. As a result, we can conclude that the participation of household in SWM needs urgent improvement.

Based on these findings, the challenges of enabling households' participation in SWM in Balizhuang community were discussed. There are mainly four constraints stiffing the participation, which are respectively deficient publicity, irrational charging method, lack of incentives and weak implementation and enforcement of policies. In the next section, some recommendations are proposed to break these challenges.

6.2 Recommendations for Practitioners

6.2.1 Recommendations for Deficient Publicity

For both residents in Level 1 and 3, deficient publicity is a restriction. Although there are differences within these two groups, but it can be concluded as rising willingness and propagandizing abstract knowledge of waste separation. These two aspects can be ameliorated by following recommendations:

1. Hold more community events about household waste separation. More residents will be involved effectively in this way, especially the retired and the elder. Not only the abstract information will be spread by face-to-face communication, but the doubts will also be broken such as the value of separating organic waste and why current criteria cancel the 'recyclables' bins. Further, door-to-door meetings can be given by these Level 4 residents in the community. Mostly information provided by people within the same neighborhood is more accurate, understandable and easily accepted.

2. Activities about waste separation also should be held in schools for educating students. A school is a place where students make high concentration, so knowledge about waste separation will be absorbed more effectively. Furthermore, a school is also a place where students nurture their habits, so after being educated, students can also cultivate the habit of waste separation there by duplicating waste separation behavior daily. In addition, back to home, students' willingness and behavior also affect their family members from bottom-up. As a result, the circle of participation in waste separation is widened.

3. Employee education of participation in solid waste management should be provided at workplaces. Workplace is a good occasion to equip residents with abstract knowledge and shift their behavior as employees are mandatory to abide by rules and are willing to leave colleague good impression. Therefore, if there are rules that require employees sort their waste, employees will be forced to be compliant. After that, these employees will possibly continue this habit when back to communities and drive family members at the same time.

4. Knowledge of organic waste should be emphasized particularly. As discussed, most residents have sufficient knowledge of organic waste. Residents are not only supposed to identify what organic waste is, but also what the impacts of

organic waste on healthy and environmental issue and how to sort it correctly. By these, the willingness is raised and the correct separation behavior is guaranteed.

6.2.2 Recommendations for Charging Method

The existing charging method of household solid waste, fixed management fee charged by per household, should shift to charging by quantity. Referring to experience of Japan' s household solid waste management charging system, charging by quantity has successfully reduced the amount of waste and separated the waste at source. Moreover, residents in Japan and China are in the similar living condition, communities of high density and most citizens living in apartments.

More specifically, charging by volume means residents are mandatory to buy designated bags for each type of household solid waste. To inspire residents to separate organic waste, the bag for organic waste can be cheaper than the bag for 'others', but in this condition, the contents need to be checked carefully to ensure two types of waste are not mixed with each other. In Japan, designated bags are transparent for checking. The money residents pay for bags is also another source of income for solid waste management companies, which can be used for enabling the service.

6.2.3 Recommendations for Incentive and Penalty

Penalty should be laid on the residents, collectors and waste management companies who are not in compliance with waste separation regulation. As mentioned in 5.1.4, Hong Kong, Den Haag, Japan and Malaysia all lay penalties to residents who are not in compliance with household solid waste management rules in different extents to alarm residents. For China, a country still takes baby step in this field, the penalty is not only an alarm, but also a sign that convey the correctness of waste separation at source.

Laying penalty on noncompliant residents will put an end on misusing the trash bin and compelling residents participating in separating household solid waste; Imposing penalty on noncompliant collectors can cut down the mixed transportation of two types of waste; Fining infringing waste management companies will strengthen supervision and promote waste management

standardization.

Not only penalty, but also financial incentives and extrinsic motivation should be also proposed. As mentioned in 5.1.4, in Shanghai, Wuhan, Yangzhou residents are rewarded with credits each time they dispose organic waste in correct manner, and the credits can redeem some daily necessities. There is also another motivation method in Shanghai. In Meilongsancun, the community corporates with nearby farms to facilitate waste separation. The nearby farms produce organic agriculture products by organic waste collected in Meilongsancun community and in return, residents can buy these organic products with credits which are earned from disposing organic waste into designated organic waste grinders in the community (www.cn-hw.net, 2018). These mechanisms can be tested in Beijing as well.

6.2.4 Recommendations for Implementation and Enforcement

Decentralize the power to low level institutions to nail down their respective responsibilities and establish an accountability system involving each level. In this way, residents' separation behaviors, collectors' transportation process and the service of waste management companies will be supervised by superior institutions or supervisory agencies. Therefore, every procedure in the household solid waste management chain is traceable and their responsibilities are no longer able to be dodged. In addition, local communities can also play a crucial part by setting up community-based association comprised by the elder. The elder are more aware than others and more acquainted to the neighborhood so that they know how to fit the regulation in their community and how to inspire and supervise their neighbors.

6.3 Recommendations for Further Research

Owing to the limitation of research time, this research is not comprehensive and profound enough. For further research, here are some recommendations.

To lift the level of profundity, further researches are recommended to focus one of the challenges mentioned in chapter 5 and study it deep. When it comes to deficient publicity, researchers are advised to investigate the feasibility and effectiveness of holding events of propagandizing waste separation in other

cities through case studies. In aspect of charging methods, researchers are suggested to explore the most reasonable charging rate of dumping HSW for local citizens. For incentive and penalty, it is crucial to find out the rational penalty and incentive rate. Otherwise, it is possible that excessive penalty increases the living burdens and light incentive is neglected by local citizens. In terms of implementation and enforcement, the proper method to divide the whole HSWM work is important to accomplish HSWM effectively and efficiently. But in this research, this proper method was not proposed in detail.

6.4 Summary of chapter 6

Recommendations of four aspects are proposed in this chapter covering deficient publicity, charging method, penalty and incentive, and implementation and enforcement. By these recommendations, not only interior factor, residents' ability, is improved, but also the exterior factors are also improved. Consequently, enabling participation of households in solid waste management in order to achieve high recovery rates will be achievable.

Reference

Abrashkin, John. "Volume-Based Waste Fee (VBWF): Effect on Recycling and Applicability to New York City." *Columbia University*, 2015.

Ahmadi M (2017) Evaluating the Performance of 3Rs Waste Practices: Case Study-Region One Municipality of Tehran. Adv Recycling Waste Manag 2: 130. doi:10.4172/2475-7675.1000130

Akil, A., & Ho, C. (2014). Towards sustainable solid waste management: Investigating household participation in solid waste management. *Iop Conference Series: Earth and Environmental Science, 18*, 012163-012163. doi:10.1088/1755-1315/18/1/012163

Ba Li Zhuang School District Management Center, Haidian District, Beijing. (2016). Haidian District Balizhuang School District Introduction. Retrieved from hdblzxq.com/Article/ShowArticle.asp?ArticleID=1.

Beijing Municipal Bureau of Statistics. (2017). Beijing regional statistical year book 2017. Retrieved on February 22, 2018, from http://www.bjstats.gov.cn/nj/qxnj/2017/zk/indexch.htm/

Beijing Municipal Commission of City Management. (2017). Domestic waste classification. Retrieved on August 6, 2018, from http://csglw.beijing.gov.cn/hjwsbz/ztzl/shljfl/#/

Carol, V. C. M. (2017). The Nexus between Circular Economy and Climate Change Mitigation Policies in Small and Medium-sized Dutch Cities (master's thesis). University of Twente, Leeuwarden, The Netherlands.

Chandrappa, R., & Das, D. (2012). *Solid waste management: Principles and practice* (Environmental science and engineering, environmental engineering). Berlin: Springer. doi:10.1007/978-3-642-28681-0

China Economic Net. (2013). Beijing: Why the garbage classification is not effective. Retrieved from http://www.ce.cn/cysc/ny/gdxw/201309/29/t20130929_1567879.shtml/

Chinacourt.org. (2018). Difficult to promote garbage classification experts: people need to regulatory constraints and other sectors. Retrieved from https://www.chinacourt.org/article/detail/2018/01/id/3195701.shtml/

China Association of Urban Environmental Sanitation. (2017). 60 Years of Road Reconstruction and Model Reconstruction in China's Garbage Classification. Retrieved from http://www.cnues.com/article/394/

China Daily. (2015). The first batch of 26 types of municipal garbage classified demonstration cities (districts) were published. Retrieved from http://www.chinadaily.com.cn/interface/toutiao/1120781/2015-4-30/cd_20589200.html/

Cnenergy.org. (2016), What are the countries in the world where the waste is classified to the extreme. Retrieved from http://www.cnenergy.org/hb/201607/t20160729_345474.html

Danny, C. (2016). Municipal Solid Waste in a Circular Economy Perspective: A Case Study of Lusaka City in Zambia (master' s thesis). Swedish University of Agricultural Science, Uppsala, Sweden.

David, M., Jak, F., & Rolph, H. (2018). Waste sorting plants: Extracting value from waste. International Solid Waste Association.

David, W., Ljiljana, R., Prasad, M., Reka, S., Ainhoa, R., Costas, V., Mona, I., & Otto, S. (2015). Global Waste Management Outlook. United Nations Environment Programs.

Ellen MacArthur Foundation, (2015). Towards a Circular Economy, Brussels: Ellen MacArthur Foundation.

Elison, S., (2017). Participation of Household in Solid Waste Management and Circular Economy toward Sustainability: A Case Study of Kabwe Town, Central Province of Zambia (master' s thesis). University of Twente, Leeuwarden, the Netherland.

Free Malaysia Today. (2016). Enforcement of waste separation law starts today. Retrieved from http://www.freemalaysiatoday.com/category/nation/2016/06/01/enforcement-of-waste-separation-law-starts-today/

Geng, Y., & Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving leapfrog development'. *The International Journal of Sustainable Development & World Ecology*, *15*(3), 231-239.

Global Methane Initiative. (2012. 9). An Overview of Community Participation in Solid Waste Management. Retrieved from https://globalmethane.org/documents/events_land_120910_27.pdf/

Hua, Z., & Zongguo, W. (2014). Residents' household solid waste (HSW) source separation activity: A case study of Suzhou, china. *Sustainability, 6*(9), 6446-6466. doi:10.3390/su6096446

International Solid Waste Association. (2018). Waste sorting plants: Extracting value from waste. The Netherlands: David, M., Jak, F., & Rolph, H.

Law Info China. (2008). Circular Economy Promotion Law of the People's Republic of China. Retrieved on February 22, 2018, from http://www.lawinfochina.com/display.aspx?id=7025&lib=law/

Lei, Y., Zhenshan, L., & Huizhen, F. (2011). Model of municipal solid waste source separation activity: A case study of beijing. *Journal of the Air & Waste Management Association (1995),61*(2), 157-63.

Malik, N., Abdullah, S., & Manaf, L. (2015). Community participation on soli d waste segregation through recycling programmes in Putrajaya. *Procedia E nvironmental Sciences, 30*, 10-14. doi:10.1016/j.proenv.2015.10.002

Maryati, S., Arifiani, N., Humaira, A., & Putri, H. (2018). Factors influencing household participation in solid waste management (Case study: Waste bank malang). *Iop Conference Series: Earth and Environmental Science, 124*, 012015-012015. doi:10.1088/1755-1315/124/1/012015

Ministry of Environmental Protection of the People' s Republic of China. (2017). 2017 Annual Report on Prevention of Environmental Pollution from Solid Waste in Large and Medium Cities in China. Beijing, China.

Minn, Z., S. Srisontisuk & W. Laohasiriwong. (2010). Promoting People' Participation in Solid Waste Management in Myanmar. *Research Journal of Environmental Sciences, 4: 209-222.* DOI: 10.3923/rjes.2010.209.222

Mydrivers.com. (2016). The matter of garbage sorting: driving countless Chinese in Japan crazy. Retrieved from http://news.mydrivers.com/1/493/493026.htm

National Academy of Development and Strategy of Renmin University of C hina. (2015). Management Status Assessment of Municipal Solid Waste in C hina. Beijing, China: Guojun, S.

Oberlin, A. S. (2011). The Role of Households in Solid Waste Management in East Africa. 4th ed. Waganingen: Waganingen Academic Publishers.

People.cn. (2017). Beijing waste separation implementation will be introduce d in the future to implement a waste classification system. Retrieved from http://politics.people.com.cn/n1/2017/0807/c1001-29452823.html/

People.cn. (2017). Jiangsu: Official Implementation of the Classification of D

omestic Waste. Retrieved from http://legal.people.com.cn/n1/2017/1101/c42510-29620059.html/

Research Office Legislative Council Secretariat. (2017). Separation and collection of household waste in selected places. Retrieved from https://www.legco.gov.hk/research-publications/english/1617in08-separation-and-collection-of-household-waste-in-selected-places-20170320-e.pdf

Rotich, H. K., Yongsheng, Z. & Jun, D., (2006). Municipal solid waste management challenges. Waste Management, 26(1), pp. 92-100.

Sasikumar, K., & Krishna, S. G. (2009). *Solid waste management*. PHI Learning Pvt. Ltd.

Sina. (2017). The rate of harmless treatment of domestic garbage in built-up areas in Tianjin will reach 100% by 2020. Retrieved from http://tj.sina.com.cn/zimeiti/2017-12-26/detail-ifypyuvc3583885.shtml/

Shanghai.gov.cn. (2018). Shanghai Domestic Waste Classification Assessment Method was released. Three echelons were used to achieve full coverage of the city's garbage classification. Retrieved from http://www.shanghai.gov.cn/shanghai/node2314/node2319/n31973/n31991/u21ai1308645.shtml/

SohuNews. (2017). Beijing Domestic Waste will push the limit discharge to dry and wet separation and recovery mode this year. Retrieved from http://news.sohu.com/20170322/n484271028.shtml/

SouthChinaMorningPost. (2017). There is broad agreement about the need for residents to pay for rubbish disposal, but are the charges high enough to persuade the city to change its wasteful ways? And can the system be enforced effectively? Retrieved from http://www.scmp.com/news/hong-kong/health-environment/article/2091181/hong-kong-prepares-next-battle-its-war-waste

SouthChinaMorningPost. (2017). Waste disposal charge will cost a typical H ong Kong family HK$51 a month. Retrieved from https://www.scmp.com/ne ws/hong-kong/health-environment/article/2080508/11-cents-dump-1-litre-tra sh-hong-kong-government#comments

The standing committee of Beijing Municipal People' s congress. (2017). Re port on the Implementation of the "Management of Municipal Solid Waste in Beijing" (written). Retrieved from http://www.bjrd.gov.cn/zdgz/zyfb/bg/20 1710/t20171009_176715.html/

The State Council of The People' s Republic of China. (2017). Beijing garba ge disposal rate of 60% still exist "Mix after Separation" and other phenom ena. Retrieved on February 22, 2018, from www.gov.cn/shuju/2017-05/26/co ntent_5197127.htm/

The World Bank. (2017). Solid Waste Management. Retrieved from http://w ww.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management/

Tsai, T. (2008). The impact of social capital on regional waste recycling. *Sus tainable Development, 16*(1), 44-55. doi:10.1002/sd.326

United Nations Environment Programme. (2017). Highlights Asia Waste Man agement Outlook. Nairobi, Kenya.

www.cn-hw.net. (2018). How do residents' kitchen waste disposal open up the "circulating chain" ? Successful experience of a Shanghai community. Retrieved from http://www.cn-hw.net/html/china/201803/61112.html.

Yu, S. (2017). Investigation on Physical Composition of Domestic Garbage i n Beijing and Analysis of Calorific Value, 2017(8), 112-115.

Yu., W. (2017). Determinants of urban residents' recycling behavior: A cas e study of 8 demonstration cities (Master thesis). Retrieved from http://kns.

cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD201801&filename=1017075898.nh&v=MTM0NDM2R2JPL0c5bkZwNUViUElSOGVYMUx1eFlTN0RoMVQzcVRyV00xRnJDVVJMS2ZaT2RyRml6bFZyL09WRjI=/

Yuan, Y., & Yabe, M. (2015). Residents' preferences for household kitchen waste source separation services in Beijing: A choice experiment approach. / *nternational Journal of Environmental Research and Public Health,12*(1), 176-190. doi:10.3390/ijerph120100176

Ying, Z., Songwei, W., Yunlong, W., Weixiang W., & Yingxu, C. (2008). Source separation of household waste: A case study in china. *Waste Management, 28*(10), 2022-2030. doi:10.1016/j.wasman.2007.08.012

Yuan, Z., Bi, J., & Moriguichi, Y. (2006). The circular economy: A new development strategy in China. *Journal of Industrial Ecology*, *10*(1-2), 4-8.

Zhaoxi, Z., Bingxue, S., & Qingtao, W. (2013). "A Literature Review on the Research of Circular Economy-Based Green MICE." *Advanced Materials Research*, vol. 616-618, 2012, pp. 1615–1619., doi:10.4028/www.scientific.net/amr.616-618.1615.

Appendix 1 Survey

Dear Sir/Madam,

I am a Master student at the University of Twente and I am conducting this survey as part of my master thesis to assess how the current situation of household participation in solid waste management in Haidian district.

The traditional linear model, "take-make-dispose", is based on exploitation of real resources. To halt the trend of exhausting nature resources and shift to a sustainable development, the concept of "Circular Economy" has been proposed. Circular economy aims to rely on renewable energy, minimizes the use of toxic chemicals and eradicates waste. Solid waste is one of the most important parts in this value loop, being of magnificent quantity, potential hazards and yet unemployed value. My research, based on household level, aims to activate the power of households to contribute to the transition of our countries toward circular economy.

My study first assesses the level of household participation in solid waste management and then makes some recommendation to this circular transition according the current circumstances.

Your participation will be anonymous and will be done by completing this survey, which will take between 5-10 minutes to be completed. The surveys will be used for the purpose of the study only.

Thank you!

1. Gender?
   A. Male B. Female
2. Age?
   A. 17 or younger
   B. 18-25
   C. 26-35
   D. 36-
   E. 60 or older

3. Education level?
    A. High school or less
    B. Bachelor
    C. Master or more
4. Income level?
    A. 5000 RMB/month
    B. 5000-10000 RMB/month
    C. 10000-20000 RMB/month
    D. 20000 or more RMB/month
5. Have you ever visited a solid treatment plant?
    A. Yes
    B. No
6. Have you ever considered to participate in separating household solid waste?
    A. Yes.
    B. No.
7. Which categories do you think the following listed wastes belong to?

	Organic solid waste	Others
Old clothes		
Fruit peels		
Broken bowls		
Light Bulbs		
Dust		
Old toys		
Toilet paper		
Expired food		
Newspaper		
Flowers		
Bread		
Shampoo bottle		
Cardboard		
Wine bottle		
Plastic bags		

Eggshell		
Leftovers		

8. Please score the degree of satisfaction of current criteria of solid waste separation? (1-5, 1 means very unsatisfied and 5 means very satisfied)

9. What are the reasons for your dissatisfaction if you are not very satisfied?
   A. Poor execution
   B. The criteria are too rough
   C. There are overleaps in the criteria.
10. Please score the degree of satisfaction of relevant facilities of solid waste separation? (1-5, 1 means very unsatisfied and 5 means very satisfied)
11. Please score the degree of satisfaction of collection service of solid waste separation? (1-5, 1 means very unsatisfied and 5 means very satisfied)
12. Please score the degree of satisfaction of public education of solid waste separation? (1-5, 1 means very unsatisfied and 5 means very satisfied)
13. In the real life, when you throw garbage, which trash bins do you use for listed wastes?

	Organic solid waste	**Others**
Old clothes		
Fruit peels		
Broken bowls		
Light Bulbs		
Dust		
Old toys		
Toilet paper		
Expired food		
Newspaper		
Flowers		
Bread		
Shampoo bottle		
Cardboard		
Wine bottle		

Plastic bags		
Eggshell		
Leftovers		

14. Where do you usually acquire information about household solid waste separation?
    (support multi-choices)
    A. The signs on the trash bins
    B. Government/NGO’ s education propaganda
    C. Internet
    D. Newspaper
    E. School education
    F. Communication with families, friends and neighbors
    G. Television
15. What is the charging method of household solid waste management in your neighborhood?
    A. By household
    B. By the quantity of waste
    C. Included in the property management fee
    D. No charge
    E. I don’ t know.
16. Are there incentives for household’ s participation in solid waste separation in your neighborhood?
    A. Yes, there are incentives for reward.
    B. Yes, there are incentives for punishment.
    C. Neither rewards nor punishment.
    D. I don’ t know.
17. Which factors do you think challenge your participation in sorting the household solid waste?
    (support multi-choices)
    A. The criteria of sorting household solid waste are irrational.
    B. The number of trash bins is irrational.
    C. The locations of trash bins are irrational.
    D. The neighbors don’ t sort.

E. The sorting behaviors are on vain because although I have sorted in advance, finally all the solid wastes are mixed with each other when they get collected and transported.
F. Government doesn’ t make enough efforts to conduct propaganda.
G. Relevant laws and regulations are not comprehensive enough.
H. I don’ t know how to sort these solid wastes.
I. The solid management of relevant municipal authorities is lagging behind.