MASTER THESIS

TOWARDS A CIRCULAR ECONOMY - HOUSEHOLD PARTICIPATION IN SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT IN CHENGDU, CHINA.

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ABSTRACT

This study is about the household participation in municipal solid waste management in Chengdu, China. The study focuses on identifying the level of waste sorting and the practice of the 3Rs (Reduce, Reuse and Recycle) principle in households, as well as the perceived factors and difficulties that influence household participation in local municipal solid waste management. In this study, a range of theories on municipal waste management, sustainable waste management, circular economy and household participation are reviewed.

The objectives of this study are to identify the current situation of municipal solid waste management in Chengdu, China, and the level of household participation in local municipal solid waste management; thereby to explore approaches for improving household participation to develop the sustainability of local municipal solid waste management. In this research, a survey is implemented to identify the current situation of household participation in local municipal solid waste management, as well as perceived factors and difficulties that influence households' participation behavior. The desk research is implemented as well to validate the empirical data. It is found that the local municipal solid waste management and the level of household participation cannot be considered sustainable enough. The main difficulties of the current household participation in local waste management that are identified include the lack of technical facilities for waste sorting, low level of public awareness and in-adequate social activities regarding waste management. Recommendations to overcome them are proposed at the end of this study.

Keywords: Municipal Solid Waste Management, Sustainable Waste Management, Circular Economy, Household Participation.

CHAPTER 1 INTRODUCTION

In this section, the background and some related information of this research project are briefly introduced.

1.1 BACKGROUND

Municipal solid waste management (MSWM) has always been a concern, especially in developing countries. In contrast to traditional solid waste management focused on waste treatment, *Lansink (1979)* proposed the hierarchy of waste management that emphasizes the maximum use of materials and the minimum generation of pollutants throughout the waste management process. In 1987, Brundtland commission published the *'Our Common Future'* report, which created the concept of sustainable development for the environmental concerns. Sustainable waste management involves the *Reduce*, *Reuse* and *Recycle* of waste materials, which is also known as the *"3Rs principle"*.

Nowadays, with the growth of population and urbanization process, the amount of wastes generated is rapidly increasing, putting a significant burden on the waste disposal process. The available land for landfills is decreasing and large amounts of greenhouse gases are emitting through incineration process, which also cause serious environmental problem such as leachate leakage, harmful emissions and water contamination *(Ghosh & Hasan, 2011)*. As the situation becomes more and more critical, sustainable waste management has been treated as an expected solution to the problems. For many developed countries, such as Germany and Japan, sustainable waste management practices have significantly mitigated the burden of waste disposal, such as the availability of land for landfills and subsequent environmental problems *(Janya Sang-arun et al., 2014)*. And the practice of the 3Rs principle can also contribute to the transition from the existing linear economy to a circular economy in a country *(Masaru Tanaka, 2014)*.

In order to develop sustainable waste management in a country, households can make a great contribution through their participation, such as sorting out waste, practicing the 3Rs principle in daily life, and participating in clean-up campaigns and educational programs, etc. The scale of public participation in municipal solid waste management varies significantly between developing and developed countries. Households in developing countries view municipal solid waste management as a public service without extra charges, and ignore their responsibility for environmental protection and contribution to local municipal waste management *(Bournay, 2006)*. In addition, for many developing countries, local governments lack the financial and human resources to develop municipal waste management. Households' participation can provide this needful human resource, thereby mitigating the financial burden on local municipalities, and their involvement in local municipal solid waste management can enhance their sense of responsibility for maintaining such public services *(Cotton et al., 1998; Colon*

& Fawcett, 2006).

1.2 PROBLEM STATEMENT

In recent years, China is facing municipal waste management problem and is exploring ways to improve the sustainability of existing municipal waste management systems. According to *Zhujie Chu et al. (2016),* due to the inadequate level of municipal solid waste sorting collection, which affects subsequent treatment processing, China is facing municipal household solid waste problem and its subsequent environmental impact. Household participation is treated as an expected solution to these problems. Therefore, to explore the possible approaches to develop sustainable municipal solid waste management through household participation, in this research, Chengdu - one of the metropolitan areas in relatively good municipal solid waste management condition, is chosen as a case study.

1.3 RESEARCH OBJECTIVES

The objectives of this research project are to investigate the current situation of household participation in municipal solid waste management in Chengdu, China and thereby to explore approaches for developing the sustainability of local municipal solid waste management at household level. To reach these research objectives, a series of theories related to municipal solid waste management and household participation are studied firstly. Subsequently, a survey process and desk researches are carried out to identify the current situation of local municipal solid waste management, waste sorting collection and the 3Rs (Reduce, Reuse and Recycle) principle practice at household level, as well as the people's perception of factors and difficulties that influence their participation behavior. Based on that, some recommendations are proposed for improving the sustainability of local municipal solid waste management at the end of this study.

CHAPTER 2 LITERATURE REVIEW

This section is dedicated to introduce theories on municipal solid waste management, sustainable waste management, circular economy and household participation. Based on relevant literature, some situations of waste management in different countries are discussed as well.

2.1 MUNICIPAL SOLID WASTE AND HOUSEHOLD WASTE

The definition of municipal solid waste (MSW) varies from country to country, reflecting diverse waste management practices (*European Environment Agency, 2013*). According to the definition made by *Eurostat (2018)*: *"municipal solid waste consists of waste collected by or on behalf of municipal authorities, or directly by the private sector not on behalf of municipalities, such as business or private non-profit institutions"*. It is mainly produced by households, but similar waste from commerce, offices and public institutions are also included. It includes bulky waste but excludes waste from municipal sewage networks and municipal construction and demolition waste *(Eurostat, 2018)*.

In China, the definition of MSW is relatively different. According to the '*Classification of municipal solid waste generated source and discharge*', municipal solid waste includes household waste, cleaning waste, landscape waste, commercial service site waste, business offices waste, medical waste, transport and logistic waste, construction and demolition waste, industrial waste and others. And according to *Lijun Zhao (2009)*, household waste is the waste produced from residents in their daily lives, it accounts for about 60% of total MSW generation in China and mainly consists of organic, paper, plastic, glass, textile, metal and others.

According to *Yuanyuan Ban (2017)*, the annual output of household waste exceeds 400 million tons, including 200 million tons in urban area, 70 million tons in county town and the rest in rural area. In recent years, the management of household waste in China has become a thorny problem for the government and a hot topic for researchers.

2.2 WASTE MANAGEMENT

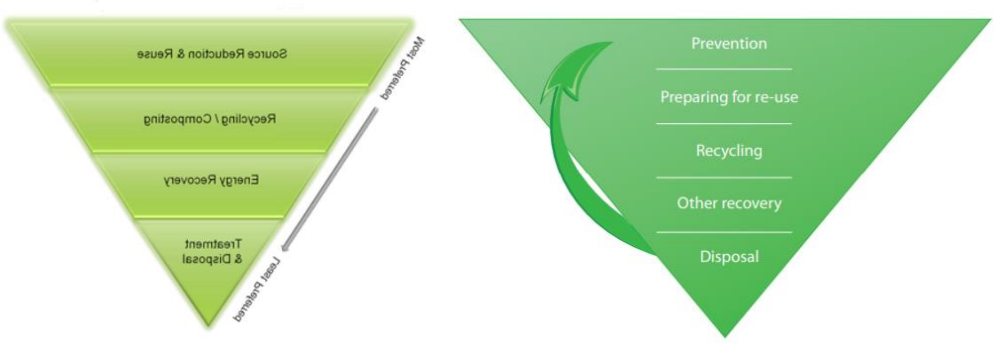
United Nations Statistic Division (2018) defines waste management as *"the activities related to managing wastes, including collection, transport, storage, treatment, disposal, monitoring and regulation of waste materials"*. This definition has been widely recognized in the world, however, in terms of the practice of waste management, it varies from country to country due to the influences of various factors such as economy, politics and culture.

2.2.1 WASTE MANAGEMENT STRATEGY

In terms of waste management strategy, it could be diverse in different countries. In the United States, the *United States Environmental Protection Agency (USEPA)* established a four-tiered hierarchical waste management strategy for decision making: Source Reduction & Reuse, Recycling / Composting, Energy Recovery and Treatment

& Disposal. For the European Union, according to the report '*the EU's approach to waste management*', the hierarchy of waste management is composed of: Prevention, Preparing for re-use, Recycling, Other recovery and Disposal *(European Commission, 2010)*.

Figure 1. Hierarchy of waste management strategy in United States (left one) and



Europe (right one) (United States Environmental Protection Agency; European Commission, 2010)

Compared to developing countries, the developed countries have relatively advanced municipal waste management systems, rich practical-experience and advanced technologies. The emphasis of China's waste management strategy is slightly different. As the biggest developing country in the world, China is comparatively late in municipal solid waste management. The first law on solid waste management named '*Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution*' was enacted in 1995, which established the waste management strategy of China: harmlessness, reducing and recycling of waste materials. Due to the vast output of municipal solid waste and relatively backward waste management capacity, harmlessness is given more attention in China's waste management strategy. In addition, *Guojun Song (2017)* proposed that China had fallen into a vicious circle of mass production, mass consumption and serious environmental pollution caused by incineration and landfill. Municipal solid waste management became more and more costly, reducing the costs of waste management should be new core goal under the premise of harmlessness.

2.2.2 WASTE MANAGEMENT SYSTEM

The basic components of municipal waste management systems are often common, such as waste collection, sorting, treatment, incineration, landfill, etcetera (see Appendix 2). The effects of waste management in different countries depend on its waste management strategy and capabilities.

Waste collection not only refers to the collection of solid wastes from the various sources, but also to the transporting of these wastes to the location where the contents of the collection vehicles are emptied and the unloading of the collection vehicle *(Tchobanoglous et al., 1993)*. Although the transporting and unloading activities are similar for most collection systems, the gathering of waste varies depending on the

characteristics of the facilities, activities, or locations where wastes are generated, and the methods used for on-site storage of accumulated wastes between collections *(Tchobanoglous et al., 1993)*. In addition, the main types of waste collection are: commingled (unseparated) waste collection and source-separated waste collection *(Theisen, 2002)*. Regarding commingled wastes, according to *Health and Safety Executive (HSE) (2018), "sorting depends on the nature of the materials, there are many kinds of sorting activities utilized that range from labor intensive hand-picking operations to highly mechanized or technically complex processes. The chosen sorting methods depends on several factors including the nature of the waste, the ease of segregation and the yield and quality of resultant recyclate"*.

At present, the main methods of municipal solid waste disposal are: landfill, incineration and composting. Landfill refers to placing solid and semi-solid wastes on the ground, isolating these wastes from environment by compacting and covering them with suitable materials. And this is still one of the most common and favored approach of solid waste disposal *(Ghosh & Hasan, 2011)*. Modern landfill management consists of the planning, design, operation, environmental monitoring, closure, and post-closure control of landfills *(O'Leary and Tchobanoglous, 2002)*. Incineration is defined as the combustion of waste materials, converting waste materials into gas, particles and heat (Waste Management Resource, 2009). It reduces the volume and hazard of waste materials, and enables recovery of energy, mineral and chemical content from waste *(European Commission, 2006)*. Composting refers to the transformation of organic materials into biologically stable, humus substances that are suitable for soils and plant uses. It is a controlled decomposition, which is the natural breakdown process that occurs when organic residue comes in contact with soil. The composting process always occurs in nature. However, in recent years, the practice and technology have significantly relied on scientific principles *(Cooperband, 2000; Hamoda et al., 1998)*. According to *Hamoda et al. (1998)*, modern composting operation mainly consists of three essential steps: 1) sorting of the municipal solid waste, 2) decomposition of organic fraction of the municipal solid waste, and 3) preparation and marketing of final compost product.

The municipal solid waste management of each country is affected by its waste management strategy and capacity, such as economic conditions, technical condition, geographical condition and demographics condition, etc. In the United States, according to *'Advancing Sustainable Materials Management 2014 Fact Sheet' (United States Environmental Protection Agency, 2016)*, 52.6% of total municipal waste was landfilled, 34.6% was composted and recycled, and only 12.8% was incinerated. Nevertheless, for developed countries with small territory and advanced technology, generally landfill is not the preferred approach of waste disposal. *Nelles et al. (2016)* stated that in Germany and Belgium, landfill accounts for less than 1% of total municipal solid waste disposal in 2015. Around 63% of total MSW was recycled and composted, and 33% was incinerated. In Japan, incineration is very popular. In 2010, 79% of generated MSW was went through incineration, and around 2% was landfilled *(Masaru Tanaka, 2014)*. Economic and technical conditions are relatively backward in developing country, and these factors notably affect their practices of waste disposal.

In Indonesia, 68.86% of MSW was landfilled, 9.58% was open dumped, 4.79% was open burned and 2.99% was thrown into the river in 2006, whereas composting and small-scale incineration only accounted for 13.78% *(Damanhuri et al., 2014)*. There are no explicit and accurate statistics on municipal solid waste disposal at national level published in China, but *Su Lianghu et al. (2014)* investigated municipal solid waste disposal situation of China, stated that in 2010, among the wastes collected, around 66.94 % was landfilled, 16.20 % was incinerated, 1.29 % was composted, and the rest was dumped at random.

All in all, the practice of municipal solid waste management varies in different countries, or even varies in different regions within a country. As a public service provided by public authorities like municipalities, it is affected by several factors such as economy, technology and population, etc. But it reflects the capacity of a country or region.

2.2.3 CIRCULAR ECONOMY

According to *Andersen (2006)*, the concept of circular economy was introduced in 1989, addressing the inter-linkages of the four economic functions of the environment: amenity values, a resource base for the economy, a sink for residual flows and a life support system. In the traditional linear economy, little attention is given to the social cost of waste. In contrast, in a circular economy, materials are reused wherever possible, keeping residual waste to a minimum *(Internationale Nederlanden Groep (ING), 2017)*.

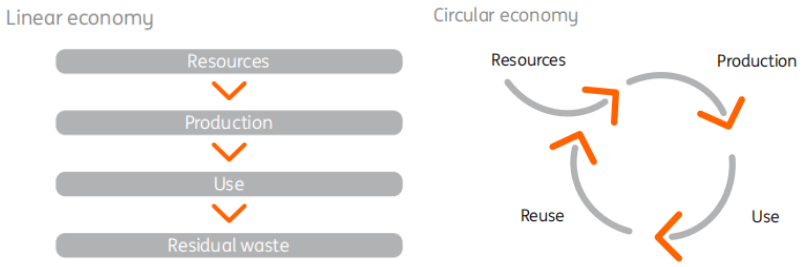


Figure 2. Linear economy and circular economy (ING, 2017)

Ellen MacArthur Foundation (2017) indicated that the circular economy relies on three principles:

1. Design out waste and pollution.
2. Keep products, components, and materials at their highest value and in use.
3. Regenerate natural systems.

In a circular economy, material flows are divided into two types (see Appendix 3): biological cycle and technical cycle. In biological cycle, consumption occurs and renewable (biological) materials are regenerated. In technical cycle, technical materials are recovered and mostly restored, without entering the biosphere *(Ellen MacArthur Foundation, 2015)*.

Since the moment the concept of circular economy has been proposed, it has gained wide attention world widely, especially in China. *Hongchun Zhou (2006)* noted that circular economy can be traced to the same origin with conservation and holistic resources use, cleaner production and pollution treatment, where each has its own emphasis. In addition, it not only emphasizes on lowing consumption of resource, but

also on the efficient use of resources to promote the efficiency of utilization and to eliminate the pollutant discharge. Furthermore, *Zhijun Feng (2004)* proposed that circular economy is the cornerstone for sustainable development strategy of China, it can facilitate pollution prevention and is in line with the mind-set of prevention and control strategy. Moreover, it can effectively support transition of industry and expansion of employment, enhancing the international competitiveness. *Dangguo Zhao (2016)* stated that China need to develop the model of circular economy in industry to enhance the pollution prevention. However, from the linear economy to a circular economy, full systemic changes are required throughout the value chains. It not only involves the innovations in design and technology, but also the renovations of financial approaches, policy frameworks as well as business and consumer modes *(European Commission, 2014)*.

2.2.4 SUSTAINABLE WASTE MANAGEMENT TOWARDS CIRCULAR ECONOMY

In recent years, with the expansion of cities and growth of human population, the availability of land for waste disposal is decreasing. In addition, serious problems including groundwater contamination, soil and air pollution have caused by years of uncontrolled and unplanned dumping of waste on land in various areas of the world *(Ghosh & Hasan, 2011)*. The current main approaches for municipal solid waste disposal seem not to be a long-term solution. In terms of landfill, it can destruct natural virgin sites, generates landfill gas and leachate which have potential risk to pollute water resource and to contaminate the soil. In addition, it requires long term and cost intensive clean-ups remediation and monitoring *(United Nations Environment Programme (UNEP), 2002)*. According to the *World Bank (1999)*, for incineration, an incineration plants involves heavy investment and high operating costs. This results in the increase of waste treatment cost and motivates the waste generators to seek alternatives. Moreover, incineration requires applicable waste that meeting the requirements as well as the skilled staff to operate. The residues from the flue gas cleaning can contaminate the environment if not handled appropriately, and must be disposed of in controlled and well operated landfills to prevent ground and surface waste pollution *(World Bank, 1999)*. As a waste disposal method with minimal impact on environment, composting has severe weak point. It breaks down easily degradable plant and animal tissue but does not produce appreciable changes in difficult-to-degrade organics (wood, leather, polymers) and in inorganics (dirt, glass, ceramics, and metals) *(Luis Diaz et al., 2002)*. These conventional waste disposal approaches are not long-term solutions for municipal solid waste management, therefore for the long-term development of society, sustainable waste management was proposed.

Sustainable waste management refers to exploiting the value of material resources as much as possible by handling waste materials from source to disposal. It incorporates feedback loops focused on processes, embodies adaptability and diverts wastes from disposal *(Seadon, 2010)*. Sustainable waste management is not only vital for conservation of natural resource value, but also for reducing the emission of greenhouse gases (GHGs) and protecting public health and natural ecosystems. And it is based on

waste hierarchy proposed by Ad Lansink in 1979 which is known as *Lansink's Ladder (Unnisa & Bhupatthi Rav, 2012).*

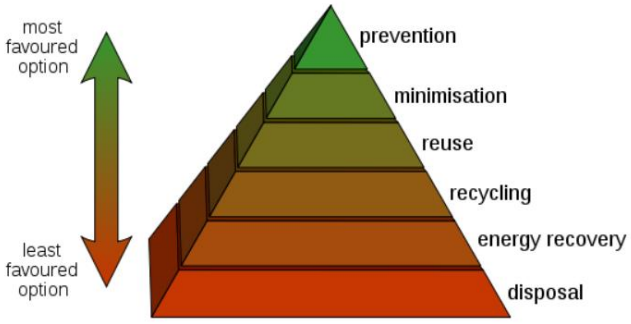


Figure 3. Lansink's Ladder (Ad Landsink, 1979)

According to *Unnisa and Bhupatthi Rav (2012)*, the hierarchy components include the following:

1. Reduce or prevent waste arising: waste minimization initiatives to help businesses and households reduce waste generated.
2. Reuse waste: reuse waste and thus avoid energy-consuming reprocessing.
3. Recycle: reprocess waste for further use.
4. Energy recovery: generating energy from waste by using a range of technologies.
5. Disposal: put waste in landfill site.

The prevention and minimization are known as Reduce as well, which is combined with Reuse and Recycle into the 3Rs principle as the above mentioned. The 3Rs principle practice in municipal solid waste management not only maximizes use of resource, but also contributes to reduction of greenhouse gas (GHG) emission, minimizing environmental loads from landfill and incineration, improving social well-being, etc (Jnya Sang-arun, Menikpura & Agamuthu, 2014). In modern world, the 3Rs principle is widely recognized, and recycling rate has viewed as an important indicator in waste management practice. According to *European Environment Agency (2013)*, there are 16 countries with over 25% recycling rate in European Union. As biggest developing country with huge waste generation, China is in urgent need of sustainable waste management. *Guojun Song (2015)* stated in *'Evaluation report of municipal household solid waste management in China'* that there are 25.32% and 20.11% of used papers and plastic recycled in Beijing and Suzhou respectively, China actually has a great potential for recycling development. Recycling does not only maximize the use of materials, but also promotes the start-up of micro-enterprises and provides local people with employment opportunities *(ADB, 2002)*.

However, in addition to recycle, reduce and reuse should also be paid attention to. Although there is no explicit indicator regarding reuse and reduce rates for waste management report, their importance is not less than recycle. *Chen Jie (2002)* stated that the key to alleviate the problem of MSW in China is to reduce the amount of waste at the source. In addition, reduce and reuse are combined together to maximize the use of product or materials before them enter recycling (at the source). For instance, household can reuse used glass bottles as flower vase or spices container, or donates old clothes to the welfare house and etc. Another example is *'clear you plate'* campaign

supported by Chinese government from 2013. It appeals to people not to waste food because according to *Lijun Zhao (2009)* the organic waste (mainly kitchen waste) accounts for over 50% of annual total municipal household solid waste generation and the waste of food is a common problem in China. Reduce and reuse are even more effective and cost saving than recycle because recycling process consumes energy and releases harmful substances that need to be treated.

Furthermore, the practice of the 3Rs principle can facilitate the transition from the linear economy to a circular economy in a country, and even in an international region. According to *Masaru Tanaka (2014)*, the Japanese Government launched its *'New Action Plan towards a Global Zero Waste Society'* in 2008. This action plan is composed of actions including support for the development of strategies and policy dialogues in line with the needs of each country, contributing to global warming countermeasures through environmentally sound waste management and 3Rs, and actions to establish a Sound Material-Cycle Society (3R society) at regional levels in Asia (see Appendix 4).

All in all, sustainable waste management and the 3Rs principle practice are essential elements for the transition from the linear economy to a circular economy inside the country and in international region. It is not only about saving resources, environmental protection and improving social welfare, but also about the sustainable development of human society and our planet.

2.3 HOUSEHOLD PARTICIPATION

In recent years, municipal household solid waste generation has been increasing due to several reasons such as the rapid growth in population, pushing for economic development and the urbanization of rural parts of the country *(Minghua et al., 2009)*. The rapid increase in food consumption has also resulted in the booming of the amount of waste generated in households *(Adeoye, Sadeeq, Musa, & Adebayo, 2016)*. Therefore, for countries facing with municipal solid waste problem, establishing an efficient and sustainable waste management system is primary task of local government. However, in many parts of the world, especially in developing countries, the importance and effects of household participation in municipal solid waste management are often underestimated. In addition, households also seem to ignore their responsibility and contribution to waste management, and even seem to think that it is the concern of local government to properly manage waste at no extra charge *(Bournay, 2006)*. For example, in many parts of China, especially in small cities, littering and dumping rubbish at random sites is still common. Although local government has been supervising and punishing on these actions, it definitely aggravated the financial burden of local government, and the effect seems to be not good enough.

The requirement of effective public participation is undoubtedly based on the fact that the people can be directly and indirectly affected by the waste they produced if these wastes are not well managed (Squires, 2006). Moreover, for many developing countries, the local government lacks technical, financial and human resources to properly manage local municipal solid waste. Household participation can provide this needful human resource in municipal solid waste management and thus alleviate the financial

and time burden of local governments. In addition, involving households in local municipal solid waste management can arouse their sense of responsibility to contribute to the maintenance of this public service and enhance their understanding and agreement of cost sharing, as well as facilitate cooperation (agreement) and prevent conflicts between stakeholders *(Cotton, et al., 1998; Colon & Fawcett, 2006)*. Therefore, the households' support and involvement are important to proper and sustainable municipal solid waste management, at least sorting wastes at the source (households) before collected, otherwise even the effects of recycling process could be affected and become more-costly *(Nzeadibe, 2009)*.

2.3.1 HOUSEHOLD PARTICIPATION AND SUSTAINABLE WASTE MANAGEMENT

The scale of public participation in municipal solid waste management varies significantly between the developing and developed countries (Oberlin, 2011). In developed countries, households shoulder the task of sorting the waste they generated at home. For example, according to *'Ministry of the Environment of Japan'*, households must sort the waste at first, then these wastes are collected by local municipalities for deeper separation before being conveyed to specific corporations for recycling. Households can also put some of the recyclable wastes like plastic bottles into recyclable waste collection machine (like reverse vending machine) in retailers, then these recyclable wastes are conveyed to specific corporations directly. The situation is totally different in developing countries, especially in those with backward economic conditions. According to *Zhujie Chu, et al. (2016)*, in China there were still 15 million tons of municipal household solid waste that had not been harmlessly treated in 2014, which caused a series of environmental problems. This is mainly due to the inadequate levels of municipal solid waste sorting collection, and which results in the poor effectiveness of the subsequent processing. Separation of waste at source and separated collection of wastes is the first and fundamental step to solve municipal household solid waste problem, it is also the prerequisite for waste reduction, and causing less environmental problems than other solution. Furthermore, waste separation at household level can preserve the quality of recyclables, it not only improves the accessibility to recycling sectors, but also lightens the burden of overall waste disposal *(Matter, et al., 2013)*. However, *Mavropoulos and Sa (2009)* stated that although recently the recycling activities are well known by individuals, the recycling rates are still low due to several reasons, such as a lack of convenience for recycling and their perceived benefits from recycling.

Nevertheless, to better practice the 3Rs principle and to push forward sustainable municipal waste management, the reduce and reuse of waste material in households should also be emphasized. As mentioned above, the reuse and reduce of waste in household are combined at some extent. The reuse of waste materials can notably facilitate the waste reduction. *Damghani et al. (2008)* also stated that household waste sorting collection and reduction are two vital approaches for lighten the burden of waste disposal, for instance the landfill. *Main Uddin, et al. (2013)* examined individuals' perception of 3Rs and the practice of household in Chittagong, Bangladesh, found that

less than around 50% people have no interest in the reduce and reuse of waste, and stated that the involvement of non-governmental organizations (NGOs) have positive influences. In recent times, many NGOs fight for our environment in the real or on the internet. One NGO called *'The Green Guide'* continuously publishes tips for reuse and reduce of waste as well as 'green' activities in households. In fact, both governmental and non-governmental organizations are making efforts to raise public awareness, which could be as important as the construction of waste management facilities. After all, individuals are the generator of the waste, or in other words, the source of the problem.

2.3.2 FACTORS INFLUENCING HOUSEHOLD PARTICIPATION IN MUNICIPAL SOLID WASTE MANAGEMENT

Both internal and external factors can influence the behavior of household participation in sustainable waste management. In order to promote the household participation in sustainable waste management, it requires an understanding of factors affecting this *(Atthirawong, 2016).*

The existing researches on internal factors affecting people pro-environmental behavior mainly base on two complementary theories: 1) the Theory of Planned Behavior (TPB) and 2) the Value - Belief - Norm (VBN) theory. According to *Izagirre-Olaizola, et al. (2014),* the Theory of Planned Behavior mainly focuses on egoistic behavior, and since the personal sacrifices have to be made in order to protect the environmental when recycling, the moral-based theory also needed to understand the altruistic and biosphereric behavior which is the Value - Belief - Norm (VBN) *theory*. Based on that, the motivation of household participation is built on egoistic, altruistic and biospheric values. Individual's attitude towards environment is another significant factor. According to *Tilikidou (2007),* people with pro-environmental attitude are expected to behave in a way in accordance with that attitude, such as recycling and supporting environmental protection activities. *Minton & Rose (1997)* indicated that environmental attitude is the determinant of waste separation behaviors, people who care about nature have more potential to engage in waste sorting. Apart from that, *Izagirre-Olaizola, et al. (2014)* indicated that environmental knowledge is a remarkable factor influencing pro-environmental behavior. According to *Vining & Ebreo (1990),* the knowledge about general environmental issues or specific knowledge about recycling is a significant predictor of recycling behavior. *Desa, et al. (2011)* also stated that the level of knowledge influences waste sorting behavior. Another factor that can affect pro-environmental behavior is perceived consumer effectiveness (PCE). *Laskova (2007)* stated that PCE refers to the fact that the consumers have the demand to ensure that their behavior have a positive impact on the environment. Individuals will have more willingness to engage in specific activities if they believe that this activity could solve an environmental problem. Socio-demographic factors such as age, education and income can also have impact on pro-environmental behavior *(Izagirre-Olaizola, et al., 2014)*. However, the age and education could have potential conflict with the level of environmental knowledge which could interference with the results of analyses.

Therefore, in this research, income is chosen as the last internal factor to indicate the economic condition of individuals.

Apart from these internal factors, there are external factors that can have impact on pro-environmental behaviors. *Lin Xu, et al. (2017)* stated that government and market could have impacts on waste sorting behavior. *Zhujie Chu (2016)* stated that the external factors could be divided into four dimensions: political, economic, societal and technical dimension. *Noehammer & Byer (1997)* indicated that the compulsory recycling programme conducted by government have more participant than voluntary programs. *Noh et al. (2012)* indicated that the penalties could stimulate individuals' participating initiative of waste sorting. In this research, this dimension is called 'governmental regulation'. In economic dimension, *Lin Xu, et al. (2017)* indicated that market incentives have a significant impact on recycling intention of individuals. *Everett & Peirce (1993)* stated that the financial incentive is the direct impetus to waste sorting behaviors. Here this factor is called 'economic incentive'. Apart from that, *Atthirawong (2016)* stated that promotional campaigns and training programs have influence on households' behavior of waste sorting and recycling activities. *Wellar & Barry (1984)* indicated that the propaganda could promotes the better waste separation behavior of residents. *Colon & Fawcett (2006)* stated that the households can be collectively responsible in organized activities such as meetings and clean-up campaigns. Hence, this factor is called 'societal incentive' in this research.

Then, the last one is technical dimension. According to *Derksen & Gartrell (1993)*, the residents' behavior of waste sorting could be affected by the location of dustbins. If the separated dustbins are convenient to reach in communities, even people who have no concerns about the environment would also perform recycling. *E. Achankeng (2003)* also stated that the recycling behavior of people is influence by facilities and the convenience. Hence, in this research, this last factor is named 'the availability of technical equipment'.

CHAPTER 3 RESEARCH DESIGN

Research design refers to a plan that indicates when, where and how the data are to be collected, to answer the research question or to test the research hypothesis *(Parahoo, 1997; Polit, et al., 2001)*. In this research, Chengdu, China is designed to be the case for study.

3.1 RESEARCH FRAMEWORK

According to *Verschunren & Doorewaard (2010)*, the research framework refers to the schematic presentation of steps (activities) required to achieve research objectives. The steps are shown as below:

Step 1: Characterizing briefly the objective of the research project

The objective of this study is investigating the household participation in municipal solid waste management in Chengdu, China, which includes two main parts: 1) investigating the current situations of household participation and local municipal solid waste management, and 2) identifying the potential approaches to improve the sustainability of local municipal solid waste management through household participation.

Step 2: Determining the research object

The research object is the household participation in municipal household solid waste management in Chengdu, China.

Step 3: Establishing the nature of research perspective

The research perspective is basically a conceptual model to determine the practice and the analysis of household participation in municipal household waste management. To propose the recommendation, a range of information sources are integrated, desk research and questioning are both included in this research to ensure the validation of information.

Step 4: Determining the sources of the research perspective

The research uses scientific literature to develop the conceptual model as shown below:

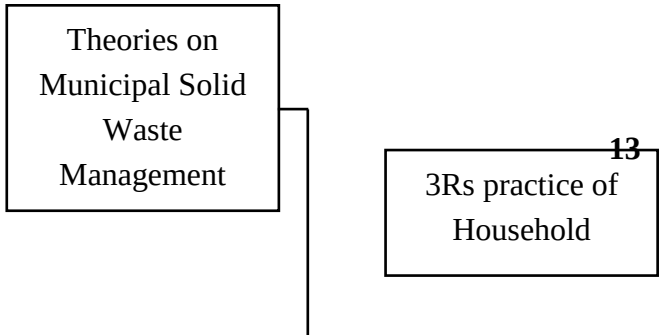
Table 1 Sources of the research perspective

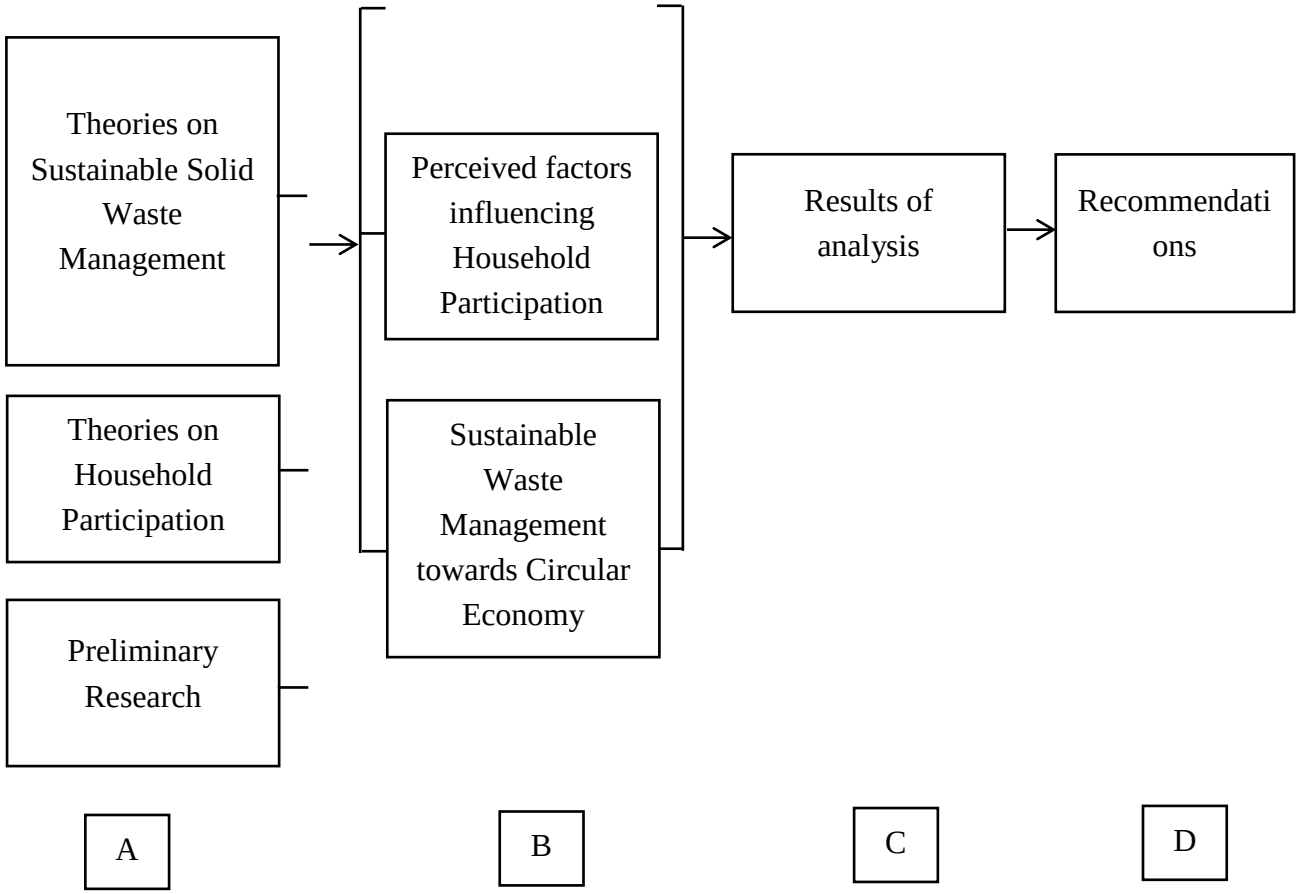
Key concepts	Theories and Documents
Household Participation	Theories on Municipal Solid Waste Management
	Theories on Sustainable Waste Management (3Rs)
The 3Rs principle in sustainable waste management	Theories on Household Participation
Circular Economy	Theories on Circular Economy
Sustainable Waste Management	Theories on Sustainable Waste Management

Step 5: Making a schematic presentation of the research framework

The research framework is illustrated as following:

Figure 4. Schematic presentation of research framework





Step 6: The steps to be taken in the course of the research are formulated as follows:

(A) The theories on municipal waste management, particularly the household participation, 3Rs principle, sustainable waste management and circular economy are studied;

(B) Based on step A, investigations and analyses of household participation in local municipal household solid waste management regarding sustainability (3Rs) and circular economy are implemented;

(C) Analyses of the results obtained in step B are implemented;

(D) Recommendations for future improvement of sustainability of local municipal solid waste management in Chengdu, China.

Step 7: Checking whether the model requires any change:

There is no indication that any change of research model in this research is required.

3.2 RESEARCH QUESTIONS

Main research questions:

What is the current situation of municipal solid waste management in Chengdu, China?

How can the existing situation be improved through possible household participation?

Sub research questions:

The study (research) seeks to answer the following research questions:

1. What is the current situation of waste sorting collection and 3Rs practices in households in Chengdu?

2. What are the perceived factors and difficulties that influence households' participation in Chengdu?
3. What are the best practices of household participation in sustainable municipal solid waste management in China and internationally?

3.3 DEFINING CONCEPTS

According to *Verschunren & Doorewaard (2010),* defining the concepts is important because it influences the progress of research and the steering capacity of research questions. For the purpose of this research, the following concepts are defined:

Household solid waste: The solid wastes produced from residents in their daily life (*Lijun Zhao, 2009).*

Municipal waste management*:* The activities related to managing wastes, including collection, transport, storage, treatment, disposal, monitoring and regulation of waste materials *(United Nations Statistic Division).*

Sustainable waste management: Running out the value of material resources as much as possible by handling waste materials from source to disposal.

Circular economy: An economic concept that emphasizing on maintaining the value of materials, maximizing the use of materials, minimizing the waste and pollution, to contribute to natural system regeneration *(Ellen MacArthur Foundation, 2017).*

Household participation: The actions or activities of residents in the house that involved in community programme for fulfillment of certain demands *(United Nations Human Settlements Programme, 1986).*

3.4 RESEARCH STRATEGY

According to *Verschunren & Doorewaard (2010),* a research strategy is a coherent body of decisions regarding the way in which researcher is going to implement the research itself.

3.4.1 RESEARCH UNIT

The research unit of this research is the household in Chengdu, China. The municipal household solid waste management situation at household level in the city is to be analyzed.

3.4.2 SELECTION OF RESEARCH UNIT

Verschunren & Doorewaard (2010) defined the informant as the people who supplies data or information about others, and the respondent as the people who provides the information or data about himself or herself. And explained that the selection of informants and respondents for collection of data and information collection is based on following approaches:

Households: Serving as both informants and respondents. The information or data about the real situation regarding municipal household solid waste management at household level are collected from them, including the situation of waste sorting collection, the level of the 3Rs principle practices, the difficulties they are facing with and the perceived factors influencing their participation behavior.

3.4.3 SAMPLING METHODOLOGY AND SAMPLE SIZE

According to *Babbie (2004),* purposive or judgmental type of sampling technique should be taken when it is difficult to conduct a questionnaire covering the whole population. The sample selected should be representative, if the scale of sample in the research is small. And the logic of sample selection should be based on the research objectives and questions. In this research, a sample of 120 respondents were selected from two residential areas in Chengdu. The data or information are to be collected through a questionnaire (see Appendix 1).

3.4.4 RESEARCH BOUNDARY

For achieving the research objectives within a limited time frame, the research boundary is required to determine the limitation of the research. The emphases are only on the current situation of household participation and the real practice of the 3Rs principle of households in municipal household solid waste management. And perceived factors and difficulties influencing the behavior of households' participation are also involved. Therefore, other actors except households in municipal solid waste management are not included, the toxic waste, the medical waste and other kinds of wastes excluded from household solid waste are also not considered in this research.

3.5 DATA SOURCES AND COLLECTION METHODS

According to *Verschunren & Doorewaard (2010),* for answering the research questions, research material and accessing methods are needed to be considered by researcher. This includes the source of data and information and the approaches designed to access the sources.

In this research, data sources are individual people (in each household), the media, documents, literature and empirical information. The approaches for accessing these sources are questionnaire, analyses of documents and observations from empirical information. To investigate the current situation of municipal solid waste management in Chengdu and best practices of sustainable municipal solid waste management in China and internationally, the online media, literature and opening public documents are to be analyzed. The questionnaire is designed to investigate the situation of waste sorting, the practice of the 3Rs principle in household and perceived factors and difficulties influencing participation behavior of household. The realities of waste separation and 3Rs practices are accessed from observation in public and private places.

3.5.1 TYPES OF DATA

In this research, data are to be obtained from both primary and secondary sources. The primary data refers to the original data collected by researcher at first hand from respondents through questionnaires, interviews, direct observations and experiments *(Bless & Higson, 1995)*. In this research, the primary data are to be obtained from reality and residents in Chengdu. Secondary data refers to the available data that have already been collected or compiled by other people *(Denzin & Lincoln, 2000)*. In this research, the secondary data are to be obtained from books, documents, journals and the internet.

3.5.2 DATA COLLECTION

Table 2. Data and information required for the research and accessing method

Research questions	Type of data/Information Required	Data/information sources	Accessing methods
1. What is existing situation of municipal solid waste management in Chengdu, China?	Existing municipal solid waste management system in Chengdu	*Secondary data* Documents Literature	Document and Literature review
2. What is the current situation of waste separation and 3Rs practices in households in Chengdu?	The real situation in households regarding waste separation and 3Rs practices	*Primary data* Individual people Empirical situation	Written questionnaire Informal interview Observation
3. What are the perceived factors and difficulties that influence households' participation in Chengdu?	The perceived factors and difficulties influencing household behaviors regarding waste separation and 3Rs practices	*Primary data* Individual people	Written questionnaire Informal interview Observation
4. What are the best practices of household participation in sustainable municipal solid waste management in China and internationally?	The existing best practices in terms of household participation in sustainable waste management in China and internationally	*Secondary data* Documents Literature Empirical situation Media	Content Analysis Observation Search Method

3.5.3 ETHICS STATEMENT

In this research, the informants and respondents - individuals of households in targeted residential area, are randomly selected. And there is no discrimination based on gender and education background. Individuals are considered equal and equally entitled to participate in the research. The research aims to investigate the real situation of waste sorting, the practice of the 3Rs principle in households, and the perceived factors and difficulties influencing the individuals' participation behavior, which includes internal factors: motivation, attitude, the level of environmental knowledge, perceived consumer effectiveness (PCE), income, and individuals' cognition of external influencing factors: governmental regulation, economic incentives, social incentives and technical equipment availability. In other words, all the questions are inquiring individual's own feeling among the factors mentioned above, and informed consent is kindly presented on the first page of questionnaire stating that individuals have right to refuse to participate in this survey and stop participating whenever they feel uncomfortable or being invaded, all the participants are truly voluntary and autonomous. In addition, all the questions have no biases that the questions are not leading the participant to certain answers. And all the questions are kindly asked, there is no potential risk of harming participant. In addition, the photos related to individuals will only be taken with their permission during observation.

Moreover, the whole research is aimed to improve general situation of sustainable municipal waste management from the perspective of households, which means that there is no targeted vulnerable group in this research; all the individuals are treated equal. The research aims to identify the factors that improve willingness and dealing with requirements in household participation behavior. There is no risk to harm the benefits of individuals and the environment. This research is for academic purpose, not for other purposes which could have potentially harmful risks.

3.6 DATA ANALYSIS

Data analysis refers to the evaluation process of data through the analytical framework. In this research, in order to come up with the required information, qualitative method is to be used as data analysis method. According to *Blaxter, et al. (1996)*, qualitative method refers to collecting and analyzing information in many forms (mainly non-numeric), and it tends to concentrate on exploring smaller numbers of instances being examined in as much detail as possible. Quantitative method refers to gathering numerical data through questionnaire and survey, to explain a certain phenomenon or to generalize it across group of people by data analysis *(Muijs & Daniel, 2010).*

3.6.1 DATA ANALYSIS METHOD

The methods of data analysis are illustrated as below:

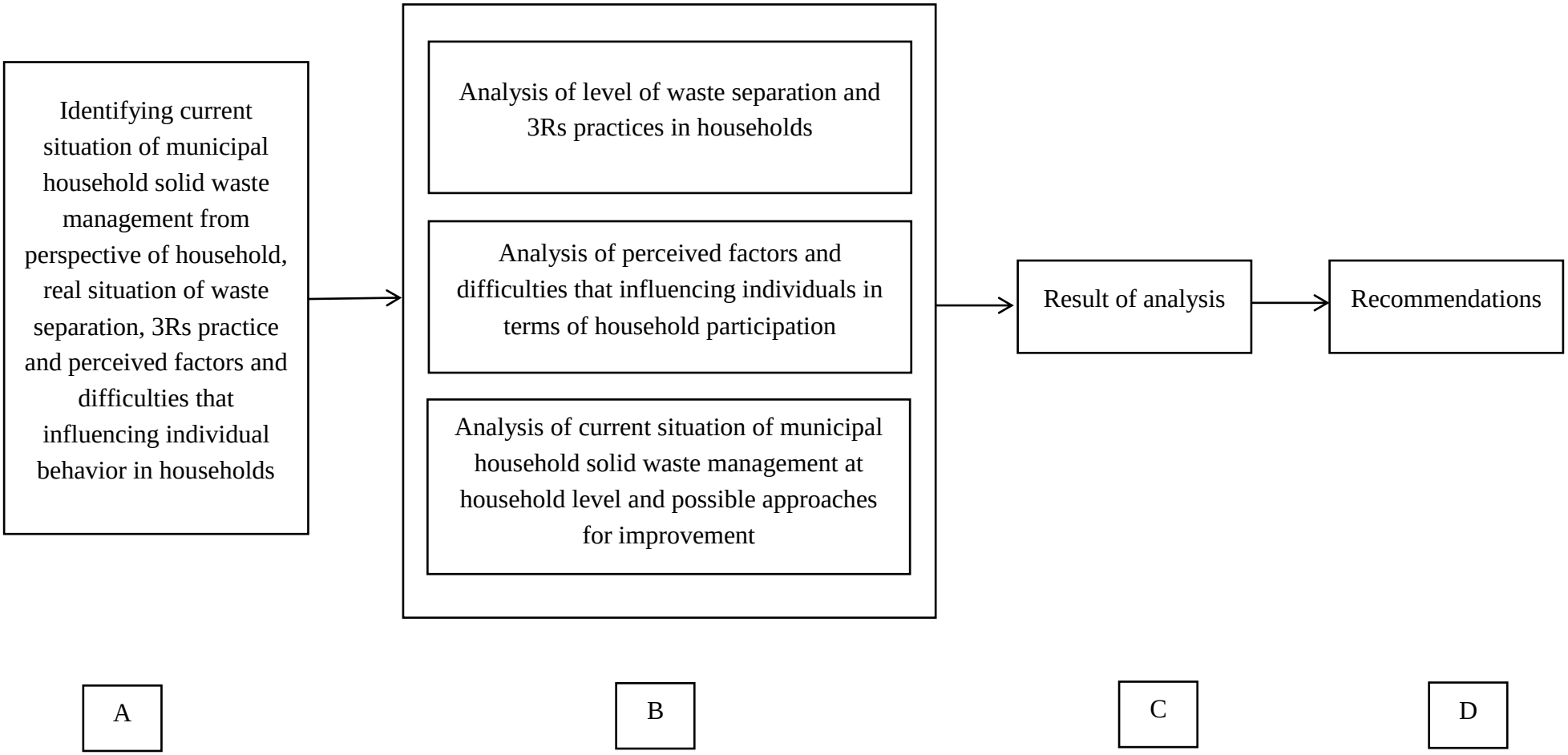
Table 3. Required data/information and methods of analysis

Data/ Information to be collected	Methods of Analysis
Existing municipal solid waste management system in Chengdu	*Qualitative method:* Analyzing the existing municipal solid waste management situation in Chengdu
The real situation in households regarding waste separation and 3Rs practices	*Qualitative and quantitative methods:* Analyzing the existing level of waste separation and 3Rs practice in households
The perceived factors and difficulties that influencing household behaviors regarding waste separation and 3Rs practices	*Qualitative and quantitative methods:* Analyzing the perceived factors and difficulties that influencing individuals' behavior of participation in local municipal solid waste management
The existing best practices in terms of household participation in sustainable waste management in China and internationally	*Qualitative method:* Analyzing the possible approaches for improving sustainability of existing municipal solid waste management through household participation

3.6.2 ANALYTICAL FRAMEWORK

The schematic presentation of analytical framework is shown as below:

Figure 5. Schematic presentation of analytical framework



Data analysis was conducted by the following procedure:

A. Firstly, the study will identify the current situation of municipal household solid waste management from the perspective of households, the real situation of waste sorting and the 3Rs principle practice in household and the perceived factors and difficulties that influence household participation. Meanwhile the analysis of the situation of municipal household solid waste management at household level and the level of household participation will be done. In this step, the research sub-question 1 and research sub-questions 2 will be answered, and some results and descriptions will be used in the next step of analysis.

B. Secondly, based on the results of comprehensive analysis in step A, identification of possible approaches for improving household participation in local municipal household solid waste management will be done. The research sub-question 3 will be answered.

C. Then, through the combing the results of analyses in step A and step B, the comprehensive results and summary will be done. The results generated in this step is used to answer the research main question.

D. Finally, based on the answer of research sub-questions and main questions, the summary of results will be done and the recommendation will be formulated.

CHAPTER 4. CURRENT SITUATION OF MUNICIPAL SOLID

WASTE MANAGEMENT IN CHENGDU

Tsai (2007) stated that the process of household participation in municipal solid waste management depends on the chosen approach and the characteristics of the household in a particular location. And the municipal solid waste management could be slightly different between various cities in the same country. Therefore, it requires to select certain area as case study for the research. In this research, the chosen case is Chengdu, China.

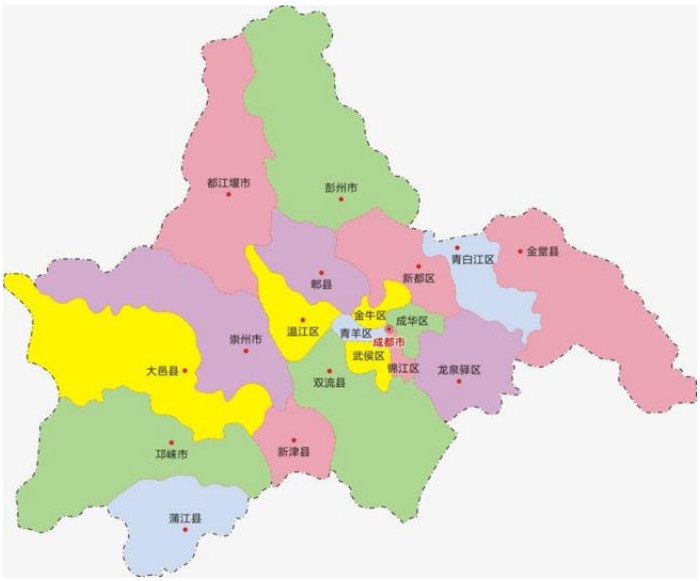


Figure 6. Chengdu Administrative Map (Ant map storage, 2018)

Chengdu is one of the metro-city in southwest China, which has around 14 million populations and 12100 square kilometers land divided into 11 districts and 9 counties (Chengdu Government, 2017). According to *'Annual report of environmental prevention and control of solid waste pollution in large and middle cities of China'* published by *Ministry of Environment of China* in 2016, the total generation of household solid waste generation of Chengdu in 2015 is 4.675 million tons. In addition, the organic waste and the recyclable waste account for around 55% and 30% respectively in total household solid waste generation, which implies the feasibility and necessity to develop the sustainable waste management *(Shen Shuai, 2012)*. As discussed in section 2.3, household participation can make estimable contribution in the development of sustainable waste management. Nevertheless, according to *Shen Shuai (2012)*, Chengdu government initiated a waste separation pilot programme in cooperation with Vanke Group in 2010, for stimulating the household participation in two of the Vanke residential communities. The effectiveness of programme is significant at the beginning, but it didn't persist a long time. Then, what is the current situation of municipal solid waste management in Chengdu in recent time?

In this section, the current conditions of municipal solid waste management are described and discussed based on public documents and literature of relevant studies by desk research.

4.1 HOUSEHOLD WASTE IN CHENGDU

Waste composition can be diverse in different area as it is influenced by many factors including economic development, geographic location, culture norms, energy sources and climate *(The World Bank, 2012).* According to waste characterization done by *Yanchun Yin* in 2016, the main components of household waste in Chengdu are: organic waste, paper, plastic, textile, metal, glass and the others including non-recyclable waste and harmful waste. Organic waste occupies the largest proportion (57.9%) in total household waste output and the waste of paper, plastic, textile, metal and glass account for 15%, 10.5%, 1.3%, 1.86% and 0.15% respectively as presented in figure 7.

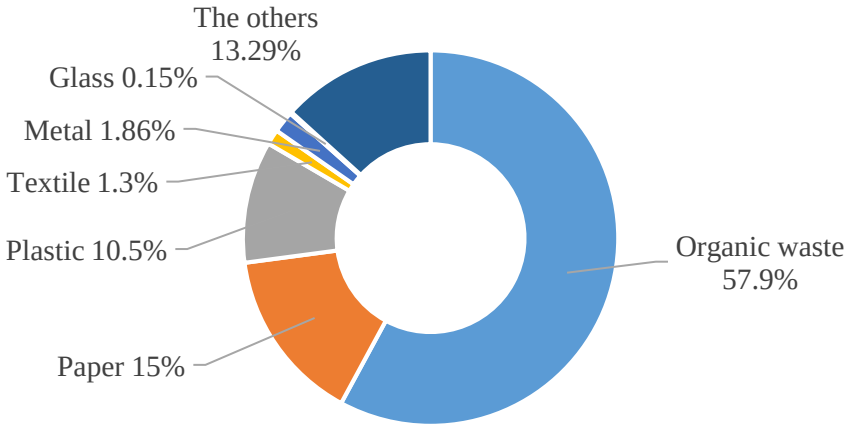


Figure 7. The household composition of household waste in Chengdu (Adapted from statistic made by Yanchun Yin, 2016)

It can be seen from figure 7 that around 86.7% of municipal solid waste generated from household still has residual value that can be used for composting and recycling.

4.2 HOUSEHOLD WASTE MANAGEMENT AND STRATEGY IN CHENGDU

This section presents the waste management strategy and municipal solid waste management system in Chengdu.

4.2.1 WASTE MANAGEMENT STRATEGY

As introduced in section 2.2.1, the national government formulated municipal solid waste management strategy (harmlessness, reducing, recycling) through legislation in 1995. In order to well implement this strategy, Chengdu government published *'The implementation scheme of Municipal Solid Waste Sorting Collection of Chengdu (2018-2020)'* in April 2018, which confirmed the targets need to be achieved by the end of 2020 as shown in table 4:

Table 4. The target for municipal solid waste management 2018-2020. (Adapted from Chengdu government, 2018).

	Harmlessness	Recycling	Reducing
2018	-	The household waste sorting collection equipment covers 35% of residential area	The reduction rate of municipal solid waste for terminal disposal reaches 5%
2019	-	The household waste sorting collection equipment covers 50% of residential area	The reduction rate of municipal solid waste for terminal disposal reaches 10%
2020	The rate of harmless disposals reaches 99%	The household waste sorting collection equipment covers 60% of residential area; The total recycling rate[1] reaches 35%	The reduction rate of municipal solid waste for terminal disposal reaches 15%

4.2.2 CURRENT HOUSEHOLD WASTE MANAGEMENT SYSTEM

Waste Management System

The Solid Waste Management Office of City Administration Bureau of Chengdu is responsible for the management of local household wastes including collection, sorting, transportation, disposal of wastes as well as the implementation of regulations, policy making and establishment of scheme and plan for waste management *(City Administration Bureau of Chengdu, 2008).* The Environmental Protection Bureau of Chengdu holds the supervisory power to all environmental issues including municipal solid waste management *(The Environmental Protection Bureau of Chengdu, n.d.)*. According to *City Administration Bureau of Chengdu (n.d.)*, the management regulations among household wastes at present are: *(i) 'Management regulations for household waste'*, *(ii) 'Management regulations for kitchen waste'*, *(iii) 'Management regulations for household waste bagging' and (iv) 'Management regulation for household waste charge'*. And the *'management regulation for waste sorting collection'* is in the process of formulation.

At present, the method of household waste collection in Chengdu is mainly in commingled approach introduced in section 2.2.2. As shown in Appendix 5, since the wastes are generated from households, they are directly thrown into the garbage bin in the residential areas without sorting out. Then these wastes are packed up by a black bag and delivered to the garbage collection station by electric-tricycle which are close to the residential area, and the dump trucks will transport them to the wastes transfer

[1] The total municipal solid waste recycling rate including 10 kinds of waste defined by *Ministry of Housing and Urban-Rural Development of China*, which are: household waste, cleaning waste, landscape waste, commercial service site waste, business offices waste, medical waste, traffic logistic waste, construction and demolition waste, industrial waste and others.

station that located far away from living area after then (Xiangfan Wu, 2007; Dandan Xue et al., 2008). In wastes transfer station, the household wastes will be classified into 4 categories: recyclables, organic wastes, combustibles, non-combustibles (including harmful wastes) for recycling, composting, incineration, harmless treatment and landfills *(Jian He & Huiqun Wang, 2001)*. The landfills and incineration constitute the main approaches of waste disposal in Chengdu. Since the combustibles are disposed in incineration plants for energy recovery, the ash generated from combustion process will be disposed by landfill together with non-combustibles. And the inorganic substance generated from incineration (including nitrogen, phosphorus and kalium, etc.) will be mixed with composts for producing fertilizer, which is named as comprehensive treatment *(Jian He & Huiqun Wang, 2001; Na Li et al., 2009)*.

Waste Disposal Capacity

According to Chengdu government (2017), the total household waste generation in Chengdu is around 15000t per day. Currently, Luodai environment-friendly incineration power plant, Jiujiang environment-friendly incineration power plant, Xiangfu environment- friendly power plant and Wanxing environment-friendly power plant are treating a total of 8700t wastes per day. Changan household waste sanitary landfill site is disposing 3400t wastes per day. The rest of wastes are delivered to small-scaled simple landfill site located in each district. And Longfeng environment-friendly incineration power plant (daily disposing capacity of 1500t), Baolin environment-friendly incineration power plant (daily disposing capacity of 1500t), Dalin environment-friendly incineration power plant (daily disposing capacity of 2400t) and Jintang environment-friendly incineration power plant (daily disposing capacity of 800t) are in the process of construction. In addition, Chengdu-Central kitchen waste composting and recycling plant (Phase 1) have been put into operation since 2013, which is managing 200t per day, Chengdu-Central kitchen waste composting and recycling plant (Phase 2) is in the process of construction, which can manage 300t kitchen waste per day. The distribution of waste disposal plants in Chengdu is shown as Appendix 6.

Public Responsibility

Similar to other public services, people have the responsibility to maintain local waste management as well, such as complying with regulatory requirements, paying waste disposal fees and keeping the environment clean, when government entitles them the rights to know and to supervise *(Mengqing Xiong et al., 2009)*.

For being open to public scrutiny, the City Administration Bureau of Chengdu publishes the monthly statistics of waste disposal regarding landfills, incineration and composting on official website. And illegal violations related to local waste management can be responded and solved by City Administration Bureau through openly anonymous reporting procedure on website.

To fulfill the obligation required by *'Management regulation for household waste charge'*, each household is charged 8 CNY[2] (Around 1.23 US dollars) per month for the maintenance of waste management and this fee has not been changed since 2005.

[2] CNY: Chinese Yuan, the currency in Chinese Mainland. 1 CNY equals 0.15384 US dollar (1th August 2018).

And according to *Statistics Bureau of Chengdu (2018),* per capita disposable income of residents in 2017 is 38918 CNY (Around 5987 US dollars). People are actually paying less than 0.247% for household waste management.

4.3 SUSTAINABLE WASTE MANAGEMENT

In this section, the current situations of sustainable waste management in Chengdu are introduced and discussed.

4.3.1 SUSTAINABLE WASTE MANAGEMENT AND CIRCULAR ECONOMY

Sustainability of Existing Waste Management System and Circular Economy

As priory mentioned, currently incineration and landfill are main approaches of waste disposal in Chengdu and local government is making efforts to substitute traditional simple landfills for environment friendly incineration plants and sanitary landfills. And as it can be seen from Appendix 6 that all new environment friendly incineration power plants are located at the districts where there were only small-scale simple landfill sites earlier. This can be beneficial to the alleviation of local waste disposal pressure of landfills and the protection of local environment and public hygiene. Furthermore, Changan household waste sanitary landfill site has embedded with 'Comprehensive Utilization of Biogas (CDM[3])' programme in 2017, which has been the China's biggest biogas power generation project (20.8MW). However, this does not indicate that the municipal solid waste management system in Chengdu has sufficiently reached the standards of sustainable waste management. *Mengqing Xiong et al. (2009)* proposed that the sustainable waste management system must be built up through 4 phases as shown in Appendix 7, and only a few economically developed cities in China have reached the second phase.

Therefore, it can be apparently observed that Chengdu is making efforts on completely developing the second phase of waste management system when simultaneously exploring the schemes to reach the third phase, which is from an unsustainable model toward a quasi-sustainable model. In addition, as introduced in section 2.2.4, the sustainable waste management refers to running out the value of material resources as much as possible by handling of waste materials from source to disposal (Seadon, 2010). And it can be observed from the *Lansink's Ladder* as introduced in section 2.2.4 that the current practice of household waste management in Chengdu is mainly in the stage of development from disposal to energy recovery, which represents the least favored option for sustainable waste management.

According to *Lansink's Ladder*, compared to the disposal and energy recovery,

[3] CDM: Clean Development Mechanism. 'The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction limitation targets.' *(United Nations Framework Convention on Climate Change (UNFCCC), 2018)*

recycling is a better choice for sustainable waste management, and the recycling rate has been treated as a significant indicator in modern sustainable waste management. As introduced in section 2.2.3, in a circular economy, material flows are divided into biological cycle and technical cycle *(Ellen MacArthur Foundation, 2015)*. In terms of the biological cycle of household waste, besides energy recovery (biogas), the organic wastes can also be recycled to fertilizer and other biological materials. In terms of technical cycle of household wastes, the recycling industry and business in Chengdu have begun to take shape in recent years. According to *Chengdu Administration for Industry and Commerce (n.d.)*, till May 2018, there are 49 companies running business of recycling including paper, plastic, metal, glass, textile, rubber, electronic product, etc. Nevertheless, as mentioned in section 2.2.3 that a circular economy relies on three principles: (i) Design out waste and pollution; (ii) Keep products, components, and materials at their highest value and in use; (iii) Regenerate natural systems *(Ellen MacArthur Foundation, 2017)*. From these principles, it can be seen that the sustainable waste management is associated with circular economy situation, and certainly Chengdu has not reached a circular economy yet.

The Efforts Made on 3Rs of Wastes at Household Level

The collection of recyclables from producers is an important element for the development of recycling processing and businesses. In recent years, the recyclables collection business in Chengdu has been gradually developed. In the past, besides the waste transfer station, the small-scaled recyclable wastes collection business is another big supplier of recyclables. These recyclables are mainly purchased from scavengers, and some households are also selling recyclables to small-scale recyclable waste collection businesses irregularly *(Xiangfan Wu, 2007)*. And *Yingfang Lu & Xiangjun Sun (2002)* proposed that in order to well implement the separated waste collection, the involvement of government is indispensable and the government needs to build up a stated-owned recycling business. For propelling the recyclables collection at household level, Chengdu government signed the contract with innovative recyclable wastes collection company '*Chengdu Green Earth Co., Ltd.*' in 2011 that from 2012, Chengdu government would use the innovative business model created by *Chengdu Green Earth Co., Ltd.* for pilot programme of waste segregation collection in Jinjiang district. And this pilot programme is actually the predecessor of '*Wastes Bank*' programme which was initiated by the end of 2016, together with the construction of waste sorting out facilities.

Furthermore, as introduced in section 2.2.4, the reduce and reuse of waste can be considered as more favorable option in sustainable waste management when comparing with recycling. Regarding to the reduce and reuse of household wastes, household's behavior plays an indispensable role and propaganda activity is an effective measure that influences household's pro-environmental behavior *(Wellar & Barry, 1984)*. In order to well practice the 3Rs principle at household level, Environmental Protection Bureau of Chengdu initiated *'Let Environmental Protection Get Into Campus'* programme from April 2017 to January 2018 in all schools (including kindergarten) in

Chengdu. And City Administration Bureau of Chengdu has been continuously organizing propaganda activities every month in residential area of various district since 2017. These activities publicize the knowledge of separated waste collection and the practice of reduce, reuse of household wastes *(Environmental Bureau of Chengdu, 2017; City Administration Bureau of Chengdu, n.d.).* Moreover, Chengdu government has determined to distribute *'Handbook of household waste segregation'* to all the residents gradually from 2017.

From all the above here described, it can be seen that local government authorities have indeed made a substantive effort in different aspects to improve sustainability of local municipal solid waste management system over these years, such as constructing composting plant and environmental-friendly incineration plants, launching renovative programme (including Comprehensive Utilization of Biogas (CDM) programme of Changan sanitary landfill and 'Waste Bank' programme), and carrying out propaganda activities constantly. However, it also can be observed that Chengdu still has a long way to go before truly reaching the sustainable waste management.

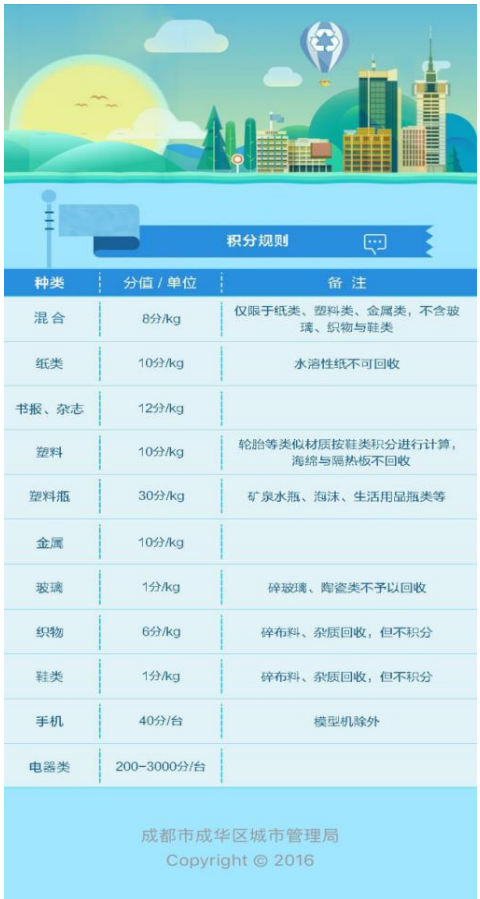
4.3.2 WASTE BANK AND HOUSEHOLD PARTICIPATION

As mentioned earlier, the 'Waste Bank' business model was created in 2008 by an innovative recyclable waste collection company called 'Chengdu Green Earth Co., Ltd.', which has been taking on the job of recyclables collection for City Administration Bureau in Jinjiang district since 2012. It was originally a pilot project, but after years of improvement, it has become more systematic and refined. And finally, City Administration Bureau determined to popularize the 'Waste Bank' programme in large-scale in 2017. At meantime, according to *City Administration Bureau of Chengdu (2017)*, the enterprises that want to do business of recyclable waste collection must be selected through a bidding process. The applicant enterprise can be either a private enterprise or a state-owned enterprise, but the operation must be managed by the government.

Figure 8. QR code stickers, degradable garbage bag and recyclable garbage bin (Chengdu Green Earth, 2018)

In simple terms, the core of the 'Waste Bank' is transaction between the residents and the City Administration Bureau. The City Administration Bureau will provide different points to the residents based on the type and weight of recyclables collected from them,

these points can be exchanged for commodities or cash. To use the 'Waste Bank', residents must first register an account with their real name (the same name on the ID card) and the real home address through the smartphone app of 'Waste Bank'. The recyclable waste collection company will then send the user special QR code stickers (as shown in figure 8) and degradable trash bags. Before throwing recyclables into the recyclable waste bin, the user needs to attach a special QR code sticker to that degradable garbage bag. Since these recyclables are collected from recyclable bins, the company will identify the information through different special QR codes and transfer the points into the user's account. Finally, users can redeem these points into goods or cash from designated stores and bank, each point is worth 0.05 CNY (Around 0.0077 US dollar) at present (May 2018).



The rules of accumulating points of 'Waste Bank' (as shown in figure 9) are:

1) Mixed wastes of paper, plastic and metal (excluding glass, textile and shoes): 8 points/kg;
2) Paper only (excluding water-soluble paper): 10 points/kg;
3) Newspaper and magazine: 12 points/kg;
4) Plastic only (excluding sponge and thermal baffle): 10 points/kg;
5) Plastic bottle: 30 points/kg;
6) Metal only: 10 points/kg;
7) Glass only (excluding cullet and ceramics): 1 point/kg;
8) Textile only (excluding rag): 6 points/kg;
9) Shoes: 1 point/kg;
10) Mobile phone: 40 points for each one;
11) Electrical equipment: 200-3000 points for each one.

Figure 9. Rules of accumulating points (City Administration Bureau of Chengdu, 2018)

Furthermore, to help users who have no knowledge about waste sorting collection, the guidelines for waste sorting collection are available on smartphone app of 'Waste Bank'. Again, for being open to public scrutiny, City Administration Bureau also publishes monthly statistics of recyclables collection and households had covered by waste sorting out collection programme on their website.

However, the results of recyclables collection and status of household participation are not ideal enough. According to Statistics made by City Administration Bureau, as of the end of 2017, the 'Waste Bank' had covered 1,216,931 households and in total of 90976.36 tons of recyclables had been collected. And according to 'The Sixth National Census of Population' (National Statistics Bureau of China, 2016), Chengdu has in total of 4,547,109 households. Therefore, based on calculation, the amounts of recyclables recovered from households in 2017 is around 421951.68t, which means that only less than 21.56% of recyclables generated from covered households had been collected. Furthermore, based on the statistics made by City Administration Bureau from January 2017 to March 2018 (latest data, accessed on 27th May 2018), the number of covered households and recyclables collected are presented in Appendix 8. And It can be observed from Appendix 8 that, as the number of covered households has increased significantly, the amounts of recyclables collected per month has stabilized at around 7000t to 8000t rather than steadily increasing. And it has drastically decreased to around 5500t from November 2017. It can be assumed that some problems had occurred on household participation or waste collection capacity. This assumption can be confirmed by the document of *'Progress Report of Waste Segregation Collection'* published by City Administration Bureau in 2017, which noted the encountered obstacles have met in the management of waste sorting collection are:

1) Residents lack knowledge and awareness of waste sorting collection, the situation of throwing commingled waste is still in existence;
2) Propaganda activities are still insufficient and simple;
3) The working efficiency of staff is relatively low and the management still needs to be improved.

CHAPTER 5. HOUSEHOLD PARTICIPATION IN LOCAL

In order to figure out the real conditions regarding practices of the 3Rs principle at household level and household's perceptions of factors that affect their participation behavior in local waste management, a survey was conducted to understand these issues from the household's viewpoint. This section is dedicated to present the results of survey and the discussions about household participation in local waste management. The data were collected through questionnaires, direct observation and informal interviews with residents of the two communities (as shown in figure 10). In addition, a desk-research was made as well to validate the empirical data.

5.1 THE COMMUNITIES ANALYSED IN CHENGHUA

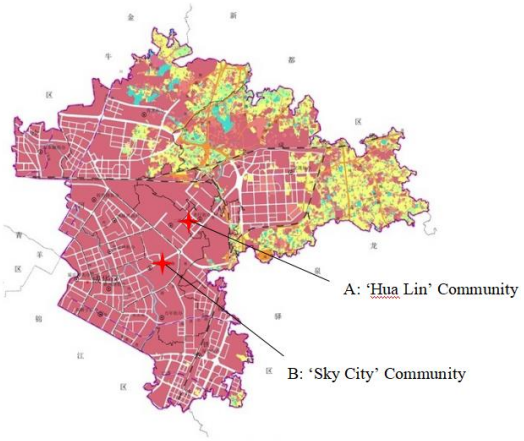


Figure 10. The location of targeted communities (Adapted from The Bureau of Land and Resources of Chengdu, 2017)

As mentioned in section 3.4.3, the selected sample should be representative if the simple size in research is small, and the logic of sample selection should be based on the research objectives and questions *(E. Babbie, 2004)*. In this research, two communities in Chenghua district (see figure 10) were selected and the respondents involved in this research were 60 adults randomly selected from each community. The two communities can be considered representative and similar in the following aspects:

Living Conditions

As the local City Administration Bureau provides waste management service covering all districts in Chengdu, similar to other local residential areas, these two communities have a good living environment as well. People did not live in an environment surrounded by trash because there are many communal waste bins conveniently available to residents inside the communities, and the garbage is usually cleaned up in time. Moreover, as the government has gradually carried out the shantytown renovation project for over 10 years, currently the typical residence (building) type is normal

apartment, instead of old tube-shaped apartment[4] and bungalow. Similarly, the two communities are also composed of normal apartments, each with more than 2000 households. The only difference between them is that A (Hua Lin) community has implemented the 'Waste Bank' programme and B (Sky City) community does not have it yet. The effectiveness of the "Waste Bank" programme was evaluated by comparing two communities.

Composition of Residents

As Chengdu has a few communities specifically available to single adults, elders, ethnic minorities and people who are engaged in the same work (for example, the military and the medical staff), these types of residential area cannot be considered representative because these residents might have different living habits and waste management approaches, and compared to other ordinary residential areas, the number of these communities is very small. Therefore, the two communities selected are similar to most of other ordinary local communities, which are made up of people of various profession and ages, such as children, adults and elders. Moreover, according to the survey's respondents, the monthly income of respondents' sample for the two communities are distributed as shown in figure 11. From figure 11, it can be seen that most of the respondents are grouped in two income level categories: "less than 3000 CNY[5] (Around 461.5 US dollars)" and within the rage of "3000 to 6000 CNY". In 2011, the central government regarded per capita net income of 2300 CNY (Around 353.8 US dollars) as the new standard for national poverty alleviation, which means that people with an annual income of less than 2300 CNY can apply for government poverty alleviation subsidies *(People's Daily, 2011)*, it is evident that the residents from the two communities cannot be considered impoverished. As mentioned in section 4.2.2, the average per capita disposable income of Chengdu residents in 2017 was 38918 CNY (Around 5987 US dollars) and according to the *Statistics Bureau of Chengdu (2017)*, the average per capita consumption expenditure of Chengdu residents in 2017 is 22039 CNY (Around 3390.5 US dollars). Although there are no explicit criteria to identify high-income people in China at present, it still can be seen from above that the residents from the two communities cannot be considered rich as well. It is more appropriate to classify them as ordinary residents.

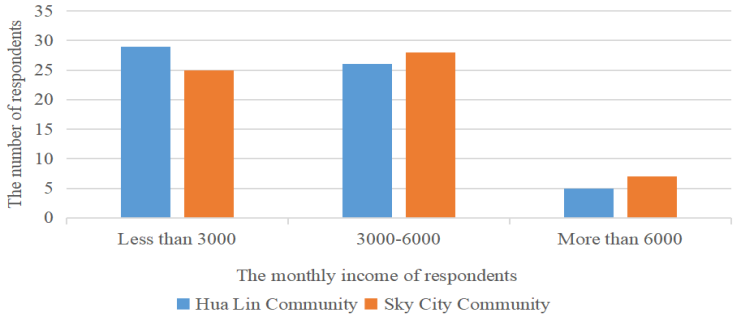


Figure 11. The distribution of respondent's monthly income

[4] Tube-shaped apartment: A type of apartment with a corridor running through the main structure with rooms on both sides of it. Usually there are over ten families living on one floor and each family lives in one room. The kitchen and the toilet are shared by families *(People's Daily, 2013)*.

[5] CNY: Chinese Yuan, the currency in Chinese Mainland. 1 CNY equals 0.15384 US dollar (1th August 2018).

5.2 THE RESULTS AND ANALYSES OF SURVEY

As introduced in section 2.3.2, there are 4 external factors and 5 internal factors that affect people's pro-environmental behavior of waste sorting and 3Rs principle practices. The 4 external factors include: *(i) Availability of Technical Facilities; (ii) Economic Incentives; (iii) Governmental Regulation and; (iv) Societal Incentives*. And the 5 internal factors are: *(i) Motivation; (ii) Attitude; (iii) Environmental Knowledge; (iv) Perceived Consumer Effectiveness and (v) Income Level*. This section is dedicated to present and discuss the household perception about these internal and external factors and difficulties involved in waste sorting collection.

5.2.1 THE SITUATION OF HOUSEHOLD PARTICIPATION IN WASTE SEGREGATION AND 3RS PRINCIPLE PRACTICE AT HOUSEHOLD LEVEL

Before discussing the impact of internal and external factors, it is necessary to first present the current situation of waste sorting collection and 3Rs principle practice at household level. Firstly, according to the people interviewed for this research, the waste sorting collection has a clear growth as the result of implementation of 'Waste Bank' programme. In Sky City Community, around 28.3% of respondents were sorting out waste before throwing away, this figure increases to 51.7% in Hua Lin Community (see figure 12). Then, the degree of reuse and reduce of waste are higher. About in total of 67.5% of respondents noted that they are reusing used products in their daily life, and almost all of the respondents consciously avoid wasting the raw materials and products. From figure 12, it can be observed that there is a slight decrease between the two communities in the number of people who reuse waste. In Sky City Community, 71.6% of respondents are reusing used materials, but about 63.3% of respondents in Hua Lin Community are doing so (see figure 12), because a few respondents in this community mentioned that they used to reuse old materials in the past, but recently they put the used products such as plastic bottles and old cloths directly into the 'Waste Bank' recyclable bins.

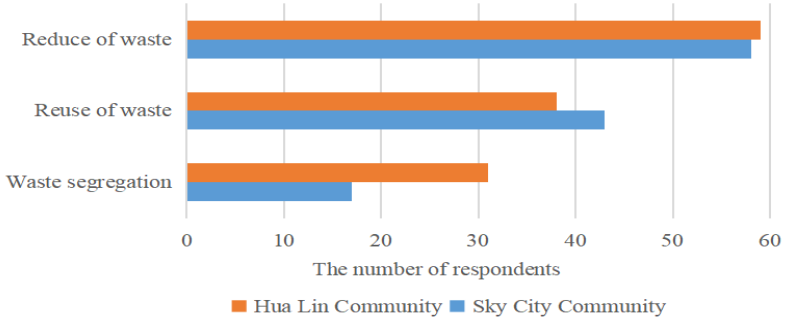


Figure 12. The statistics of the practice of 3Rs principle at household level

5.2.2 THE EXTERNAL FACTORS

In the case of the first external aspect (the availability of technical facilities), it could be observed that in both communities, there are 3 commingled garbage bins in front of the entrance of each apartment complex. Though one of the main differences between

them is that in Hua Lin community, there are two waste bins near the commingled garbage bins for recyclables and hazardous wastes (as shown in figure 13).

Figure 13. The garbage bins in Hua Lin Community (Left one) and Sky City Community (Right one) (Fieldwork, 2018)

In the case of the second aspect (economic incentive for separating the wastes), by doing desk research and interviews to key informants, it was found that there is not any kind of economic returns (money and goods) from the government to the residents in Sky City community. The only way for them to receive economic returns is by selling recyclable materials to recyclable waste collection companies. But for the residents in Hua Lin Community, it was observed that the 'Waste Bank' can be an actual source of financial returns, which seems to be more accessible to the residents.

The governmental regulations, the third aspect, through some enquiries and documents review, it was possible to confirm that there are neither compulsory programs nor penalty systems in placed on waste segregation to be imposed in any of the two communities studied, which is similar to other communities in Chengdu. The only formulated penalty is that according to *'Management regulations for household waste'*, people who litter and dump garbage at random could be fined 200 CNY (Around 30.77 US dollars), which is applicable to all residents in Chengdu.

As for the forth aspect, the societal incentives, no evidence was found about any promotional programme such as clean-up campaigns, or regular propaganda activities and/or educational programs in any of the two communities that make part of this research. The only difference between them was that there are bulletin boards (see figure 14) near the garbage bin in Hua Lin Community, which show how waste segregation should take place.

Figure 14. The bulletin board in Hua Lin Community (Fieldwork, 2018)

Regarding the individual's perception of these external factors, according to the answers to the questionnaires, the governmental regulation appeared to be the least favored option to respondents. Only around 15.8% of respondents think the penalties and compulsory programs are acceptable to them. People seem to be averse to compulsory activities, even for some respondents who expressed their willingness to contribute to local waste management by voluntary. The acceptance of societal incentives appeared to be much better. In total of 45% of respondents feel acceptable to attend the social activities including propaganda activity, educational programs and clean-up campaign. Then, as far as the availability of technical facilities is concerned, 73.3% of respondents in Sky City Community noted in questionnaire that they would sort out the wastes or have a try to do so before throwing it away if there are facilities for waste segregation in their community. However, if compared with the actual situation of waste sorting in Hua Lin Community, it can be seen that many of the respondents in Sky City community might not seriously determined to engage in waste segregation. Finally, in terms of financial incentives, according to the answer to the questionnaire, it was the most favored option to all of the respondents. Therefore, from above, the household's perceived acceptance to 4 external factors can be summarized into table 5:

Table 5. Individual's acceptance to external factors

Most favored option	Financial incentives
↓	Availability of technical facilities
	Societal incentives
Least favored option	Governmental regulations

5.2.3 THE INTERNAL FACTORS

Motivation

According to the survey's answers, only less than 9.2% of respondents had a negative view on waste segregation (have no interest to sort out the wastes), most of the respondents thought it was not completely unacceptable to them and pointed out that they could have a trial if it is needed. For respondents who are sorting out the wastes, economic return represents the most popular reason, even for respondents who expressed real concerns about the environment from the answers. Meanwhile, the availability of technical facilities has indeed played an important role in promoting waste sorting collection. Many respondents mentioned during the interviews that the 'Waste Bank' provides them with convenience that they used to have no time to go to the recyclable collection station to sell recyclables, but now there is 'buyer' (the 'Waste Bank') nearby. And some-one noted that they prefer to use this type of 'novelty'. Then, there are diverse perceived difficulties mentioned by respondents who have not sorted out the wastes and who have negative views on waste sorting. Apart from lacking in recyclable waste bin noted by residents from Sky City community, there are still some frequently occurred reasons: busy in work; time-consuming to sorting out waste and

troublesome; not accustomed to waste sorting; and lack of knowledge about waste segregation.

Regarding the reuse and reduce of waste, all respondents were willing to consciously avoid wasting raw materials and products, but there was no significant increase in positive views of reusing used products. There are various approaches of reusing used products noted by respondents, such as using old plastic and glass bottles as sprinklers, flavor containers and water glasses, or making cushions by old cloths, etc. Some respondents also mentioned that they usually donate old books and old clothes for others to reuse, to make full use of these old things. Nevertheless, the most frequently occurred reasons noted by respondents who have negative views on reusing the used products are: the used materials could have toxic effects on their body; and the used materials have no practical values. For the reason to avoid wasting raw materials and reuse old products, many respondents thought this is because their economic conditions are not very good, only a few answers noted that reusing and reducing waste are beneficial to our environment. There is a noticeable and interesting point that many answers appeared in questionnaires and interviews including: practicing thrift is the traditional virtue of the Chinese nation; saving is beneficial to our descendants; saving is glorious and waste is shameful. In fact, all these answers are propaganda slogans of Chinese government over the years.

Attitude

According to the answers to the questionnaires, almost all respondents agreed that environmental protection is important. And there are some propaganda slogans occurred as well such as: clear waters and green mountains are silver and gold mines; or protecting environment is everyone's duty. However, respondents' attitudes towards the responsibility of local solid waste management are negative. Less than 26.7% of respondents thought that they could do something voluntarily or felt responsible for it. Around 48.3% of respondents viewed it as the mission of local municipal authorities, and noted that the government has to shoulder that mission because they have paid taxes already; or compared with garbage issues, they are more concerned about the air pollution and water pollution that they have suffered for years, like smog and contaminated rivers outside the community. Regarding the effectiveness of waste management in the two communities, almost all respondents thought it is acceptable because the garbage in the waste bin would be emptied by the staff every day (as shown in Appendix 9).

Environmental Knowledge

According to the answers to the questionnaire and interviews, only 10% of respondents were found having relatively comprehensive understanding about waste management including waste disposal, recycling processes and other environmental issues. For instance, many of them understand that the reuse and reduce of waste contribute to the mitigation of air pollution and energy consumption. But for the rest of the respondents, most of them were unaware that the practice of 3Rs principle could alleviate many other environmental problems, and some respondents even have no concerns about where the garbage would be delivered to and how it would be disposed. And it was found that respondents who have relatively comprehensive knowledge about waste management

were holding obvious positive perception regarding pro-environmental activities. All these respondents are reusing and reducing waste, sorting out garbage regularly or sometimes, having the sense of responsibility and willingness to do some contribution to the local waste management voluntarily.

Perceived Consumer Effectiveness

According to the answers to the questionnaires, approximately 68.3% of respondents noted that they are willing to buy products that have less negative impact on environment if the price is acceptable and the quality is the same. The most frequently occurred reason was that they believed that the product that has less negative impact on environment is beneficial to themselves as well, such as organic vegetables, LED light bulbs, non-phosphate powder detergent and non-disposable products like chopsticks, shopping bag, etc. However, when they were asked for the reason to buy non-phosphate power detergent and non-disposable products, they answered that for non-phosphate power detergents, they just had previously heard that this product was environmental-friendly and less harmful to their body, and many of them even did not know what the phosphate is. And for non-disposable products, they believed that the non-disposable means durable and good quality. Meanwhile, some respondents mentioned that they are now using their own shopping bag, because since the national government implemented the *'Restricting plastic order'*[6], free plastic bag was no longer available in all supermarkets.

Income Level

According to the answers to the survey, it was found that almost all the respondents who sort out the waste were earning monthly income of either less than 3000 CNY (Around 461.5 US dollars) or 3000 to 6000 CNY (Around 923 US dollars) (as shown in figure 15). And as mentioned earlier, these respondents considered their economic condition not good enough, and pleased to receive economic returns from waste sorting and to practice thrift including reusing old products and avoiding waste of raw material in their daily life.

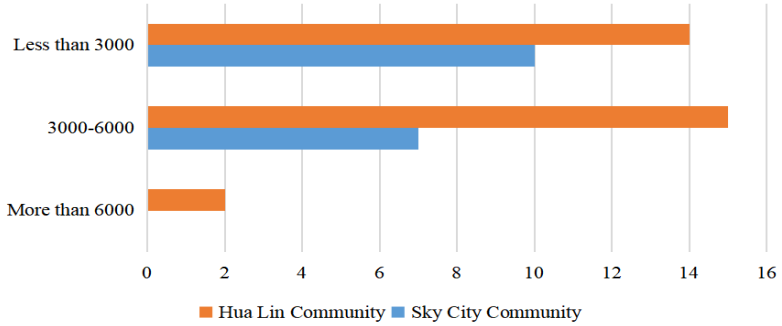


Figure 15. The number of respondents sorting out the waste and their income situation

5.3 DISCUSSION

[6] Restricting plastic order: to control the 'white pollution', from the 1st of June 2008, the Chinese central government forbids to produce and sell plastic shopping bags with thickness less than 0.025 millimetres. Moreover, the plastic shopping bags that are used in supermarkets, shopping malls, markets and other retailers are forbidden to be provided free of charge (The General Office of the State Council of China, 2008).

According to the results of the survey, it was found that in total 40% of the respondents were sorting out the wastes. And it was observed from reality that the scavengers came to the community to collect recyclables as usual, because there were still lots of recyclables thrown into the commingled garbage bins (see Appendix 9). And the phenomenon of randomly dumping garbage and littering are still in existence (see Appendix 9).

Therefore, in order to improve the level of household participation in local waste management and to improve the sustainability of waste management at household level, it is needed to analyze the factors that contribute to the emergence of current situation to find the possible solutions. Some of them in accordance to the literature (section 2.3.2) are here described.

Attitude

As introduced in section 2.3.2, people with pro-environmental attitudes are expected to behave in a way in accordance with that attitude, such as supporting environmental protection activities and the environmental attitudes are the determinant of waste sorting behaviors *(Tilikidou ,2007; Minton & Rose, 1997)*. However, it was found from survey that, although almost all respondents agreed that environmental protection is very important, 40% of respondents were sorting out the wastes, 45% of respondents were acceptable to support environmental activities and less than 26.7% of respondents had willingness to contribute to local waste management voluntarily. Then why apparently the pro-environmental attitude is not directly observed in the people's behavior by participating in the waste management options?

Feng Wang (2007) made a comparative analysis based on the surveys of Chinese citizens' pro-environmental behavior made in 1998 and 2006, proposed that as the result of the remarkable improvement of public environmental knowledge, their attitudes towards environmental protection has been switched significantly. But people evidently lacked the sense of responsibility for environmental protection, their pro-environmental behaviors were strongly bundled with self-interests, and they were toughly dependent on the government regarding environmental protection. Similarly, based on a survey conducted in 34 cities in China (including Chengdu) in 2013, *Lei Wang & Yang Zhong (2014)* proposed that people had an obvious dependence on the government regarding environmental governance, and their pro-environmental behavior and willingness to participate in have a positive correlation with the extent to which they were exposed to the environmental problem and their understanding of the causes of the pollution.

As mentioned earlier, it was also found in this research that the respondents have more concerns about air pollution and water pollution than garbage problem because they thought the current waste management in their community was acceptable. And around half of respondents viewed the waste management as the mission of local government. And it seems to be impossible to arouse residents' attention to local waste management through letting them live in an environment surrounded by garbage. Therefore, to switch residents' attitude and increase their sense of responsibility, it is needed to arouse their awareness primarily.

Environmental Knowledge

So how can people's awareness be aroused? As introduced in section 2.3.2, *Izagirre-Olaizola, et al. (2014)* proposed that environmental knowledge is a significant factor that influencing pro-environmental behavior. The knowledge about general environmental issue and specific knowledge about recycling have significant influences on waste sorting behavior as well *(Vining & Ebreo, 1990; Desa, et al., 2011)*. Similarly, *Ningning Li (2001)* proposed that the arousal of public awareness has three stages and it is affected by the level of environmental knowledge. At the first stage, individuals only have little and piecemeal environmental knowledge. They just passively accept the environmental knowledge from outside and have almost no understanding of environmental issues. At this stage, they do not care about environment and would not associate environmental issues with themselves. They also would not restrain their behavior for protecting environment, and the level of their participation in environmental protection activities is quite low. At the second stage, individuals have sufficient environmental knowledge and would learn more environmental knowledge forwardly. At this stage, people start paying attention to environmental problems, they would have sense of crisis and anxiety when they realized that the environment is deteriorating. Meanwhile, they would be aware of their responsibility for environmental protection and do contributions to environmental protection based on their capacity. At the third stage, people have comprehensive environmental knowledge, and strong sense of responsibility. They would energetically participate in environmental protection activities and organizations, and they might even choose a career in relation to environmental protection. Likewise, *Feng Wang (2008)* found that the environmental knowledge is a prerequisite for people to form pro-environmental behavior, for instance, people with a high level of environmental knowledge are more likely to monitor and report environmental violations.

As mentioned earlier, it was found from the survey that only 10% of respondents have relatively comprehensive understanding of waste management and other environmental issues, and these respondents were more willing to contribute to local waste management and behaving in a pro-environmental way. For the rest of respondents, they were unaware of the significance of the 3Rs principle practice, and even viewing old products is worthless and harmful (toxic). From discussion above, it can be seen that most of respondents are at the first stage of awareness arousal, they have piecemeal environmental knowledge and less sense of responsibility for waste management. Therefore, it is needed to awaken public awareness by spreading environmental knowledge. And the propaganda seems to be an important approach since people are passively accepting environmental knowledge when they are at the first stage of awareness arousal.

Income Level

According to *Bin Ouyang, et al. (2015)*, there is a positive correlation between people's income level and their pro-environmental behavior. And *Xiaobing Guo & Hongmin Guo (2015)* conducted a survey in Urumqi, China in 2013 and found that people with lower income had weaken environmental awareness and worse pro-environmental behavior. Household (2 adults) with total monthly income exceeding 10000 CNY (Around 1538.4 US dollars) are more likely to behave in an environmental-friendly

way in the daily life than household with total monthly income below 5000 CNY (Around 769.2 US dollars). As presented earlier, 90% of respondents were grouped in two income level categories: "less than 3000 CNY (Around 461.5 US dollars)" and within the rage of "3000 to 6000 CNY (Around 923 US dollars)", and around 42.6% of them were sorting of wastes. These respondents expressed that they were sorting out the wastes and reusing old products because their economic conditions were not good enough and practicing thrift is good behavior. And as mentioned earlier, it was observed that randomly dumping and littering were still in existence in the two communities. Therefore, since rising public environmental awareness needs a long-term effort, the economic returns could be indispensable in current phase.

Motivation

As introduced in section 2.3.2, according to *Value- Belief -Norm (VBN)* theory, the motivation of household participation is built on egoistic, altruistic and biospheric values *(Izagirre-Olaizola, et al., 2014)*. *Xiaole Huang & Zhijian Jiang (2010)* explained that people's behavior is built on different value orientation and the prosocial behavior is derived from the activation of personal norms (PN). Personal norms refer to the informal obligations that enforced through internalized sense of responsibility, which triggers emotions related to guilt when the individual did not execute. Personal norms will be activated when an individual acknowledges that the failure to perform prosocial behavior will cause adverse consequences to others, which is called awareness of consequence (AC), and subsequently the individual will feel responsible for these adverse consequences, which is also named ascription of responsibility (AR) (see figure 16).

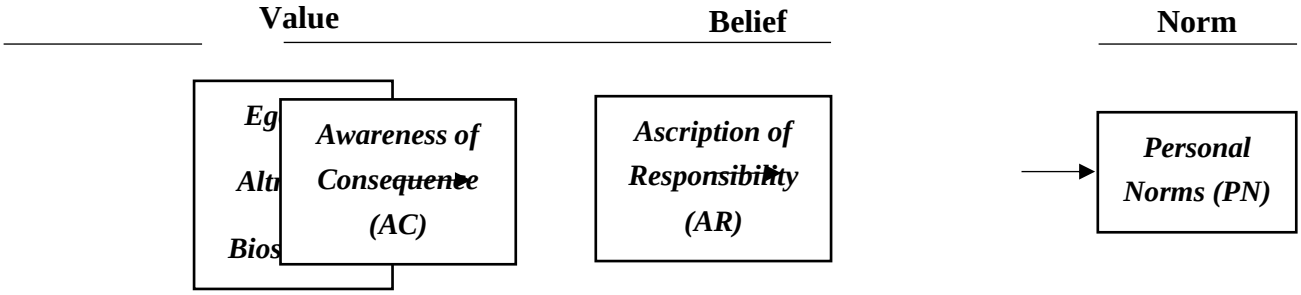


Figure 16. Value – Belief – Norm (VBN) theory (Adapted from Xiaole Huang & Zhijian Jiang, 2010).

J. Groot & L. Steg (2009) proposed that although egoistic consideration might lead to a pro-environmental action, the most stable basis for pro-environmental behavior is mainly formed by altruistic and biospheric considerations. Likewise, *Xiaole Huang & Zhijian Jiang (2010)* insisted that the form of altruistic and biospheric values are prerequisite to the activation of personal norms. And environmental education can facilitate the transition of value orientation as well as arousal of awareness (AC) and sense of responsibility (AR). As introduced earlier, it was found from survey that 60% of the respondents did not sort out the waste, they considered waste sorting inconvenient, time-wasting, troublesome and worthless. And for people who were sorting out waste and reusing old products, only a few respondents expressed their

concerns about environment rather than themselves. Hence the environmental education is necessary for transforming individuals' value orientation and awakening their awareness of consequence (AC) and ascription of responsibility (AR).

Perceived Consumer Effectiveness

As introduced in section 2.3.2 perceived consumer effectiveness refers to the fact that the consumers have the demand to ensure that their behavior have a positive impact on the environment. They will have more willingness to engage in a specific activity if they believe that it could solve an environmental problem *(Laskova, 2007)*. Similarly, *Aizhong He, et al. (2012)* found that consumer's behavior would be changed if they felt the harm caused by environmental problem. When consumers perceived that the deterioration of the local environment and ecology has begun to affect their lives, they were more inclined to buy 'green' foods and travel in a 'green' way. As priory mentioned, 68.3% of respondents in the survey were certainly acceptable to purchase environmental-friendly products based on the premise of acceptable price and same quality but most of them did not show clear understanding about environmental-friendly products. Again, it can be seen that popularizing the environmental knowledge is demanded.

Governmental Regulations and Societal Incentives

As mentioned in section 2.3.2, the propaganda could develop household's waste sorting behavior and people can be collectively responsible in organized activities such as meetings and clean-up campaigns *(Wellar & Barry, 1984; Colon & Fawcett, 2006)*. In addition, compulsory programs conducted by government have more participants than voluntary programs and penalties could stimulate household participation initiatives *(Noehammer & Byer, 1997; Noh et al., 2012)*. As discussed earlier, both societal incentives and governmental regulations are insufficient in the two communities. Though it was found that the governmental regulation represented the least favored choice to local residents, sometimes it is still needful due to the emergence of littering and randomly dumping. In the case of propaganda, many respondents from Sky City community mentioned that they had heard nothing about the 'Waste Bank' and the bulletin board in Hua Lin community only displayed basic knowledge for waste sorting collection. Neither educational programs nor organized activities such asclean-up campaign were shown in existence in the two communities. As priory discussed, environmental education plays a crucial role in increasing public awareness and their sense of responsibility for local waste management. Hence societal incentive, especially the environmental education is the field where more efforts needed to be made.

Availability of Technical Facilities and Financial Incentives

Financial incentive can be a direct impetus to promote waste sorting behavior *(Everett & Peirce, 1993; Lin Xu, et al., 2017)* and the availability of technical facilities is a remarkable contributor as well *(Derksen & Gartrell, 1993; Achankeng, 2003)*. Indeed, these two aspects have shown an appreciably positive impact on households' waste sorting behavior in the survey. It was found that around 28.3% of respondents from Sky City community sorted out the wastes for economic returns, and this figure have increased to 51.7% when a more accessible recyclables acquirer (Waste Bank) emerged

in Hua Lin community. But many elder respondents from Hua Lin community complained that they were still not getting used to the ‘Waste Bank’ and they could receive more money if directly selling recyclables to recyclable wastes collection station. In the case of reusing old materials, around 67.5% of respondents was found reusing and donating old products, and no evidence has shown that there are available technical facilities near the two communities in the case of reusing old products, such as regularly opened flea market and workshops for the renovation of old products. Therefore, in order to facilitate the sustainable waste management at household level, more opportunities (technical facilities and financial incentives) need to be offered to local residents apart from awareness arousal.

CHAPTER 6. IMPROVEMENT APPROACHES FOR LOCAL MUNICIPAL SOILD WASTE MANAGEMENT AT HOUSEHOLD

LEVEL

In this section, the possible approaches for improving sustainability of local waste management at household level are proposed and discussed.

6.1 TECHNICAL FACILITIES

As presented in section 5.2.2, the existing garbage containers placed in residential areas in Chengdu were only simply divided into comingled garbage bin, recyclable waste bin and hazardous waste bin, which means that the recyclables are collected from the recyclable waste bin in an integrated manner without further classification. As recyclables still require deeper separation after collection, further classified waste container could allow them to be more sufficiently separated at the source.

In Japan, before throwing out the trash, households need to separate recyclables into *(i) Waste Paper; (ii) Cartons; (iii) Plastic Containers and Packages; (iv) PET Bottles; (v) Cans and (vi) Bottles (Geihoku Kouiki Kirei Center, 2010)*. *Yingfang Lu & Xiangjun Sun (2002)* also proposed that in order to develop waste sorting collection in China, communal garbage containers need to be further classified into recyclable paper bin, recyclable glass bin, and metal recyclables bin. In the Netherlands, it was observed that there were further classified recyclable waste bins available in residential area (see figure 17). And the bottle even needs to be separately put into recyclable glass container according to its color *(White, Green and Brown)*.

Figure 17. The recyclable wastes bin in the Netherlands (Fieldwork, 2018)

Additionally, there is no reverse vending machine available for recyclables collection in supermarkets and retailers in Chengdu at present. The ‘Waste Bank’ only intends to cover residential area, and the waste containers placed in supermarkets and shopping malls are still commingled waste bins. The City Administration Bureau could encourage local companies to develop recyclables reverse vending businesses in collaboration with large-scaled local retailers and shopping malls such as *“Hongqi Chain”*, *“Wudongfeng”*, *“WoWo”*, which can be a complementary element to the ‘Waste Bank’ programme. Chengdu City Administration Bureau can draw lessons from these types of further separated recyclables collection approaches, which not only facilitate the waste sorting collection but also provide more convenience to local residents. For instance, an innovative company named *“TOMRA JAPAN”* has become

a successful business case of reverse vending machines in the field of recyclables collection, which captures over 35 billion used beverage containers and avoids total greenhouse gas emission equals the emissions from 2 million cars (each driving 10000 kilometers) every year *(TOMRA JAPAN, 2017)*.

6.2 WASTE DISPOSAL CHARGE

As introduced in section 4.2.2, currently the waste disposal charge to each household in Chengdu is 8 CNY[7] per month, which has not been changed since 2005. To some extent, this type of charging is unreasonable because it does not charge households based on the amount or the volume of waste generated by them and the number of people in the household. It does not reflect the principle of fairness and polluter pays.

According to *Xinhua Net (2017)*, Environment Bureau of Hongkong would implement a new garbage charging method from 2019 on the basis of the polluter pays principle. Residents have to use 9 types of designated garbage bags from 3L to 100L, which charges 0.11 Hongkong dollar (HKD[8]) per liter. In addition, for oversized garbage that cannot be put into the designated garbage bag, a specified label must be attached on it before throwing off, which charges 11 Hongkong dollar (HKD) for each one. And in Hongkong, the illegal actions such as littering and randomly dumping can result in a fine of 1500 Hongkong dollar (HKD). Likewise, according to *Japan Info (2015)*, the oversized wastes can be charged according to its volume. In Shibuya, Tokyo, the disposal charge for each chair, bed mattress and sofa are 400 Yen (JPY), 1200 Yen (JPY) and 2000 Yen (JPY[9]) respectively. In fact, the Chengdu City Administration Bureau can draw lessons from these charging methods. The revision of current charging method and the practice of the polluter pays principle could alleviate the financial pressure for waste disposal as well as raise public awareness. Residents need to realize that as the consumer of products and the producer of wastes, they are also responsible for disposal of these wastes. And it could have positive impact on the reuse and reduce of waste as well.

6.3 CORPORATION WITH MANUFACTURERS

In order to enhance the prevention of pollutions and wastes generated in China, the government needs to develop a circular economy model in collaboration with manufacturers in industry *(Guodang Zhao, 2016)*. Currently, no evidence was found in Chengdu that there are these types of cooperation and agreements between local government and manufacturers.

In Germany, according to *Umweltbundesamt (Federal Environmental Agency) (2015)*, the federal government enacted the packaging ordinance *"Verpackungsverordnung"* in 1991 which had been amended 7 times after then. The packing ordinance required product manufacturers to shoulder the mission of waste management of product stewardship that the packages they placed on the market must be taken back for reusing and recycling, or it can be implemented by a third party. And the retailers are also obligated to return the packages. Moreover, it stipulated that at least 65% of packaging

[7] CNY: Chinese Yuan, the currency in Chinese Mainland. 1 CNY equals 0.15384 US dollar (1th August 2018).
[8] HKD: Hongkong Dollar, the currency in Hongkong, China. 1 HKD equals 0.12784 US dollar (1th August 2018).
[9] JPY: Japanese Yen, the currency in Japan. 1 JPY equals 0.008835 US dollar (1th August 2018).

waste must be recycled and 55% of them need to be used in recycled products annually. Regarding electrical and electronic waste, the federal government established a mechanism called *"Divided Product Responsibility"* indicating that the recycling companies in public sector and the electrical and electronic device manufacturers are both obligated for the disposal operations of electrical and electronic waste *(Umweltbundesamt, 2015)*.

The manufacturer holds the professional knowledge and technologies for their products and materials, which are needful elements to waste management apart from labor forces, financial supports and technical equipment. The cooperation between waste management authorities and manufacturers in industry can close the loop of materials flow, thus the effectiveness of waste and pollution prevention can be upgraded (*Guodang Zhao, 2016).* Therefore, Chengdu City Administration Bureau, local manufacturers and retailers can reach an agreement that jointly seeking the possible approaches for recycling management, which can have positive impact on the growth of sustainable waste management and the transition toward a circular economy.

6.4 FORMULATION OF SOCIAL ENTERPRISE

As discussed in section 5.3, it was found that currently there was no business related to the reuse of old products near the two communities. And the emergence of *"Re-use"* businesses such as renovating workshops and flea markets can provide local residents with more opportunities to maximize the use of their belongings.

For instance, a social enterprise in Bedford, England named *'The Re-Use Centre'* is running the business of product renovating. It collects donations from households in local communities, such as old clothes, crockery, furniture and domestic appliance, and sells them at low prices after renovation and cleaning. And it also provides volunteers with training in a range of skills. The Chengdu government could encourage the establishment of social enterprises related to *"Re-use"* business in each local residential area. It could either facilitate the reuse of old materials or provide local residents with employment opportunities and working skills.

6.5 EDUCATIONAL PROGRAMME

As introduced in section 4.3.1, the Environmental Protection Bureau of Chengdu initiated educational programme named *'Let Environmental Protection Get into Campus'* from April 2017 to January 2018 in local primary and secondary schools. It was a comparatively large-scaled programme in recent years, though the duration was only around 10 months. Similar to the most of cities in China, the environmental education in Chengdu is at the initial stage as well. *Youyi Tian & Jingwei Li (2016)* stated that the main problems of existing environmental education in China are: (i) the absence of systematic theories on environmental education system and (ii) the lack of related laws or ordinances supporting environmental education. Although the national government had been paying attention to environmental education since 1973, the Ministry of Education had so far only recommended rather than ordered the environmental education to be integrated into the existing education system. And 89% of the primary and secondary schools in 25 provinces in China had no weekly opened environmental education courses *(Youyi Tian & Jingwei Li, 2016)*.

Japan is a country that benefits from its advanced environmental education system. According to *Jihe Liu (1998)*, the government of Japan enacted *"The Basic Law for Environmental Pollution Control"* and instituted National Research Association of Public Nuisance in Primary and Secondary School to grow environmental education in 1967 due to the serious environmental deterioration resulted from the economic and industrial development. And the Environmental Education Research Association was established toward college students in 1975. Subsequently, The Japan Society of Environmental Education was founded for research on environmental education theories in 1990 and from 1991 to 1995, the Ministry of Education, Science and Culture gradually published *"Guidance Materials of Environmental Education"* for primary, secondary and high school students respectively. Furthermore, in order to support the development of environmental education, the government of Japan enacted *"The Law for Enhancing Motivation on Environmental Conservation and Promotion of Environmental Education"* in 2003. It can be seen that the government of Japan has attaches great importance to environmental education and has continuously made efforts to prosper the environmental education over the past half century. Nevertheless, there are no laws or ordinance related to environmental education in existence at present, though the Chinese Peasants and Works Democratic Party submitted proposal among this in 2016. And currently the Environmental Protection Bureau of China and Chinese Society for Environmental Sciences are in charge of environmental education affairs at national level, there is no local organizations or agencies specialized in this field in Chengdu. In the case of environmental education system, *Toshiya Kodama (2017)* stated that, in fact, there is no curriculum named *"Environmental Education"* in schools in Japan. The classes in schools are conducted with an environmental perspective, which is incorporated into each curriculum in the entire educational system. The government of China can draw lessons from this type of educating approach. But according to *Environmental Protection Bureau of Chengdu (2018)*, in order to develop environmental education in primary and secondary schools, they are formulating new working scheme in collaboration with Education Bureau of Chengdu. It seems to be a good beginning to local environmental education. However, this is regarding environmental education towards students; but how about popularizing environmental knowledge towards adults?

6.6 PUBLICITY

The publicity can be an approach to popularize environmental knowledge to adults who have graduated from school. *Na Li (2006)* stated that the main feature of publicity is the ability to convey information, ideas, or viewpoints in a broad, rapid, and targeted manner. Indeed, as introduced in section 5.2.3, it was found that the residents had affected by propaganda. However, it was also found that there are two weak points in current publicity practices.

First of all, the contents and slogans are too simple and inexplicit. The posts attached on the bulletin boards in Hua Lin community mainly displayed the basic knowledge of the classification of household wastes. And even there was no environmental publicity posts found in Sky City community or public places near the two communities. As discussed in section 5.3, the knowledge about general environmental issues also have

significant influences on waste sorting behavior *(Vining & Ebreo, 1990)*. In order to raise public awareness among sustainable waste management, it is necessary to popularize more knowledge among this field through publicity. For example, the knowledge among recycling process, 3Rs principle and waste disposal could make residents realize that the sustainable waste management can also alleviate environmental pollution, energy expenditure and resources consumption, which provide people with a more comprehensive understanding among waste management. And *Xiufen Ren (2006)* also stated that besides the knowledges among environmental protection and environmental laws, the concept of sustainable development also needs to be integrated in publicity. In addition, *Yingxin Yang (2013)* noted that in recent years, the publicity slogans are too inexplicit, such as *"Saving energy, reducing emission"*, *"Taking care of the earth"* and *"Saving resource"*. It would be better to popularize these concepts in a more explicit manner, such as *"Please try to use less plastic bags"* and *"Please purchase energy-saving appliances"*.

Secondly, the way of publicity is comparatively unitary. It was found during the survey that the main approaches of publicity were to put up posts on the bulletin board and to organize publicity activities in communities. *Xiufen Ren (2006)* proposed that environmental knowledge needs to be continuously popularized through newspaper, television and internet. And *Yingxin Yang (2013)* proposed that the mobile phone can be a new media that has great influences among environmental publicity because till November 2012, there were more than 1.1 billion mobile phone users and 750 million mobile internet users in China. *Ying Li (2011)* found that organizing environmental knowledge lectures in public libraries can be an effective approach as well. Moreover, currently the publicity activities are relatively insufficient. As introduced in section 4.3.1, though the City Administration Bureau and Environmental Protection Bureau organizes publicity activities in different communities in Chengdu every month, it is difficult to conduct regular publicity activities covering all the communities. Therefore, local authorities should adopt more approaches and conduct the short-term environmental education lectures in public places to spread the environmental knowledge.

6.7 SOCIETAL ACTIVITY

Apart from publicity, the households can be collectively responsible in organized social activities such as meetings and clean-up campaigns *(Colon & Fawcett, 2006)*. But as mentioned in section 5.2.2, similar to other communities in Chengdu, no evidence was found that there are regular organized activities related to waste management in existence. *Guangyi Li & Yongrong Qin (2007)* proposed that in addition to publicity in the community, there are still three key elements to promote the public participation in local environmental protection, which are: *(i) the formulation of public participation mechanism, (ii) the form of relevant organizations in community, and (iii) financial supports.* Public authorities should encourage local residents to establish the *"community environmental council"* within their community to formulate managerial regulations and working scheme. A group of residents should be selected to conduct the managerial activities such as supervision and publicity. Meanwhile, the financial support from public sector is required as well. In this way, residents are more likely to

reach the consensus to avoid conflicts between each other, and their sense of responsibility for local environmental protection could also be aroused *(Guangyi Li & Yongrong Qin, 2007)*. Furthermore, *Tao Jing (2015)* pointed out that in order to encourage people to participate in local environmental protection activities, relevant polices or regulations are indispensable as well.

The above approach could be an effective solution as it seems to be difficult for the City Administration Bureau to organize relevant social activities in all communities in Chengdu on a regular basis.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

In this section, the research questions were answered based on the research findings and the recommendations are put forward for the improvement of municipal solid waste management in Chengdu. Recommendations for further research are also drawn.

7.1 CONCLUSIONS

The research questions driving this research project are guiding here the final conclusions. Hence they are used here as subtitles.

What is the current situation of municipal solid waste management in Chengdu, China?

Currently the total municipal solid waste generation is around 15000 tons per day, and over 86% of them can be used for recycling and composting. City Administration Bureau of Chengdu is in charge of waste management and the managerial strategy is based on: recycling, reducing and harmlessness. In the case of waste management, the comingled approach still represents the main method of waste collection and the waste disposal mainly consists of incineration and landfill. In recent years, City Administration Bureau has put a lot of effort into the development of sustainable waste management, such as constructing environmental-friendly incineration powerplant, developing composting center and energy-recovery landfills, as well as initiating the 'Waste Bank' for promoting recycling.

What are the current situations of waste sorting collection and 3Rs principle practices in households in Chengdu?

It was found in this study that 40% of respondents of the survey were practicing waste sorting and 67.5% of respondents were reusing old products, though all respondents consciously avoided wasting the raw materials and products in their daily life. The waste sorting collection in Chengdu cannot be considered successful, though, because it was found that only around 21.56% of recyclables has been well collected.

What are the perceived factors and difficulties that are influencing households' participation in Chengdu?

In this study, respondents viewed the lack of classified waste containers as the main difficulty to implement waste sorting, but it was found that the lack of awareness and the sense of responsibility that resulted from egoistic consideration (motivation) and inadequate environmental knowledge were the real problems, even though their attitude towards environmental protection was comparatively positive. The economic returns accounted for the most favored reason for respondents who sorted out the waste, the governmental regulation represented the least acceptable option to all respondents, and the insufficient societal incentive was another contributor to above problems.

7.2 RECOMMENDATIONS

This section summarizes the findings related to the 4th and last sub question, therefore this section starts showing it. The highlighted findings are enlisted in the format of recommendations for the practitioners. As self-reflection of the research methods used and approaches to this research, some recommendations for further research are also enlisted.

What are the best practices of household participation in sustainable municipal solid waste management in China and internationally?

In developed countries such as Japan and the Netherlands, further classified recyclable waste container, reverse vending machine are available to residents. The innovative social enterprise *'The Re-Use Centre'* was found in England. These facilities and services have noticeably contributed to the involvement of household to develop local sustainable waste management. From the experience of developing public participation

in environmental protection and waste sorting collection of Japan, it can be seen that the public environmental education and the legislation support to environmental education are indispensable as well. And improving publicity methods and slogans, conducting environmental knowledge lectures in public libraries and organizing social organizations in local communities have shown to be effective approaches to stimulate household participation in local municipal solid waste management in China.

How can the existing situation be improved through possible household participation?

1) Substituting further classified recyclable waste containers for integrated ones;
2) Developing the reverse vending machine for recyclable collection in local retailors;
3) Revising current waste disposal charging method based on the polluter pays principle;
4) Seeking the approaches for improving waste recycling in collaboration with local manufacturers and retailers;
5) Encouraging the establishment of social enterprises near the local communities in nexus to the reuse of old products, such as Re-use shop and flea market;
6) Formulating the laws or policies to support local environmental educations;
7) Integrating environmental education into existing local educational systems;
8) Improving current publicity in terms of the content and the approach;
9) Encouraging the formation of the "Community Environmental Council" to conduct social activities related to sustainable waste management in local communities.

Recommendations for further researches:

1) Involving more communities and residents into research project if time permits;
2) Classifying the respondents (residents) into more detailed categories to identify the different characteristics of each type of resident;
3) Finding out the main products used in local households' lives, which have potentials to be recycled;
4) Assessing the possibility of facilitating local recycling through the cooperation between public authorities and local manufacturers;
5) Evaluating the possibility of fostering public participation through the cooperation between public sectors and local residents.

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APPENDIX 1.

UNIVERSITY OF TWENTE.

Environmental and Energy Management Programme

Department of Governance and Technology for Sustainability (CSTM)

Questionnaire on

household participation in municipal solid waste management

Statement of Informed Consent

You are kindly being asked to participate as a volunteer in a research case study conducted by Sen Miao, a student from MEEM programme (CSTM), university of TWENTE. This study is designed to gather information about individual waste management behavior and perceived influencing factors and difficulties.

1. Your participation in this project is voluntary. You may withdraw from the study at any time without harm of any type. If you refuse to participate in or choose to not complete the questionnaire, you can stop answering questions whenever you want. The researcher will not inform anyone of your answers, and no foreseeable negative consequences will result.
2. Completing the questionnaire will require approximately 15 minutes. There are no known risks associated with completing the questionnaire. If you feel uncomfortable in any way during this process, you may refuse to answer any question, or not complete the questionnaire.
3. The researcher will not identify you by name in any report using information obtained from your questionnaire; your confidentiality as a participant in this study will remain secure. Subsequent uses of data generated by this questionnaire will protect the anonymity of all individuals.

For further information, including a copy of the results of this study, please contact:

Sen Miao *[the researcher]*

miao346039690@outlook.com *[the researcher's contact details]*

NOTE: By completing and submitting this questionnaire, you are indicating that you understand the statements above, and consent to participate in this study.

Thank you so much for your participation!

Please choose the options or write down the answer of the following questions:

Question 1: Do you sort out garbage before throwing that into garbage bin?

A. Yes B. No Comments:_____

Question 2: Do you reuse used products or materials (Such as plastic bottles, glass bottles, waste paper, old clothes and etc.) in your daily life and how?

A. Yes B. No Comments:_____

Questions 3: Do you consciously avoiding the waste of raw materials and products such as paper, food, textile, cosmetics in your life? And how?

A. Yes B. No Comments:_____

Question 4: Are you willing to sort out garbage before throwing away? Why?

Have no interest	*Not sure*	*Could have a try*	*Yes I am*
☐	☐	☐	☐

Why? _____

Question 5: Are you willing to reuse used products or materials in your daily life? Why?

Have no interest	*Not sure*	*Could have a try*	*Yes I am*
☐	☐	☐	☐

Why? _____

Question 6: Are you willing to avoid the waste of raw materials and product in your daily life? Why?

Have no interest	*Not sure*	*Could have a try*	*Yes I am*
☐	☐	☐	☐

Why? _____

Question 7: How do you think about environmental protection?

Not important	*Could be not important*	*Not sure*	*Could be important*	*Very important*
☐	☐	☐	☐	☐

Comments: _____

Question 8: How do you think about municipal household solid waste management?

It's mission of municipality	*I could do something if someone asked*	*Not sure*	*I could do something for it by voluntarily*	*I'm responsible for it*
☐	☐	☐	☐	☐

Comments: _____

Question 9: Do you have knowledge about recycling and waste separation?

Not at all	*Juts a little*	*knowing some of them*	*Very well knowing*
☐	☐	☐	☐

Comments: _____

Question 10: If you are knowing that some products have less impact on environment, will you prefer to buy them?

Have no interest	*Not sure*	*Could have a try*	*Yes I am*
☐	☐	☐	☐

Why? _____

Question 11: How much is your monthly income?

Less than 3000	*3000 to 6000*	*More than 6000*
☐	☐	☐

Comments： _____

Question 12: How do you think about improve waste separation in your community through compulsory project or penalty by government?

I don't like that	*If it's inevitable*	*Not sure*	*Could have a try*	*I support that*
☐	☐	☐	☐	☐

Comments： _____

Question 13: How do you think about improve waste separation in your community by economic incentive? (For instance, some company will buy recyclable waste from you regularly?)

I don't like that	*If it's inevitable*	*Not sure*	*Could have a try*	*I support that*
☐	☐	☐	☐	☐

Comments： _____

Question 14: How do you think about improve waste separation in your community through social activities? (Such as clean-up activity and educational activity)

I don't like that	*If it's inevitable*	*Not sure*	*Could have a try*	*I support that*
☐	☐	☐	☐	☐

Comments： _____

Question 15: If there are available classified garbage bins in your community, but no one will compel you to sort out garbage, will you likely to sort our garbage before throw it?

I don't like to	*Maybe sometimes*	*Not sure*	*Could have a try*	*I will do that*
☐	☐	☐	☐	☐

Comments： _____

Question 16: How do you think about the existing municipal household waste management in your community?

Bad	*Just so so*	*good*
☐	☐	☐

Comments： _____

Question 17: What are the difficulties for you to sort out the garbage?

Answer：

_____

_____

_____

Question 18: Is there any other things you want to mention?

Answer：

_____

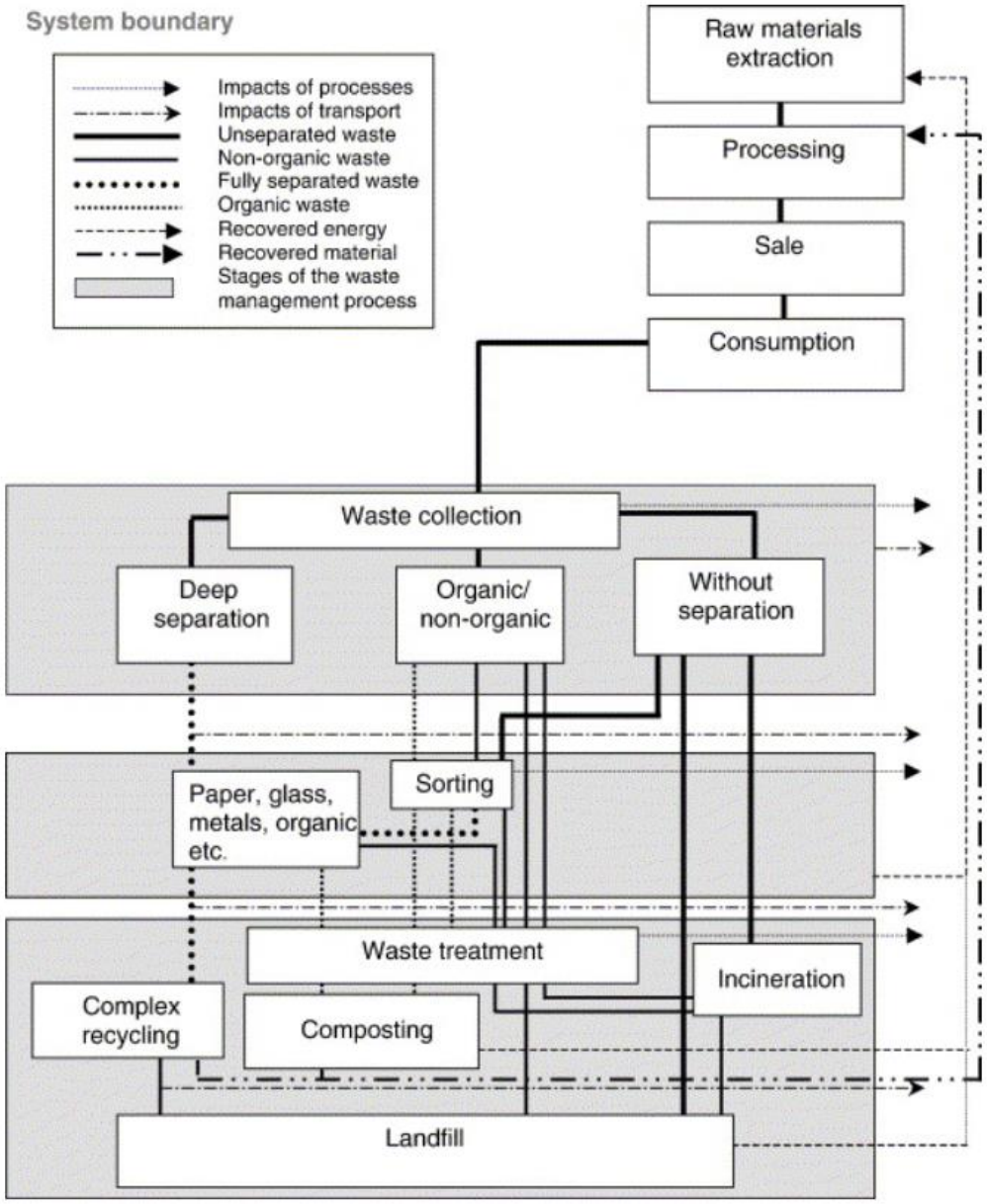
_____

_____

Thank you so much again for your participation!

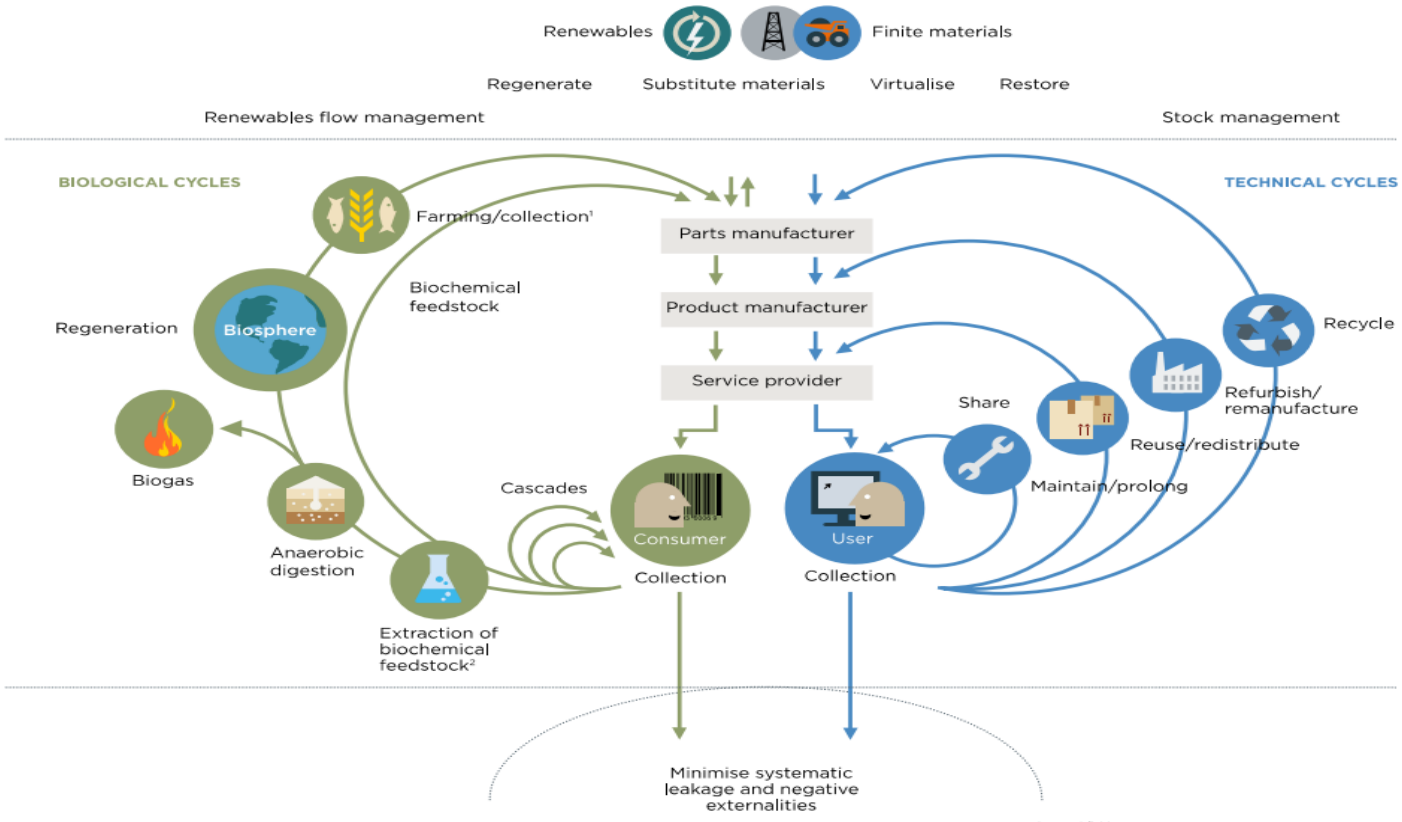
APPENDIX 2.

Municipal solid waste management system (Shmelev and Powell, 2006)


System boundary
Impacts of processes
Impacts of transport
Unseparated waste
Non-organic waste
Fully separated waste
Organic waste
Recovered energy
Recovered material
Stages of the waste management process
Raw materials extraction
Processing
Sale
Consumption
Waste collection
Deep separation
Organic/ non-organic
Without separation
Paper, glass, metals, organic etc.
Sorting
Waste treatment
Incineration
Complex recycling
Composting
Landfill

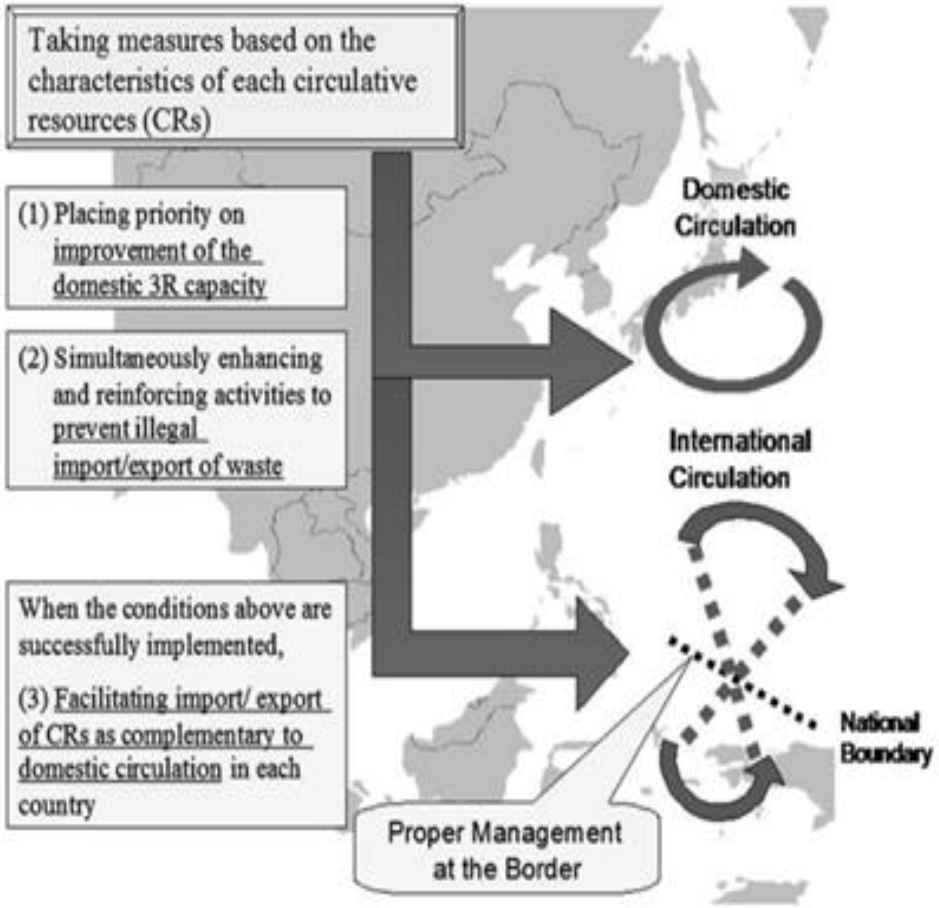
APPENDIX 3.

Biological cycle and technical cycle (Ellen MacArthur Foundation, 2015)



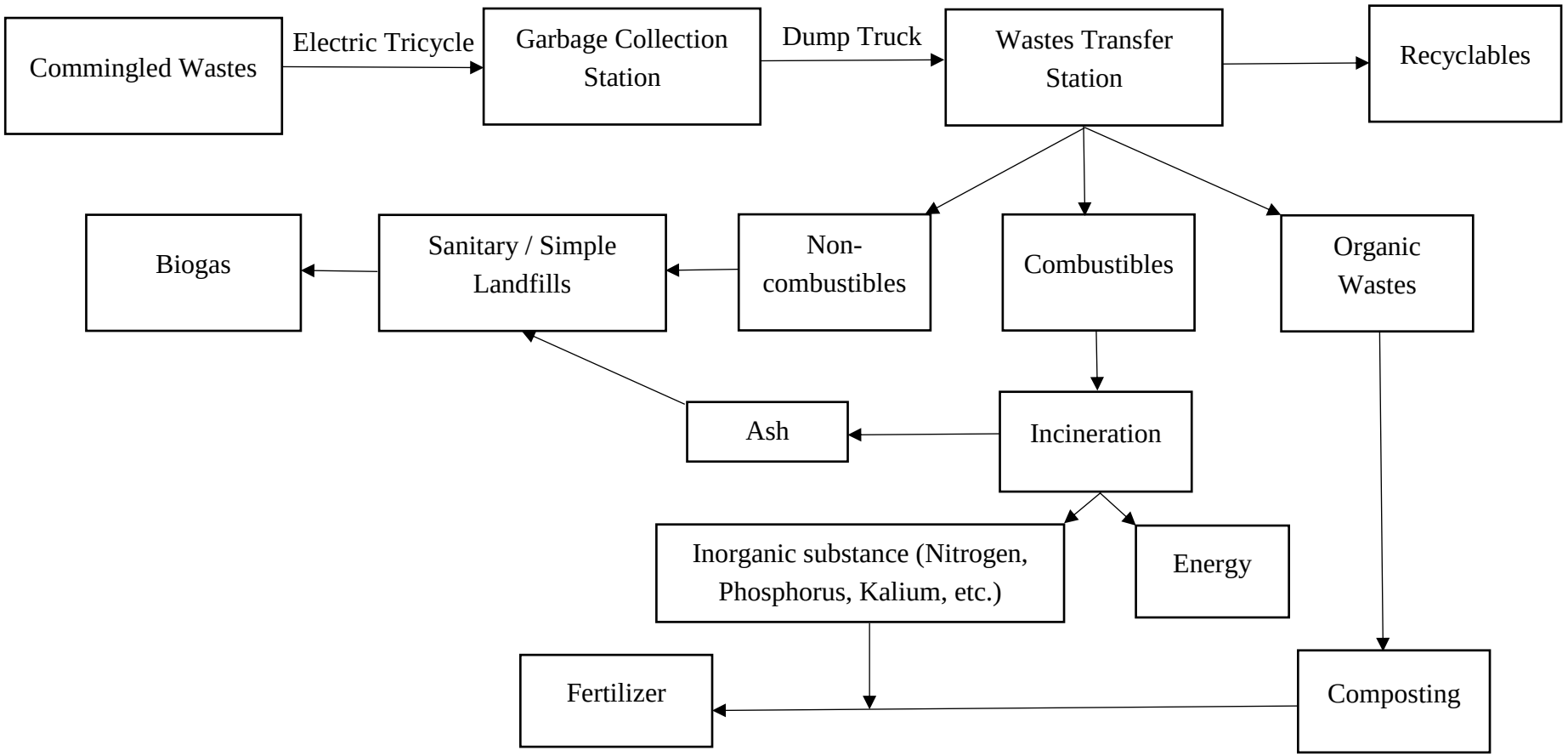
APPENDIX 4.

Vision of a Sound Material-Cycle Society in East Asia (Masaru Tanaka, 2014)



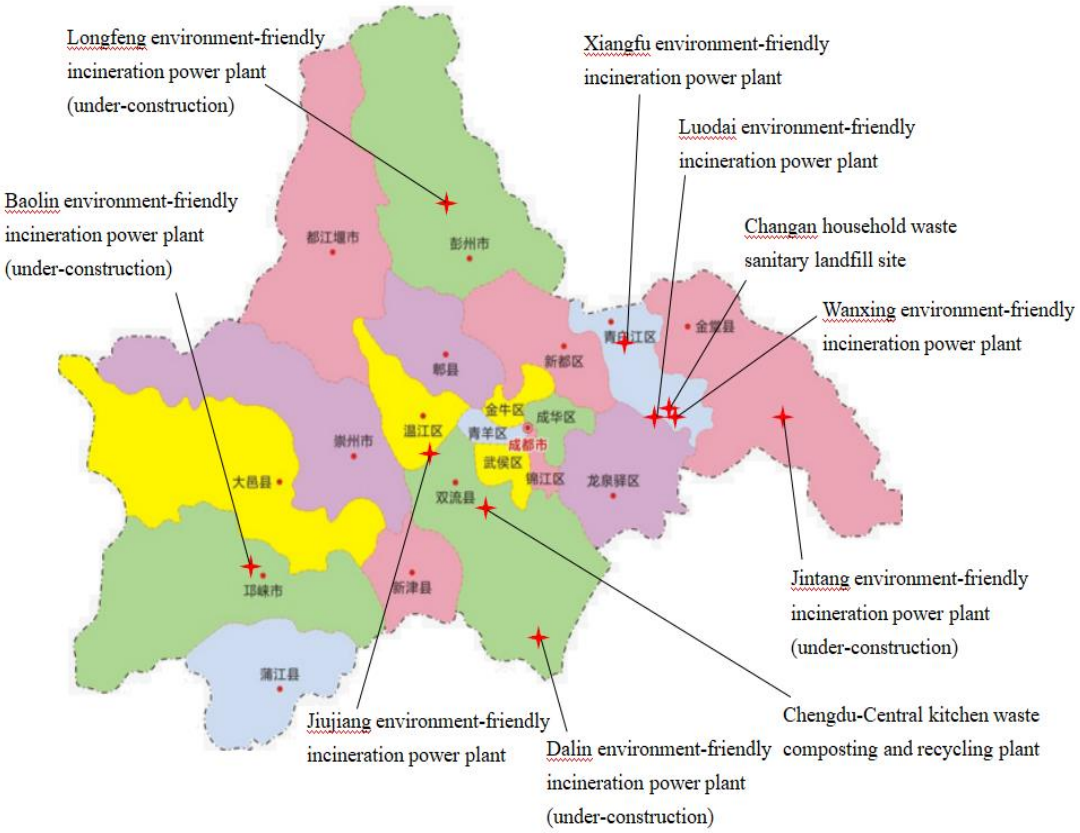
APPENDIX 5.

The household waste management procedure in Chengdu (Adapted from City Administration Bureau of Chengdu, n.d.; Xiangfan Wu, 2007; Jian He & Huiqun Wang, 2001; Na Li et al., 2009).



APPENDIX 6.

The distribution of waste disposal plants in Chengdu (Adapted from figure 6).



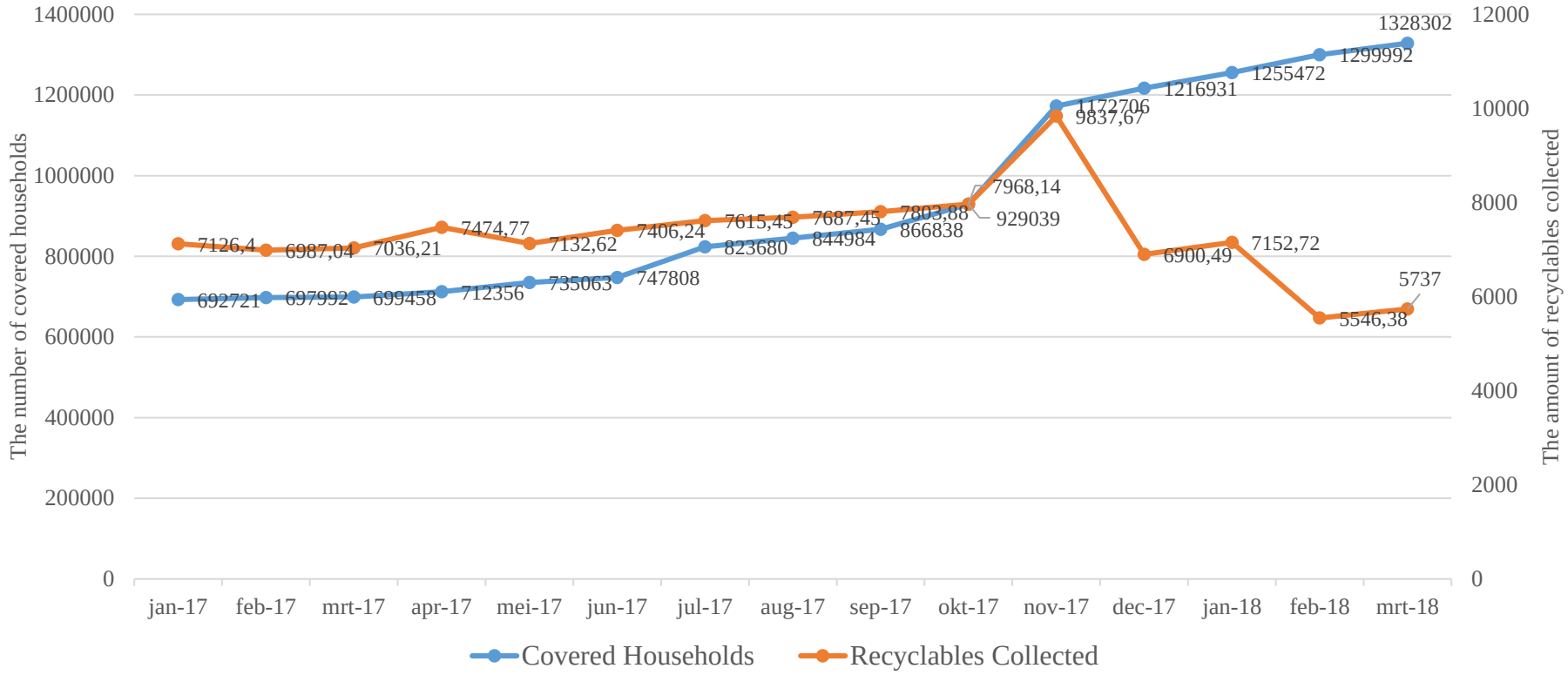
APPENDIX 7.

The Phases of waste management development (Adapted from Mengqing Xiong et al., 2009).

Waste management development	Symbolic facilities	Symbolic regulations	Main features
Phase I: 100% harmless treatment	Sanitary Landfills	Harmless treatment specification	Full sanitary landfill *-Unsustainable model*
Phase II: Commingled processing	Resource and energy recovery plants	Specified specification for composting, incineration, and etc.	Recover part of resources; Full sanitary landfill; Full incineration *-Unstainable model*
Phase III: Separated processing	Separated processing plants	Specifications of separated waste collection and processing	Efficient recovery of resources; Separated collection, transport, and disposal of wastes *-Quasi-sustainable model*
Phase IV: Full processing	Source reduction facilities	The laws of clean production, circular economy and environmental rights	Maximum recovery of resources; Separated collection, transport and disposal of wastes; Source reduction *-Sustainable model*

APPENDIX 8.

The Situation of household covered and Recyclables collected (Adapted from City Administration Bureau of Chengdu, 2018)



APPENDIX 9.

Photos about household solid waste management in Hua Lin Community (Fieldwork, 2018).

The staff is emptying the garbage in Hua Lin community

The scavenger in Hua Lin community

The randomly dumping garbage and littering in Hua Lin Community