Waste pickers as an indispensable link in municipal solid waste management system: A social survey in Nanjing, China

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Abstract:
In China, about 4 million waste pickers make their living by collecting the MSW recyclable materials for their own use or sale to higher-level traders and buy-back centers, which is subjected to social security and public health risks, as well as to scorn of general public. In this study, an extensive social survey, which covered urban management decision-makers, recycling industrial circle insiders, formal and informal waste pickers, as well as respondents from common citizens, has been conducted in Nanjing city, China. The results confirmed that 70-80% recyclable materials of MSW were collected by waste pickers in the informal sector, which became the front-end and integral component of waste recycling system. In Nanjing, the recyclable material collected annually by waste pickers is about 505,000 tons, which creates annual economic value of about 78.6-84.7 million USD. However, waste pickers account for only 6.8-7.3% of the entire industrial chain of recycling economy. In Nanjing, waste pickers are able to save annual MSW disposal cost of about17.6-22.0 million USD. The resources' recovery rate is also increased by 1.9-8.0%. The survey results support the expedience of establishing a community-based semi-official picker organizational framework, accompanied with relevant laws, regulations and preferential policies that would improve resources' recovery rate and pickers' living and work conditions, in order to achieve more effective and hazard-free MSW resourcezation. It is anticipated that the results of this research would be instrumental for the improvement of MSW recycling system and waste picker management in other cities in China and other developing countries.
Keywords: waste picker; garbage classification; municipal solid waste; resource utilization; urban management

1. Introduction

With the largest urban population in the world, China has approximately 0.7 billion people living in cities [1]. The rapid growth of economy and the continuous improvement of urbanization level led to the rise of MSW. In 2015, the total amount of urban waste has exceeded 3 million tons [2]. However, the MSW disposal was left outside the top-priority area of urban management, and limited financial resources of the most Chinese cities were preferentially applied to infrastructure and public facilities, including public transport, electricity and water supply, etc., so the current urban management decision-makers have to face the consequences of this short-sighted policy [3]. A failure of the collection, disposal, and recycling system of MSW to keep in pace with the increasing MSW volume is vividly illustrated by nearly a thousand different-sized "garbage hills" covering an area of 5.33 million m^2at the outskirts of China's capital, Beijing [4]. This "garbage siege" phenomenon is common for other developing countries, beside China [5-7]. Meanwhile, the developed countries attach great importance to the CO_2 emission reduction by the MSW recycling, since MSW figures in the list of urban greenhouse gases [8-10]. Waste classification and separation being the critical link in the recycling system, the European Union, Australia, and some developing countries have implemented a strict waste classification system to make sure that most recyclable resources are separated from household waste, which greatly simplifies waste disposal [11]. The Chinese government has also tried to tackle problems posed by MSW and launched waste source separation programs in eight pilot cities in 2000. Unfortunately, all of these pilot programs have experienced very slow progress, and no effective source-separated collection system has yet been established in China. In 2012, a so-called Green House program was established in Beijing as the first formal waste central sorting program for a community in China with a recorded daily waste separation data. However, at present, this program is reported to be running with huge financial losses, because its benefits from waste reduction are distributed among the whole society as positive environmental externalities, while in the absence of mandatory measures for enforcing residents to source separate wastes, the Beijing residents avoid implementation of the Green House program, since it is not supported by the central government [12]. This can be attributed not only to the living habits and weak consciousness of environmental protection of Chinese urban residents, but also to the defective design of China's current waste management system [13, 14]. On the other hand, this drawback creates favorable conditions for the marginalized special group of waste pickers. In China, the population of this group is about 4 million [15]. Although their waste-picking activities and modus operandi are mostly disapproved by the society, they play an important role in MSW collection, sorting, and recycling. The ideas of scientifically justified management, work co-ordination and cost-effective guidance of this large group of informal MSW recycling helpers float in the air, but cannot yet be grasped by the Chinese urban decision-makers. Their realization requires a multi-factor comprehensive approach, since beside the survival problem of a large low-income group and recycling of solid waste, other aspects have to tackled, including public health, social security, etc. So far, recent efforts made in such cities of China, as Beijing, Hangzhou, and Xiamen, to implement the innovative modes of "government direct management", "assistant management-corporatization", or "marketization" of waste picker activities yielded no satisfactory results yet [16-18].

In view of the above topical issues, a social survey of the management decision makers, recycling traders, residents, and waste pickers has been designed and conducted in the city of Nanjing, China. The current MSW management flowchart and socio-economic profile of waste pickers were elaborated and analyzed. The economic benefit of picker-related informal sector in the MSW recycling was

estimated. Besides, a feasible community-based integrated management mode was established, which can improve the standardized management of MSW recycling, increase garbage recovery rate and the income of picker groups. This experience can provide a useful reference to the other cities in China and other developing countries.

2. Current debates of waste pickers in China

According to Hayami et al., waste pickers, which are also referred to as garbage pickers, recyclers, reclaimers, scavengers and waste salvagers, are small-scale, self-employed agents, which constitute the bottom tier of the urban informal sector [19, 20]. Socio-economic studies of waste pickers show some differences in their classification and stratification in the informal sector in different countries [21-23]. In China, this term is used in a broader sense, being applied not only to street waste pickers, who collect the recyclables and useful waste from public places and trash cans, or those who exert the same activities at informal garbage dumps, but also to higher-level waste traders, such as junkmen or street hawkers, who buy recyclables from urban inhabitants for reselling, or even to municipal street cleaners/garbage collectors [24]. The dominating attitude of Chinese people to informal waste pickers is negative or prejudiced, which can be attributed to the following four basic factors. Firstly, self-employed waste pickers have no official status or organization that would manage and control their activities within the legal field, which make them hazardous for the social security. Moreover, most street waste pickers have no fixed abode and, thus, fall into the homeless or vagabond risk group, which is infiltrated with various lawbreakers and wanted criminals hiding from the authorities. This invokes the misgiving that waste collection goes hand in glove with criminal activities by the motto: "take an easy job: pick up waste, steal, or rob". This law-breaking reputation is emphasized by the China national family planning policy violation, which is widespread among waste pickers [25]. Secondly, this occupation is associated with poverty and shabby-dressed annoying characters, whose appearance deteriorates the city or town image. Indeed, most waste pickers live in poverty and have a weak standing in the aspects of housing, medical care, education, etc., which deteriorates the living habits, educational level, and outlook of their next generations. Thus, a large urban marginalized group of waste pickers not only deepens the gap between the wealthy and poor, but also invokes the "ghetto-style" aggressive behavior patterns like "be shabby in dress" and "rip open garbage bags to find more useful waste", which are also detrimental to urban socialization and environmental health [26]. The third accusation point is that waste pickers are hazardous for the urban public health, since most of them violate sanitary norms due to the lack of basic medical and epidemic prevention conditions, while their daily contact with garbage makes them prone to germ infections. Moreover, some of them pick up garbage in the places with a high disease infection rate, including hospitals and epidemic prevention stations, without realizing the related hazards. Due to high operation fluidity of pickers, their possible infections are easily spread among larger urban groups, thus jeopardizing the urban public health [27]. Finally, waste pickers are disapproved for being indirect accomplices to counterfeiters, i.e., illegal manufacturers of fake goods, by re-selling them packaging or glassware of famous brand products found in the process of garbage collection and disposal, in order to maximize their economic benefits [28]. However, waste pickers in China constitute a huge group of more than 4 million people and their livelihood concerns to the stability and inclusive development of Chinese society [15, 29]. In China, some cities have adopted strict rules regulating the incorporation or differentiation of waste picker groups, but the results obtained were quite depressing [17, 18, 30]. The emergence of informal waste pickers' groups can be treated as an inevitable by-product of a certain stage of the socio-economic development. In particular, in China, a large urban-rural economic gap is

observed for the available dual system. The income of pickers is usually higher than that people involved in rural farming, due the lack of arable land per capita, which is less than 0.10 hm^2 [31]. This fact accounts for a massive overflow of surplus rural labor and their migration to cities. At present, there are more than 0.6 billion rural inhabitants China [32], while the lack of necessary job skills of the most surplus rural labor migrants limits their opportunities to find a formal employment in the city and make them potential waste pickers. Finally, the MSW management system of all developing countries is seriously lagging behind the urban development, China being no exception. Therefore, the MSW classification and recycling entirely depend on the municipal government financial resources, while no MSW management services adapted to the market economy have obtained the required support or manifested their viability or/and economic feasibility yet. Meanwhile, by the year of 2000, the number of formal waste junk shops in Beijing was less than 200, as compared to 2000 in1965, the most reduction being experienced after 1980 [16]. This left a huge survival space for informal waste pickers and also reflected the evolution of their contribution to MSW. The socio-economic studies on waste pickers in India, Brazil, and South Africa have established their role in the MSW informal economy, while only few publications have been dedicated to the social contribution of waste pickers in China [19-21, 30, 33, 34]. In fact, average picker sorts and utilizes about 40-50 kg recyclable waste on daily basis, thus alleviating the problem of deficient disposing capacities of the formal MSW utilities. In Beijing only, 100 thousand waste pickers are able to dispose about 1.5-2 million tons of waste annually, which amounts to 20% of the total city's MSW. Not only the waste disposal fee of 300-500 million CNY (43.5-75.5 million USD) can be saved every year, the recovery value of about 10 billion CNY (145 million USD) can also be created, which makes waste pickers "the most prominent actors of the Chinese resource recycling", according to [28, 33]. Therefore, the decision-makers of urban management policy cannot ignore anymore the indispensable effect of the marginalized group of waste pickers on the MSW disposal, their deprived standing in the current resource-recycling industry, and a promising potential in the future one.

3. Methodology and data collection

3.1 Study area

Nanjing city is the capital of Jiangsu Province, which is located in Yangtze River Delta area and the center of east China at 31°14'~32°37' N, 118°22'~119°14' E. In 2016, the total population of the city was 8.2 million, including the official urban population of 6.7 million. The urban built-up area is 923.8 km^2, and the per capita GDP is 19.0 thousand dollars. In the current economy of the city, service industries are dominating, accounting for about 60 percent of the GDP of the city, and financial industry, culture industry and tourism industry are top three of them. Industries of information technology, energy saving and environmental protection, new energy, smart power grid and intelligent equipment manufacturing have become pillar industries. The MSW generation of Nanjing in 2016 amounted to 3,139 million tons (Figure 1a) along with growth of urban population and economy (Figure 1b). The single disposal method used in Nanjing leads to a low incinerating disposal rate of less than 10%, and most MSW is treated as landfill waste [35]. At present, there are five formal refuse landfills in Nanjing. Multiple historically formed "garbage hills" exist in three districts (Pukou, Jiangning, and Xixia), and the stock waste is about 20 million tons [36]. This opens work opportunities for informal waste pickers, whose number in 2015 was estimated about 31 thousand persons, according to the results of 1% census of the Nanjing Statistical Bureau and Civil Affairs Bureau [37].

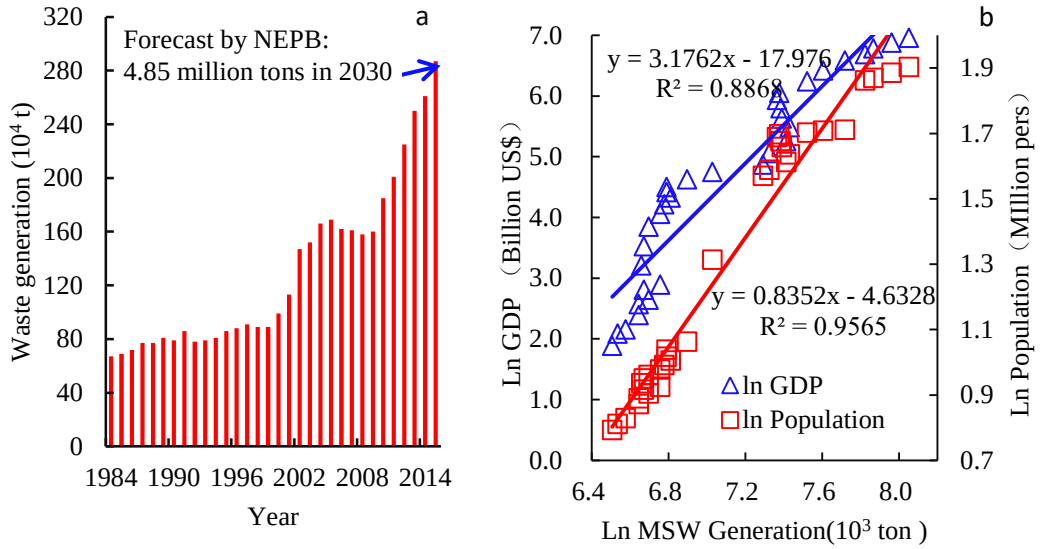

Fig. 1. Evolution of MSW generation in Nanjing in 1984-2016 (a) and MSW correlation with GDP and urban population (b)

Table 1. The municipal solid waste composition in Nanjing City, China (%)

Waste classification	Food	Wood	Paper and cardboard	Plastics	Textile	Glass	Metal	Fines	Stones and brick	Total
Wet weight fraction (%)	46.2	2.3	12.6	7.2	6.4	1.6	1.1	21.7	3.2	100
Moisture content (%)	64.2	44.3	27.8	34.2	37.2	7.8	6.4	14.3	9.4	40.4
Dry weight fraction (%)	16.5	1.3	9.1	4.7	4.0	1.5	1.0	18.6	2.9	59.6

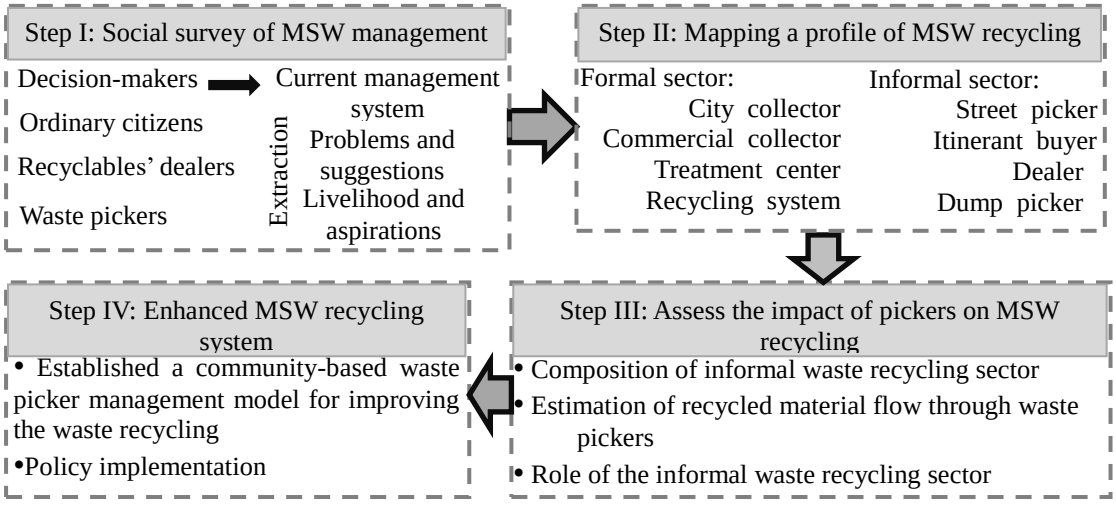

Fig. 2. Research framework for waste recycling through pickers in this study

3.2 Methodology

The informal economy sector of MSW in China is hard to be assessed via the official statistical reports and requires a special investigation. Since the prices of useful recycling waste are not regulated, but fully market-oriented, there is hardly any cross-regional sale among the recycling waste recycled by

pickers [19]. Therefore, through pickers' informal waste recycling, the waste eventually flows into the recycling industrial system of the formal economy sector. In order to clarify the input of waste pickers into the waste recycling system, a qualitative and quantitative research framework was developed (Figure 2). There are four steps in this research framework, containing the field investigation as an indispensable part, which was designed to reveal the disadvantages of the current MSW management and the pickers' work/living conditions. The remaining three steps included the qualitative and quantitative analyses of the data obtained from the field investigation.

The economic value obtained from the pickers' informal waste recycling sector can be assessed by the recycled material flow analysis (MFA), which allows one to compensate the neglect or little support of government statistics department of the informal economic activities [38]. The above analysis provides a systematic evaluation off low and storage of the recycled material under study in a specific place and time, which is related to the informal waste recycling sector of the MSW disposal system [39]. The cost benefit analysis (CBA) in this research was based on the recycled material flow model, and the following equation was used to estimate the economic value of the informal waste recycling sector related to waste pickers.

$$Y = \sum_{i=1}^{n} m_{i,x} \bullet p_i \quad (1)$$

where Y is the economic value of the informal waste recycling sector relevant to waste pickers, $m_{i,x}$ is the amount of recycled materials collected by different pickers, i represents the types of materials, such as iron, copper, paper, plastics, glass, etc., x represents pickers of different collection routes, such as street pickers, iterant buyers, dump scavengers, and municipal cleaners, while p_i is the price of material of type i.

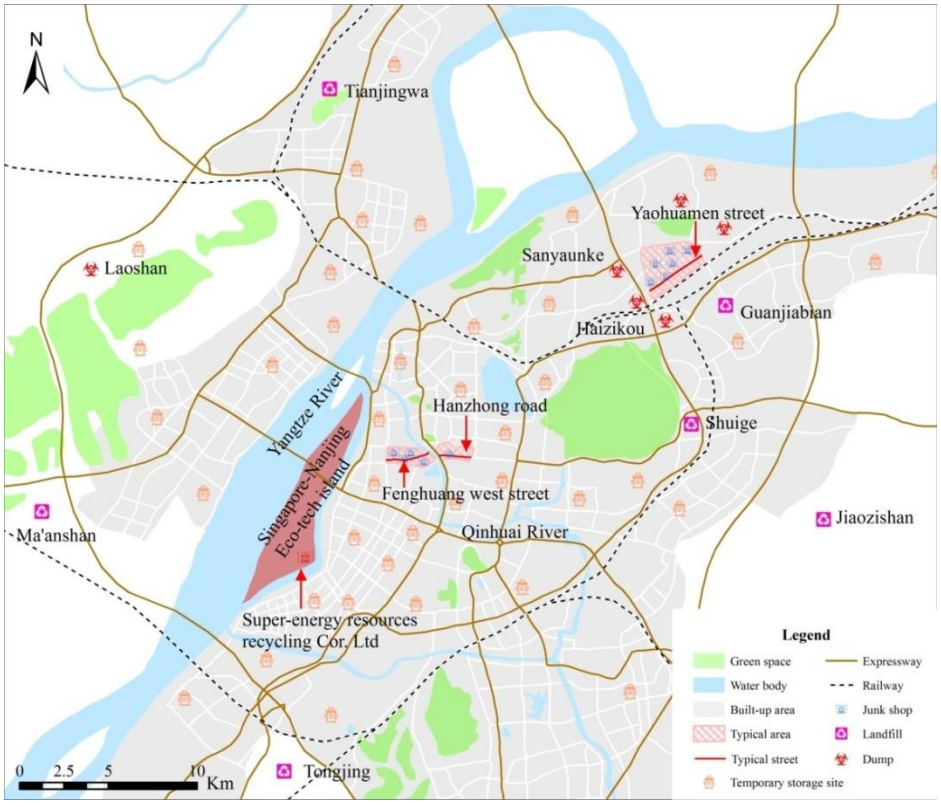

Fig. 3. The city districts covered by the field investigation in this research

3.3 Data collection

Pickers are considered to be "hard-to-reach" research objects due to their work properties [40]. Some pickers do not have definite residence, wandering around the city during the day to collect waste, and their work completely depends on the availability of waste [41]. Therefore, it is quite problematic to ensure that their sampled data probability would satisfy the normal distribution. Similar to the research of Blanche et al. (2007), a snowball sampling as a type of non-probability sampling technique was applied in this study for data collection of pickers [42]. Because of pickers' low level of education, a face-to-face interview-type survey was used to overcome the defects of questionnaire survey. Thirteen interviewers were selected and recruited among graduate students with a social survey experience for participation in the field investigation. Within framework of this research, three typical city blocks of Nanjing and one specific high-tech location with independently operating MSW management system were repeatedly (three times) investigated in April, June, and October of 2016. In Figure 3, the investigated blocks are indicated by red arrows and include: (i) Fenghuang West Street with residential area nearby, (ii) Hanzhong Road, which is adjacent to the central business district (CBD), (iii) Yaohuamen Street with suburban areas surrounded by landfill, dump, and shanty town, and (iv) the Singapore-Nanjing ecological technology island with an independently operated MSW management system. The latter study area was used as a control group with a zero informal waste-picking input to MSW recycling.

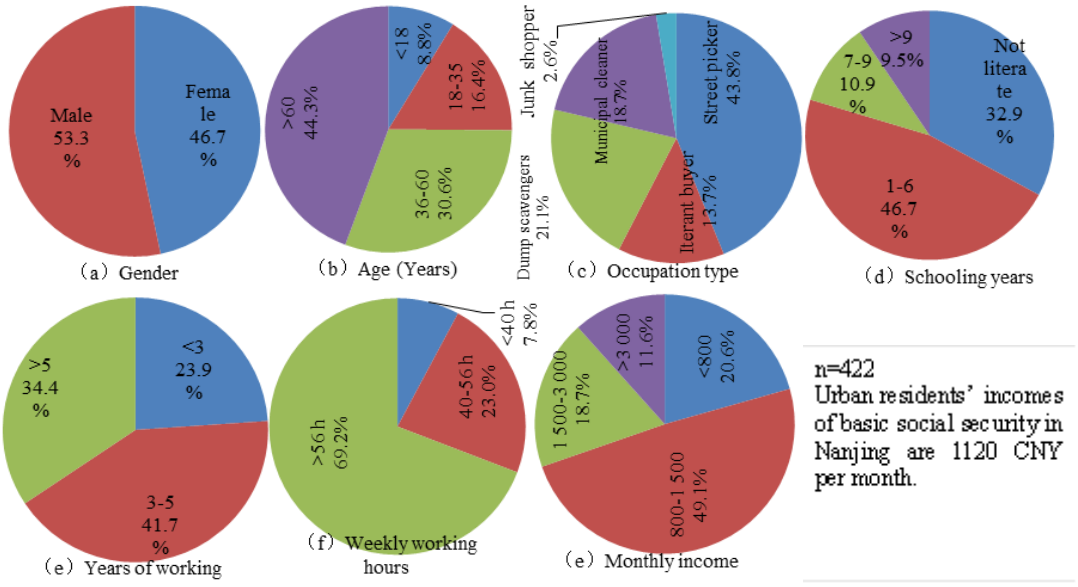

Fig. 4. Socio-economic data on 422 waste pickers interviewed in Nanjing

All the ethical norms were strictly followed in this research. The socio-economic characteristics of the surveyed waste picker group containing 422 interviewed persons are depicted in Figure 4, including their break-down by gender (53.3% male and 46.7% female), age (44.3% over 60, 8.8% below 18, etc.), education level (over 32% being illiterate), etc. Noteworthy is Figure 4c with the breakdown by waste-related occupation types: 43.8% of interviewed persons were street pickers, 21.15% were dump scavengers, 18.7% were municipal cleaners, 13.7% were iterant buyers, the remaining 2.65% being junk shoppers.

In addition to the above pickers' group of 422 persons, the Nanjing MSW management

organization, picker management organization, and some related people of waste recycling industry were interviewed by the survey team, and a random interview-type survey of 80 ordinary citizens was performed in the streets and squares of the above locations, where their opinions and suggestions on the MSW management optimization were collected. In order to estimate the waste pickers' input into MSW recycling, from June to October, 2016, the investigators were stationed in 11 junk shops of Nanjing (one week per shop), wherein the source, category, and quantity of recycling waste were recorded. All the analyses were executed using the SPSS19.0 software, and the significance level was set as 1%.

4. Results and discussion

4.1 Mapping a socio-economic profile of MSW recycling in Nanjing, China

According to the interview-type survey of the decision-makers of MSW management, personnel of waste recycling industry, citizens, and pickers, a socio-economic profile of MSW recycling was constructed (Figure 5), which outlines both sectors: formal and informal ones. In the formal waste recycling sector, the municipal treatment system is a complete industrial chain, from collection to decomposition/dispose to dispose/recycling, and there are some professional waste recycling companies to match. The informal one, which mainly includes pickers, some higher-level traders and buy-back centers (small junk shops), is unable to constitute a complete industrial chain and, instead, deals with two links of this chain, including collection and simple classification/sorting of waste. In fact, some municipal cleaners also pick recyclables from streets or waste transfer stations, and then sell to junk shops. The recyclable waste recycled by these junk shops would eventually flow to the formal waste recycling sector. Thus, the informal waste recycling sector is a quite instrumental add-on complement to the formal one, which not only relieves the disposal pressure of MSW but also enhances the economic value of recyclable waste in the MSW management system. However, the informal waste recycling sector through pickers exhibits a purely market-oriented economic behavior, so that only the most economically lucrative recyclables, leaving the "leftover" to the municipal cleaners and the formal MSW treatment system.

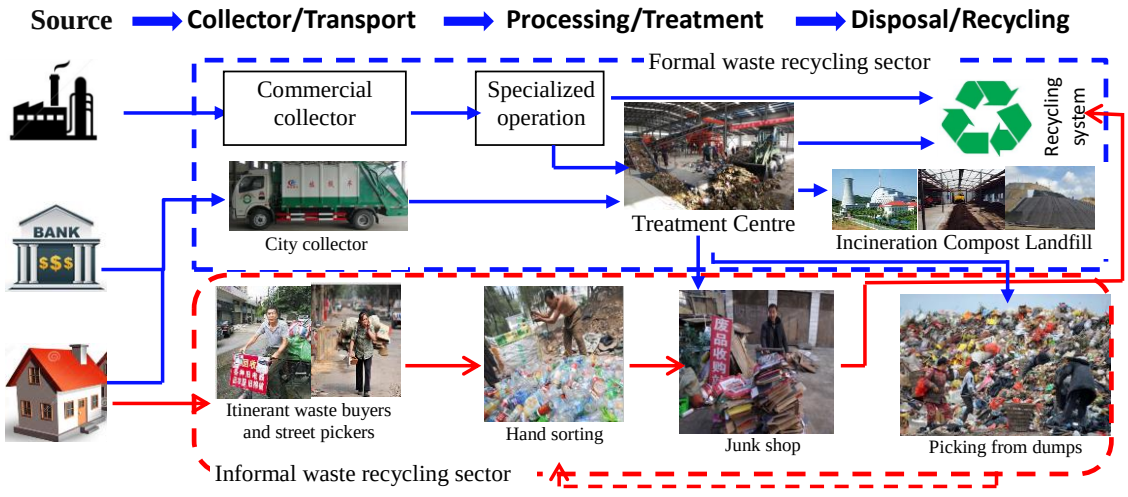

Fig. 5. Formal and informal MSW recycling sectors in Nanjing, China

4.2 Estimation of the economic value of the informal waste recycling sector through pickers

Table 2 shows the amount of recyclable materials collected in the informal waste recycling sector

through pickers in Nanjing. Each street picker, municipal cleaner, or dump scavenger collect from 28.1 to 50.0 kg of recyclable materials on daily basis. However, the economic value of recyclable materials picked by the first two types of waste collectors is obviously higher than that of a dump scavenger (metal, paper, and packing materials). Itinerant buyers shuttle between the CBD and residential community and acquire the recyclable materials with the highest economic value. However, itinerant buyers need more capital and social skills than other waste pickers. This trend is reflected in the new motto of Chinese garbage collectors: "Rather than digging garbage in dumps, you better pick it in the streets, but picking it is not as good as just buying and re-selling it". Thus, itinerant buyers are at the top of the informal MSW-fed chain, since they deal with the most profitable recyclables, in contrast to dump scavengers, who are the lowest link in this chain. The interview-type survey of pickers has revealed their social relations are reduced to their relatives, colleagues, and former fellow-townsmen or fellow-villagers. After settling down in a certain city area, they seldom move elsewhere, which is completely different from the picker groups of the other countries. Most pickers sell recyclable materials once a week. Because of the transparent price, heavy weight, and relatively low economic value of recyclable materials, no cross-regional sales are provided, since waste transportation costs make them unprofitable. Instead, the recyclable materials are usually sold to familiar junk shops based on the long-term cooperation ties. In the three typical blocks, which have been surveyed, the amount of recyclable materials collected by waste pickers and junk shoppers (Table 3) exhibited a significant correlation at 0.01 level, the Pearson correlation coefficient being equal to 0.9943, which validates the reliability of the above results.

Table 2. Break-down of collected recycling materials monitored in the field survey of waste pickers in Nanjing

Waste break-down		Itinerant buyers	Street picker	Dump scavenger	Municipal cleaner	Junk shopper
Sample size		58	185	89	79	11
Source generation		Households and small business	Streets and public facilities	dump	Streets and temporary storage site	all waste pickers
Recyclable materials	Paper and cardboard (kg d^{-1})	65.4±19.3	16.9±5.8	14.4±4.5	16.3±5.2	843.8±192.4
	Metal (kg d^{-1})	6.5±1.8	1.7±1.1	0.9±0.5	1.3±0.5	63.5±31.6
	Plastic (kg d^{-1})	15.7±5.7	11.6±4.3	10.4±2.9	12.2±3.9	426.7±109.3
	Grass (kg d^{-1})	4.4±2.9	3.1±2.0	2.9±1.2	2.3±1.5	108.8±30.5
	Woods (kg d^{-1})		2.3±1.3	6.8±3.7	1.7±0.7	37.9±10.4
	Textile (kg d^{-1})		2.7±1.1	4.9±2.3	2.1±0.9	44.7±7.8
	Total (kg d^{-1})	92.0±23.9	38.3±10.2	40.3±9.7	35.9±7.8	1525.4±237.5

Note: d^{-1} means per day

Table 3 shows the contributions of informal waste recycling sector through pickers to the MSW recycling industry. It can be seen that 70-80% of the final recyclable materials were contributed by the informal waste recycling sector. According to the calculations via Equation (1), the economic value of the informal waste recycling sector in 2016 is about 78.6-84.6 million USD. The average annual income of the pickers in Nanjing is about 2535.1-2730.0 USD, which exceeds by 30.0-39.0% the annual minimum subsistence security standard of Nanjing of 1950.4 USD per person. Besides, the

pickers in Nanjing annually collect about 505 thousand tons of recyclable materials. According to the calculation taking 34.8-43.5 USD t^{-1} as MSW disposal expense, the saved disposal expense is 17.6-22.0 million USD per year.

Table 3. Recyclable materials flow in the MSW management system in Nanjing

Recyclable materials (kg d^{-1})	Informal waste recycling sector		Actual recyclable materials captured by the MSW recycling industries [b]	Potential availability of recyclable material in the MSW [c]	Contribution of the informal sector [d]
	Estimated amount of recyclable material according to field survey though waste pickers [a]	Total recyclable materials captured by junk shoppers [a]			
Paper and cardboard	254426.6	248871.0	337211.4	395514.0	75.5%
Metal	23442.4	18728.7	30144.5	34529.0	77.8%
Plastic)	132616.1	125851.2	174010.3	226008.0	76.2%
Glass	34012.0	32089.6	45987.4	50224.0	74.0%
Wood	31236.9	11178.3	24356.8	72197.0	Invalid data [f]
Textile	29534.3	13183.9	128875.9	200896.0	22.9%

[a] Calculation is based on the field survey and waste pickers' census (NBS, 2016). [b] Data from 2015 statistical bulletin of circular industry in Nanjing(NEPB, 2016).[c] Calculation is based on Table 1 and the total MSW generation in Nanjing. [d] Contribution of the informal sector= Estimated amount of recyclable material according to field survey though waste pickers/ Actual recyclable materials captured by the recycling industries×100%. [f] Data are not valid, since the amount of waste captured by waste pickers is higher than the amount of actual recyclable materials captured by the recycling industries, because wood is less popular in the recycled market and part of wooden waste, such as old pieces of furniture and firewood, were used by scavengers for their own needs.

4.3 Influence of waste pickers on the MSW recovery rate

Table 4 shows the actual MSW recovery rate of Nanjing and Singapore-Nanjing ecological technology island in 2016. Noteworthy is that the latter has an independent MSW management system, which is under the commercial operation of Super-Energy Resources Recycling Corporation, Ltd. Since any informal waste picking activities in the Singapore-Nanjing ecological technology island are forbidden, its recovery rate of recyclable materials implies a zero contribution from pickers. From Table 5 it can be seen that the MSW resource recovery rates of the total city are higher than those of Singapore-Nanjing ecological technology island: by 1.9% for metal, by 3.5-4.5% for glass, plastics, and textile and by 8.0%for paper and cardboard. This can be attributed to the contribution of pickers. Resource recovery rate is the most important index of MSW recycling. Developed countries widely use the innovative technologies and cost benefit analysis to constantly improve the resource recovery rate, while most developing countries, including China, have to rely on vast human resources and informal activities of waste pickers, which are labor intensive and characterized by limited or no use of technology, to improve the resource recovery rate. In the MSW of Nanjing, the recovery rates of metal, paper, packing box, and glass are all higher than 85%, which is way above the recovery rate level of

other developing countries [43]. In fact, the comprehensive utilization ratio of China's MSW is not high, especially, the end utilization ratios of direct incineration and biogas power generation, which are even lower than those of other developing countries [34, 44-47].

Table 4. The potential contribution of pickers to the MSW recycling ratio in Nanjing

Recyclable materials (kg d^{-1})	Potential availability of recyclable material in MSW (kg d^{-1})	Actual recyclable materials captured by recycling industries (kg d^{-1})	Total recovery rate	Recovery rate of Singapore-Nanjing Eco-tech island [a]	Contribution of waste pickers
Paper and cardboard	395514	337211.4	85.3%	77.3%	8.0%
Metal	34529	30144.5	87.3%	85.4%	1.9%
Plastic	226008	174010.3	77.0%	72.5%	4.5%
Glass	50224	45987.4	91.6%	88.1%	3.5%
Wood	72197	24356.8	33.7%	43.8%	Data is not valid [b]
Textile	200896	128875.9	64.2%	59.6%	4.6%

[a] Calculation is based on the data of Super-Energy Resources Recycling Corporation, Ltd. and Table 1.

[b]The calculated value is invalid, due to the same reasons as described in Table 3

5. Proposed options of MSW management improvement and policy implementation in Nanjing

5.1 Establishment of a community-based semi-official picker organizational framework to improve resource recovery rate and pickers' income.

At present, the Chinese government uses multiple management schemes incorporating waste pickers, where some organizations, including civil administration, environmental protection, epidemic prevention, and public security, are involved. However, none of these organizations can solve the key issue of picker management, which is the pickers' livelihood. In order to organize pickers and improve their contribution, some cities in China pass the managerial authority of urban solid waste to commercial companies, which become responsible for recruiting pickers who participate in MSW-related activities. However, only a small share of pickers can be hired by these companies, and the resulting activities of these companies are hindered by the conflict of interest with the rest of pickers [17, 18]. In some other cities, the direct supervision mode is implemented with mandatory "three unification rules concerning obligatory uniform, vehicle, and certificate", but because the pickers need to pay some annual management fees, it is hard for pickers to accept [16, 30]. Because of the huge picker group, the city government has to manage properly to reduce the social risks, such as security risk and public health risk, and to realize the inclusive growth. Therefore, in cohesion with the survey participants, a pilot structure of a semi-official picker organizational framework based on community was proposed by the authors of this study (Figure 6), which also envisage that the relevant supporting policies and systems should be improved and formulated, in order to provide at least a double growth of pickers' income and recovery rate. This framework possesses the following advantages: (1) The support fund is originally dispersed in multiple departments, as well as some social resources, including the intensively managed shelters for homeless people and community care centers. It can be uniformly deployed and used by grassroots community organizations (GROs), which would

furthest help the picker group. (2) A new independent operating company has to be formed from the combination of pickers and municipal cleaners, which would undertake the front-end work of MSW management, including collection and transportation. It is a labor-intensive task with a low technical content. (3) The numerous pikers' integration would not only reduce the cost of human resources, but will definitely improve the recovery rate of recyclable materials, especially in view of insufficient awareness of Chinese citizens of garbage classification expediency. In the future, some staff can be dispatched to each residential area to collect heavy environmental pollution waste, such as waste batteries, electronic products, etc.

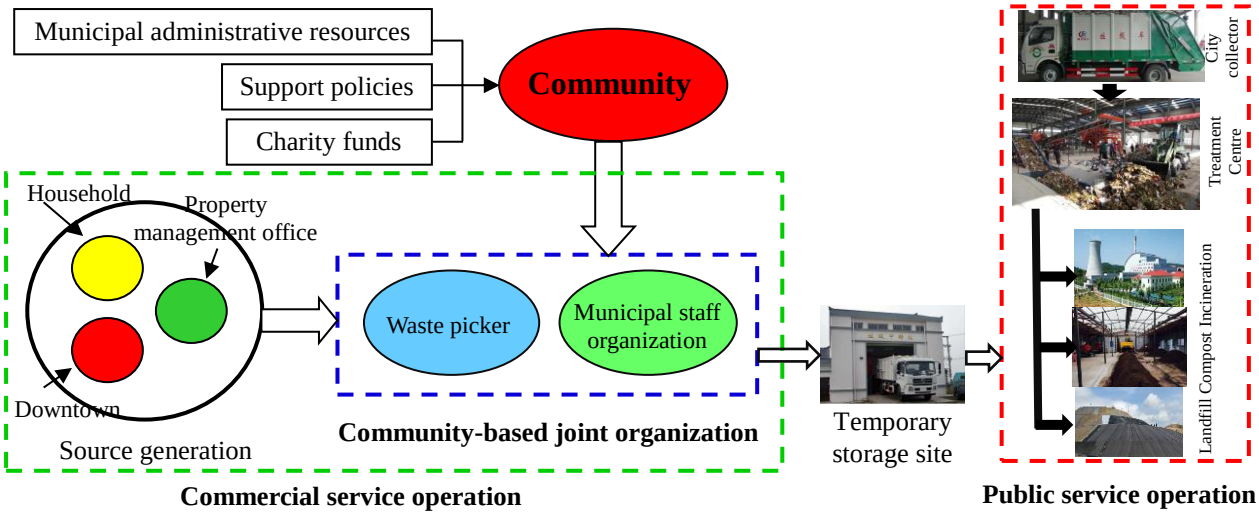

Fig. 6. Proposed community-based pickers' organizational framework linked with public service of the MSW management in Nanjing

5.2 Policy implementation

The successful implementation of semi-official picker organizational mode based on community must be supported with relevant laws and regulations. However, the current management policies in China are lagging, insofar as no amendments were yet made to regulation of 2002 concerning "the way to salvage and manage the vagrants and beggardom in the cities". The survey results and discussions with MSW-related participants made it possible to formulate the following recommendations on the improvement of the MSW management in Nanjing and integration of informal pickers:

(1) Implement the semi-official picker organizational mode based on community as a pilot project and delegate the dispersed resource, financial ability, and right to grassroots community organizations. It would be the most optimal government agency dealing with pickers, which is beneficial for coordinating and handling various complicated relationships in emergency.

(2) Accelerate the formulation of relevant laws and regulations, and promote the marketization of MSW disposal, which would eventually lead to transfer of the MSW disposal from public welfare to commercial operation, which would increase the waste recycling rate and reduce the operating costs. The experience of developed countries can be used to establish such laws and regulations, as "The law of waste disposal", "The law on recycling economy and waste utilization", and issue "Technical guide for waste classification and disposal in residential area", "Technical guidelines for special

disposal and storage of waste", and some other general administrative regulations. The enforcement of these laws, regulations, and technical guidelines should be promoted.

(3) Ensure a better balance the value chain of MSW recycling and promote the healthy development of MSW recycling. At present, the preferential policies of recycling industries in China, such as tax relief, financial subsidies, etc., are all concentrated at the end of the industrial chain, which are the final products of recycled materials. The pickers, who are located at the front end of the industrial chain, hardly enjoy any benefits of the recycling industries. Taking Nanjing as an example, the economic value created by recycling industries in 2016 was about 8 billion CNY (1.16 billion USD), while the share of pickers accounted only to 6.8%-7.3%, which could hardly stimulate their motivation. A financial support should be provided for the purchase of recyclable raw materials, in order to improve the MSW recovery rate.

6. Conclusions

In China, waster pickers' activities and living habits are mostly disapproved, due to a number of negative effects on the urban social and ecological environment. However, waster pickers are of great significance to the MSW management system and, due to their large number exceeding 4 million persons in China, their proper management is not only beneficial for improving the waste recovery rate and creating resource-saving society, but also may improve the livelihood of pickers and realize their integration into the social economy. The social survey in the city of Nanjing, which covered the decision-makers of urban management, insiders of cycling industry, citizens, and pickers, has yielded the following results:

(1) The informal sector of waste recycling through classified by them.

(2) In Nanjing, waste pickers annually collect about 505,000 tons of recyclable materials and create about 541.9-583.7 million CNY (78.6-84.7 USD) of the annual economic value, but account only for 6.8-7.3% of the entire recycling industry chain.

3) The pickers in Nanjing are able to save the MSW disposal cost of approximately 121.2-151.5 million CNY (17.6-22.0 million USD). The resource recovery rate is also increased by 1.9-8.0%.

(4) The available management modes for pickers' are shown to be inefficient. The survey results support the expedience of establishing a community-based semi-official picker organizational framework, accompanied with relevant laws, regulations and preferential policies that would improve resources' recovery rate and pickers' living and work conditions, in order to achieve more effective and hazard-free MSW resourcezation. It is anticipated that the results of this research would be instrumental for the improvement of MSW recycling system and waste picker management in other cities in China and other developing countries.

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