

# Solving the Urban Domestic Waste Classification Dilemma from a Coalitional Game Perspective

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## Abstract

The effective classification of urban domestic waste is the key to achieve a “waste-free city” and provides an essential guarantee for resource utilization. This article takes a coalitional game perspective to study the dilemmas in urban domestic waste separation from the cooperative interaction of residents, government, and enterprises. The study finds that urban domestic waste classification in China is currently facing many problems, focusing on: 1) insufficient consensus among residents, 2) shortage of input funds, 3) corporate profitability difficulties, 4) weak policy constraints, and 5) difficulties in integrating goals. In this regard, each participating body still needs to focus on collective interests, coalitional games, break the dilemma society, and promote the long-term management of urban domestic waste.

## Keywords

Waste Classification, Coalitional Game, Multiple Subjects

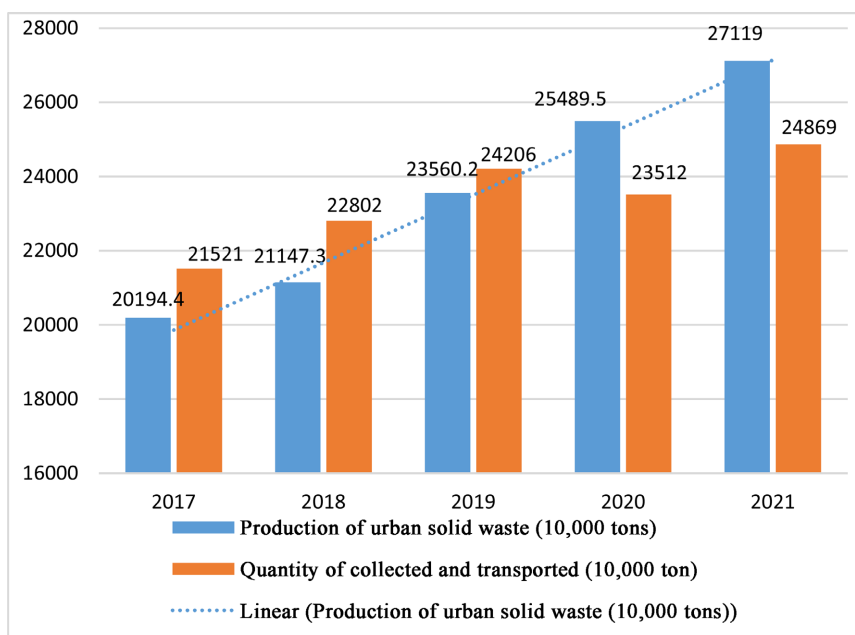
## 1. Research Background

Waste classification is to improve the resource utilization rate of domestic waste and give full play to its value in economic, social, ecological, and other aspects. Its work transport and separate disposal waste classification and management are not only an objective requirement for the extensive formation of a green way of life and production, but also an essential element in the work of improving urban and rural habitats and a real need for the country to build a modern ecological civilization system. In 2018, the General Office of the State Council of the People's Republic of China issued “*Waste-free City Construction Pilot Work Programme*” which puts forward the idea of building “waste-free cities” with partic-

ular emphasis on the classification and treatment of urban domestic waste [1]. In 2019, Shanghai took the lead in transforming domestic waste classification and management from advocacy to mandatory implementation, bringing waste classification and management to a new stage of mandatory implementation. In 2022, the National Development and Reform Commission, the Ministry of Ecology and Environment of the People's Republic of China, the Ministry of Housing and Urban-Rural Development of the People's Republic of China, and the National Health Commission of the People's Republic of China issued the “*Guidance on Accelerating the Construction of Urban Environmental Infrastructure*”. It clarified the main objectives of urban environmental infrastructure construction in 2025.

The main objectives of environmental infrastructure construction, including domestic waste treatment: the capacity of domestic waste classification and transportation reached about 700,000 tons/day, the utilization rate of urban domestic waste resource utilization reached about 60%, the proportion of urban domestic waste incineration treatment capacity accounted for harmless treatment capacity reached about 65%. The report of the 20<sup>th</sup> CPC National Congress also stressed that urban and rural living environments significantly improved, and the construction of a beautiful China is one of the main objectives of the next five years. In recent years, in the process of promoting waste separation and resource recycling, China has made continuous progress in science and technology, gradually improved policy guidance, and gradually improved the level of urban domestic waste separation and management, but despite China's long-standing emphasis on the importance and necessity of waste separation and resource recycling, and constantly put into practice, the actual implementation effect is not satisfactory [2], and still cannot match the rapidly increasing domestic waste production, and cannot meet the needs of urban habitat management and the needs of the general public for a better life.

In the five years from 2017 to 2021, China's total domestic waste production remains at a high rate of year-on-year growth, and the impact of waste pollution continues to expand. According to data from the Ministry of Ecology and Environment of the People's Republic of China and the Ministry of Housing and Urban-Rural Development of the People's Republic of China, the amount of municipal solid waste generated in China in 2021 was about 271.19 million tons, an increase of 34.29% compared to 2017. The volume of domestic waste removal and transportation was 248.69 million tons, an increase of 15.56% compared with 2017 (see **Figure 1**). Problems such as land erosion, water and air pollution, and resource waste caused by direct incineration and land-filling of a large number of unsorted wastes have gradually become restrictive factors in production and life, directly affecting people's quality of life [3]. The escalating problem of urban domestic waste has triggered urban habitat and environmental problems, which significantly affects the comprehensive and sustainable development of society. At the same time, the resource utilization of urban domestic waste cannot be efficiently realized because of the incomplete and meticulous classification and disposal. The economic



Data sources: Ministry of Ecology and Environment of the People's Republic of China, Ministry of Housing and Urban-Rural Development of the People's Republic of China

**Figure 1.** Urban waste production in China from 2017 to 2021.

value and resource value cannot be fully utilized.

Under the requirement of Chinese modernization of harmonious coexistence between human beings and nature, the coalitional game approach is used to promote the alliance of multiple participating parties in urban waste separation activities, coordinate the relationship between the rights, responsibilities, and benefits of each party, break the dilemma of collective action, and make all participating parties profit while promoting the front-end separation work of urban domestic waste management. From the perspective of the coalitional game, in addition to all parties doing their jobs, healthy cooperation and interaction are of vital importance to smooth the whole process. Without collaboration and governance among all parties, the various actors involved in the waste separation process will have their own interests at heart, even at the expense of destroying the overall interests. For example, in the aspect of waste removal, if the separated waste is collected together, the working time and cost can be reduced to get more economic benefits for themselves. On the one hand, such self-interested behavior will give negative feedback to the public, significantly reducing the public's awareness and willingness to participate in domestic waste separation. On the other hand, it will increase the workload for subsequent sorting and resource utilization, increasing the cost of the whole waste separation process and hindering the sustainability and development of urban waste separation and management. Therefore, the work of urban domestic waste classification must focus on the cooperative game of all participating subjects, requiring that the behavior of each issue should be guided by the primary goal of serving the interests of the overall society and only by breaking the boundaries of the actions of all participating sub-

jects, pinching the divided subjects together, forming an interactive system with the general interests as the common interests, and preventing individual responsible issues from pursuing the maximization of their interests to the detriment of the public. The overall interests of the public are prevented from being compromised by the pursuit of self-interest by individual responsible subjects. Only then can we effectively solve the problem of “back-end treatment but not front-end sorting” and truly make the ecological environment of the city function.

To this end, this paper focuses on constructing the interaction system of all participating parties, based on the perspective of coalitional games to crack the current dilemma of urban domestic waste classification.

## **2. Current Dilemma of Urban Domestic Waste Classification**

### **2.1. Insufficient Consensus among Residents**

Even though the concept of waste classification has been proposed for decades, the willingness of residents to separate waste has not continued to grow. Still shows a state of separation, and there is no strong sense of collective identity and collective behavior in the society. The public has the inertia and stereotype of “sorting does not depend on me,” and there are still problems of “separating bags but not sorting” and “incomplete sorting” in concrete operation. In some areas, waste classification relies on “secondary sorting” to achieve [4]. In addition, most urban residents are caught in the fast-paced life of “996”, lacking sufficient energy and motivation to participate in various activities and practices of waste separation. Even some residents with high awareness of waste separation are forced to adopt behaviors that deviate from the policy. This contradiction between high sorting intention and low sorting behavior [5] makes it impossible to form a good model among the residents. According to the survey, multiple factors such as lack of classification knowledge, inertness, and herd mentality have become obstacles for residents to classify garbage, and have also aggravated the difficulty of garbage classification [6]. At the same time, the policy of “instant heat” and the “sort first, mix later” waste management model fails to give positive feedback to urban residents, who do not receive good spiritual guidance and lack the internal driving force to separate waste. Therefore, in the absence of mandatory norms, even if there is a certain level of awareness of waste separation, it is difficult to raise the willingness of urban residents to separate their waste, and the connection between awareness and willingness is poor.

As a result, there is a lack of consensus among urban residents to actively participate in formulating waste separation policies and managing waste.

### **2.2. Shortage of Investment Funds**

The management of urban domestic waste in China is mainly focused on two stages: First, the construction stage of waste treatment infrastructure, including the placement and construction of sorted garbage bins, waste collection stations, transfer stations, and waste treatment equipment. The second is the maintenance

and operation phase of the daily work of infrastructure peacekeeping. In addition to the funds invested in construction, the second stage, the routine maintenance and operation stage, requires continuous investment of funds to carry out equipment maintenance and upgrading and ensure staff compensation, to maintain the regular operation of garbage treatment procedures. However, since the outbreak of COVID-19 in late 2019, the government has shifted its focus to epidemic prevention and control and invested a large number of human resources and money. Data show that in the first half of 2022, the vast majority of local governments across the country have a fiscal deficit. Environmental remediation funds provided by government financial departments still occupy a dominant position, and relevant investment in waste classification and treatment is inevitably affected. Therefore, a single source of funds for waste classification and treatment cannot meet the subsequent capital needs [7]. Some studies have compared the policies of various cities and found that the common problem lies in the absence of contents or implementation rules in some variables of all policies, such as the lack of means to absorb social capital in the funding system and the low enforce-ability of the policies [8]. They are hindering the effective treatment and lasting improvement of municipal solid waste.

### 2.3. Corporate Profitability Difficulties

The current waste classification, transportation, and treatment mode are single, and the waste terminal processing capacity is poor. In order to pursue the speed of waste collection and meet the collection standard, some garbage treatment enterprises adopt the mode of the collection first, and then complete the garbage sorting and treatment. Such a classification operation mode enables enterprises to complete the centralized collection and transportation of urban domestic waste in a single time with lower human and material resources, ensuring the quantity and speed of garbage collection and transportation. However, in the later stage of household garbage sorting and sorting, collection and treatment, enterprises often need to invest a large amount of extra consumption. They have put a severe squeeze on profits in its own industry. The relevant person in charge of “*Love classification*” (company name) once gave detailed data on garbage classification. The company’s sales income is about 300,000 yuan a month, and the government procurement income is about 400,000 yuan. However, the company’s manpower and operating expenses are about 800,000 yuan, and other expenses are about 200,000 yuan, so it is in a state of loss [9]. The profit or return of enterprises related to garbage treatment is too low, which reduces the vitality of the market operation of the industry. In addition, the decrease in government financial support and social attention is not conducive to the business situation of healthy competition in the garbage treatment industry, and restricts the improvement and innovation of enterprises in the garbage classification work, thus making them unable to achieve sustainable and coordinated development. They are hindering the continuous promotion of garbage classification and treatment.

## 2.4. Weak Supervision Mechanism

The waste classification work is mainly driven by the administration and the market, which inevitably involves the government, enterprises, residents, and other multi-party participants. Only by the joint efforts of all participants and the precise relationship between rights and responsibilities can the whole waste classification work be guaranteed to proceed as planned. China's garbage classification is still in the transition period from policies and regulations to institutional system. Although a basic system framework has been formed, there is still room for improvement in the correlation and complementary functions [10]. Most previous waste classification policies are more inclined to exhortations and guidance and lack of compulsiveness. Meanwhile, due to the vagueness and conflict characteristics of the policy itself, the implementation subject adopts the "symbolic implementation" strategy [11]. The weak supervision and restraint mechanism cannot timely guide and correct the behavior orientation of various subjects when they tend to be self-interested, and the supervision mechanism lacks trust. Therefore, it is difficult for each subject to form a high degree of trust with each other.

A smooth connection cannot be generated between each subject in each waste classification and management link, the participants gradually lack attention to the waste classification work. In order to pursue personal interests in the governance practice, some subjects evade their responsibilities and cut corners. The quality of waste classification work cannot be guaranteed, which affects the effective implementation of waste classification and damages the overall interests of waste classification work. The lack of standardization and efficiency of waste classification is a waste of resources and violates the values of waste classification and management.

## 2.5. Goal Integration Difficulty

Each subject in the waste classification work has its internal target differentiated and is limited to the programmed work. The failure to actively communicate soundly on the interests of all parties and the overall interests leads to untimely and asymmetric information, and the failure to reach a standard goal orientation, optimal cooperation path, and governance standards through timely consultation. In the collective action dilemma that has been formed, the targets of all subjects are self-interested short-term benefits, and the conflicting goals of residents, governments and environmental protection enterprises, coupled with the slow introduction of local standards, make it difficult to eliminate the inertia of the original treatment mode in a short time, and cannot be connected with the new standards in an orderly way, leading to frequent phenomena of "separation before mixing" and "mixing and transporting" [12]. The poor communication in the whole process of waste classification makes the process of delivery, collection, transportation and treatment disjointed, which further intensifies the effective integration of the objectives of the participants. In the actual waste classification work, there are different actions and objectives, which reduce the efficiency

of waste classification and affect the final classification effect.

### **3. Coalitional Game Perspective of Urban Domestic Waste Management**

#### **3.1. Reshape Public Status and Optimize Participation Mechanism**

First of all, the responsibilities and rights of residents, government, enterprises, and related social organizations should be clarified, the guiding force of the government should be strengthened, the innovative force of enterprises should be mobilized, the coordination force of social organizations should be highlighted, and the action force of the public should be brought into play [13]. Individual subjective cognition has a significant impact on the active garbage-sorting behaviour of actors [14]. In particular, it is necessary to play the primary role of urban residents in domestic waste classification. The General Secretary has also pointed out that extensive education and guidance should be carried out to make the general public aware of the importance and necessity of domestic waste classification. Through effective supervision and guidance, more people should take action to develop good habits of waste separation [15], and adjust their way of life, establish the subject consciousness. Secondly, it attaches importance to the practice and ability improvement of public garbage classification, implements the resident autonomous management system of household garbage classification in the community, establishes a volunteer work team mainly composed of residents, takes into account the actual situation of the community's population, facilities, location and so on, and adopts flexible and diverse forms of activities to ensure that the publicity work enters every household. At the same time, it attaches importance to summarizing experiences and opinions in practical work. It unites neighbouring communities to share and help each other to improve the level of community garbage classification management. Finally, we should absorb the public's power, improve the democratic consultation mechanism of garbage control, and let the public's voice enter into the formulation and implementation of policies, further enhance the public's subjective consciousness and sense of participation, and give full play to the public's action force.

#### **3.2. Expand the Channels of Funds and Implement the Charging System**

In order to ensure that the work of waste classification and treatment can be promoted continuously and long-term, ensure the orderly progress of all works, promote the work of waste classification and treatment to make up for the shortcomings of capacity, and upgrade to green intelligence, it is necessary to expand the channels of funds. Enough financial support is the basic condition for the smooth development of waste classification work. The various stages of garbage classification and treatment, especially the maintenance, reform and upgrading in the later stage, require a large number of funds.

As the "leader" in the whole process, the government should guide more relevant

enterprises and high-quality social capital to participate in the garbage classification and treatment work, share the financial pressure of the government in the garbage treatment work, deepen the reform of the PPP model, and strengthen the cooperation between government and enterprise. Explore establishing a market-oriented operation mechanism with “government as the leading role and enterprises as the main body” to achieve sustainable garbage classification [16]. At the same time, all localities and communities should adapt to local conditions, explore suitable household garbage charging methods according to the garbage quantity and residents’ income within their jurisdiction, constantly innovate the household garbage disposal charging mode, fully implement the household garbage charging system, and transform the current static garbage charging system by household or person into a dynamic garbage charging system by volume. Furthermore, it is gradually promoted to the whole country as a pilot [17]. Constantly improve the collection rate and the quality of garbage sorting and treatment work.

### **3.3. Promote the Development of Enterprises and Respect the Profit Demand**

As the leader, the government can cooperate with enterprises and reach mutually beneficial agreements by means of “blood transfusion” and “hematopoietic”, which can not only reinvigorate the vitality of environmental protection enterprises and help them overcome the difficulties of poor management, but also profit from subsequent profits. On the one hand, the government can formulate supportive policies, such as expanding the number of professionals in related fields, transferring waste sorting work suitable for enterprises to enterprises, giving them more business scope and profit space, improving the internal power of enterprise development, lead environmental protection enterprises to upgrade to intelligent green, reduce costs and improve efficiency.

Meet the requirements of modern garbage classification and management. Advanced energy saving, low-carbon environmental protection technology equipment and processes with high profitability are adopted to effectively solve the problems of insufficient income and complex long-term normal operation of environmental protection enterprises. On the other hand, enterprises should conduct comprehensive research and investigation, improve the garbage sorting and treatment work plan, upgrade and optimize the garbage sorting workflow, make it conform to the actual situation and the law of local garbage delivery, and carry out the construction of the whole process of the intelligent treatment system.

### **3.4. Strengthen Supervision and Management, Establish a Long-Term Mechanism**

The government as the main body of the supervision model has high costs, difficult to implement the dilemma. Therefore, it is necessary to encourage public participation with the help of social forces, and establish a social supervision mechanism involving citizens, social groups, media and other social institutions [18]. The



use of various advanced technologies and technological means to strengthen the real-time monitoring of garbage classification work, and improve the scope and time span of monitoring, make all participants participate in the supervision and management process, can further strengthen the constraints of various links of classification behavior, can also improve the sense of responsibility of all parties, and constantly strengthen the subject consciousness.

First of all, we should promote the diversification of the participants in the supervision mechanism, strengthen the supervision participation of residents, cooperate with the government supervision, and realize the multi-dimensional supervision and management of the whole process of garbage treatment.

Secondly, all departments and subjects should clarify their primary job responsibilities and supervision responsibilities in the process of garbage classification and treatment. While doing their own work well, they should comprehensively supervise whether the publicity work is effective, whether the policy formulation reflects public opinion, whether the residents' domestic waste classification is accurate, whether the relevant facilities and equipment are in place and normal operation, whether the garbage is classified and transported based on the classified collection.

Finally, government departments should improve the supervision of funds, strengthen the planned management of funds for garbage sorting and treatment projects, and do an excellent job in pre-budget, in-process supervision, and post-summary to ensure that the use of each fund is recorded in the whole process [19].

### **3.5. Promote Joint Construction and Governance to Achieve Cooperative Governance**

In order to achieve the long-term goal of garbage classification and governance, all participants should identify common interests, establish a garbage classification and governance community, mutual restriction, and mutual promotion. Through sharing governance experience, strengthening information exchange, resource sharing, and other means, cooperation among various departments is promoted, and joint efforts are made to realize the overall interests of the society. Combining the traditional cooperation mode with the advantages of information technology, integrating the interests of various subjects, establishing a cross-departmental and cross-subject domestic waste classification network platform, promoting the innovation of operation and supervision mode by digitization, improving the cooperation mechanism of garbage classification, using big data, cloud computing, AI intelligence, and other cutting-edge technologies, building a sound intelligent garbage classification and management system, sharing the workflow and real-time working trends of each subject and each link, making the work content open and transparent, and effectively solving the problems of information asymmetry, delayed communication and so on, is conducive to strengthening the consensus of garbage classification, unified action pace, timely adjustment of work details, and realizing intelligent classification and manage-

ment. Formulate a sound assessment and evaluation mechanism and incorporate it into the platform to constrain policies more effectively, motivate all parties to participate, and promote the effective implementation of household garbage classification and treatment. Make joint efforts to promote the long-term and effective implementation of urban household garbage classification.

#### 4. Conclusion

Although municipal solid waste treatment has been carried out for a long time, many things could still be improved. The power of the government or a single participant is not enough, it is necessary to gather the strength of all participants, break the dilemma of collective action, integrate goals, and form a garbage classification treatment mode of co-construction, co-governance, and sharing. The first thing to be solved is the problems of the participants themselves, such as the lack of public participation, the shortage of investment funds, and the difficulty of making profits, and reshape the values of the three, integrate the goals, and make them move towards the common goal. After that, to form benign interaction and cooperation among the three parties, it is necessary to continuously improve the supervision system to ensure the orderly and efficient conduct of garbage classification and governance. Meanwhile, relying on the Internet, a cross-departmental and cross-subject cooperation platform is formed to realize cooperative governance to improve the general interests of the society while safeguarding the self-interest of all parties and promoting the efficient conduct of garbage classification and governance.

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#### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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