

Article

# Study on Compulsory Classification Management and Behavior Synergy of Municipal Solid Waste

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**Abstract:** There is a general phenomenon of incoordination between garbage classification management and participation behavior, which seriously affects the sustainable management efficiency of domestic garbage. In order to solve this problem, this paper introduced the subject-object-process model into the waste classification management system, and constructed a mandatory classification management model of municipal solid waste and a comprehensive evaluation index system. Taking Beijing, China, as an example, the coupling coordination degree of garbage classification behaviors of residents in different was compared, and the coordination status of household waste management and behaviors was obtained. The results show that the synergy between government management and residents' household waste classification behavior is between 0.40 and 0.68, and the synergy between enterprises' participation in governance and residents' behavior is between 0.45 and 0.75. The coordination degree between domestic waste management and residents' participation behavior is generally in primary coordination or slight imbalance. The synergy degree between the secondary indicators of domestic waste management and residents' behavior is higher than that of the tertiary indicators. Superposition effect of integrated management measures is better; among the psychological factors affecting residents' classification behavior, the awareness rate and recognition degree of waste classification are very high, the awareness of environmental responsibility and social pressure are lagging behind. The study of synergy under the framework of subject-object-process not only quantifies the overall synergy between management and residents' behavior, but also provides a method to further implement garbage classification management in a targeted manner. Based on the synergy analysis, according to the weak links of various regions, classified management is carried out around publicity and education, supervision and management, assessment, rewards and punishments.



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## 1. Introduction

Domestic waste management is one of the main issues that have to be solved urgently in the field of environmental governance today [1,2]. Residents are the main producers of domestic waste, and the problem of domestic waste is even more serious in areas with dense populations and fast-paced consumption. As a populous country, China is deeply troubled by the “garbage Siege”. In 2019, China generated around 242.062 million tons of municipal solid waste (MSW), up 6.16 percent year on year [3]. Garbage classification is the basis for the effective implementation of all economic and technological means, and it is also an important manifestation of the government's governance capacity and the degree of economic and social civilization [4].

China's municipal waste classification began in the 1980s. In March 2019, the “Implementation Plan for Domestic Waste Classification System” was promulgated, marking the shift from “voluntary” to “mandatory” management of domestic waste classification

in China. While government management resources continue to invest heavily, residents' participation is relatively passive, market players and other collective public interest entities are absent and other issues. How to grasp the cooperative relationship between the government, enterprises and residents in the waste management system, promote effective communication between management subjects and objects, and then promote residents to implement domestic waste classification behavior independently, has become a hot spot of shared concern.

The dilemma of waste sorting management is caused by the interaction of unfavorable factors in the process of policy formulation and implementation. From the perspective of managers, the ideology of the managers, the difficulty of the problem, the social environment and the perception of public opinion will all have a greater impact on the implementation of the policy [5,6]. After the implementation of the policy, the complexity of policy objects, the number of audiences, and the degree of adaptation to the actual situation are also strongly related to the final effect of the policy [7]. The main object of management is residents, and the residents' household garbage classification and recycling behavior are affected by subjective and objective factors [8]. Proper conditions for waste separation play a key role in the transformation of waste classification attitude into behavior. Complete infrastructure is the basis for the subject to implement classified behavior [9]. Economic incentive is one of the effective means to promote MSW classification [10]. Pay as you throw can change the cost of classification to encourage residents to actively participate in garbage classification [11]. Public trust, perceived difficulties and reciprocity are also influencing factors for the effective implementation of waste sorting management policies. Publicity and education can improve residents' understanding of garbage classification information [12]. Citizens' knowledge of domestic waste classification and recycling information and policies will affect their trust in the waste classification management authority [13,14]. Community management can increase public trust by promoting communication among residents, thereby promoting residents' garbage sorting behavior [15,16].

In addition to situational factors, residents' garbage sorting behavior is also related to internal psychological factors such as personal attitude and cognitive level. Tonglet (2004), Seunghae Lee (2011), etc., believe that classification intentions are affected by subjective attitudes and cognition of consequences [17,18]. Social norms such as family members, friends, etc. will also affect individual classification behavior, and public opinion pressure from societal groups can increase residents' participation [19,20]. Perceived behavior control also plays an important part in promoting environmental protection willingness, and self-identity significantly regulates the influence of perceived behavior control on willingness and behavior [21].

In summary, current research on garbage classification focuses on policy, management and garbage classification behaviors and their behavioral influence factors. The purpose of these studies is to identify the influencing factors of domestic waste classification management and behavior, as well as its status and role in the entire influencing factor system. The domestic waste management system is not taken as a whole to study the synergy of system management and behavior. However, garbage classification is essentially the joint participation of multiple subjects, and the management objects select the results after measuring various management factors and behavioral environments. Research on the synergy between management and behavior is crucial to solving the dilemma of municipal solid waste management. Subject-object-process is a model that studies the relationship between governance issues and subject and object from a multi-dimensional perspective. This model is mostly used in overall system research in the field of environmental governance [22].

Therefore, this paper introduces the subject-object-process (SOP) model into the field of waste classification for the first time and expands it. From the three-dimensional perspectives of the government, enterprises and residents, the synergy between the management level and the residents' waste sorting behavior is analyzed. Provides a perspective to further implement garbage classification management and improve the coordination of en-

vironmental protection behaviors. The rest of this study is organized as follows: Section 2 introduces the research method, including research framework model, evaluation indicator system, and the calculation method of Coupling coordination; Section 3 collects relevant data. Section 4 carries out an empirical test, presents the results and discusses their implications. Section 5 draws the conclusions.

## 2. Materials and Methods

### 2.1. Research Framework

In order to explore the interaction among government, enterprises and residents in the process of management, and improve the coordination between management subjects and objects. In this paper, the subject-object-process (SOP) framework model is first constructed and implemented at the research on the synergy between the classification management of municipal solid waste and the subject behavior. The structure of the model body is as following:

Management subject: the government and its entrusted agent.

Management objects: community residents, enterprises (participating in garbage classification, recycling, resource treatment, etc.).

Management process: the production, classification, disposal and recycling of domestic waste.

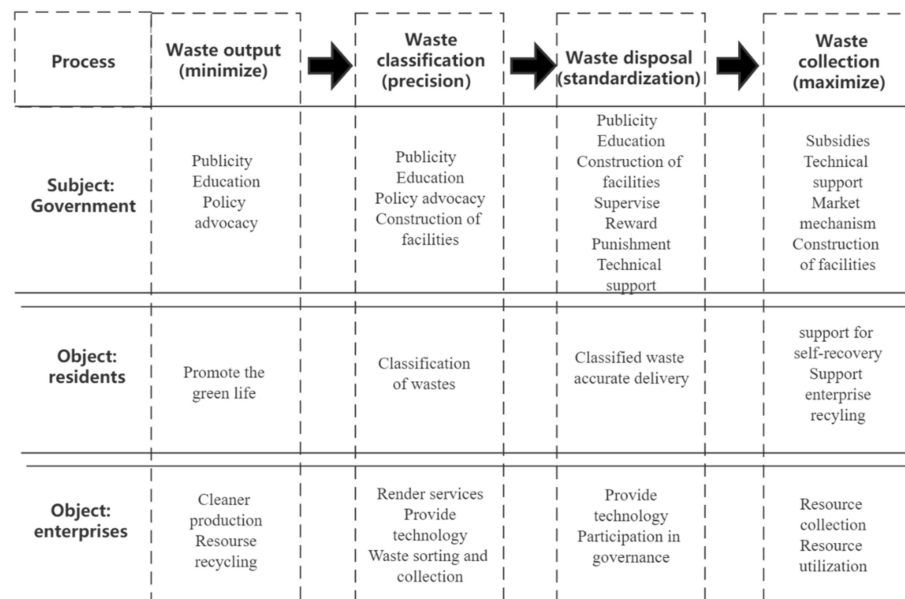
#### 2.1.1. The Relationship between the Subject and the Object of Garbage Classification Management

The behavior of the government as the subject of management can be divided into two types of factors: policy and management. Policies include mandatory laws and regulations, introduction of market mechanism, infrastructure construction, technical input and subsidies, etc. [23,24]. Management includes publicity and education, supervision and guidance, performance appraisal, rewards and punishments. The implementation of measures by the government affects residents' psychological factors (behavioral attitudes, perceived behavioral control and subjective norms). These factors indirectly act on residents' waste sorting behavior through behavioral intentions. At the same time, perceived behavioral control directly acts on personal behavior (theory of planned behavior) [25].

Domestic waste management has the characteristics of public goods [26]. The introduction of market mechanisms helps improve the allocation of funds, technological development and management effectiveness in waste classification management, and avoid government failure [11]. Enterprises participates in governance by signing long-term cooperation agreements with the government to strengthen the market-based mechanism for domestic waste management. Promote the effective implementation of waste classification management, and improve the level of recycling and recycling of renewable resources. At present, its main types of participation are: single enterprise is in charge of the whole process of domestic waste (sanitation integration), and different enterprises are responsible for the collection, transportation and treatment of domestic waste according to its types.

#### 2.1.2. The Relationship between the Subject, Object and Process of Municipal Waste Classification Management

In order to minimize the output of domestic waste, standardize the classification and maximize the recovery of resources, the government plays diverse roles in each stage. As showed in Figure 1, in the garbage generation and classification stage, the government is mainly providing classification infrastructure, responsible for publicity and education, raising residents' awareness of environmental protection and regulating the sorting behavior. At the waste disposal stage, the government, on the basis of publicity and education, provides classification facilities, conducts supervision and guidance, economic incentives and cooperates with enterprises to provide technical support. At the stage of waste collection, the government and enterprises are at the core of responsibility, and the government + enterprise operation mode is adopted to maximize waste collection.



**Figure 1.** Framework model of garbage classification management based on SOP.

In the process of reducing municipal solid waste, residents, as the principal actors, are the key targets of government management. In the whole process of waste generation, classification and delivery, situational factors (including policies and management measures adopted by the government, participation of enterprises, etc.) and residents' own psychological factors are all factors that affect waste generation, classification and delivery behavior.

## 2.2. Evaluation Indicator System

Based on the SOP framework model, a collaborative evaluation indicator system of domestic waste classification management and behavior is established, which consists of 3 primary indicators, 9 secondary indicators, 33 tertiary indicators and corresponding detailed indicators, as shown in Table 1.

Government management indicators are mainly divided into four categories: supervision, publicity and education, assessment management and classification process management [9–12]. By considering the integrity of domestic waste classification chain, process convenience and the qualified rate of residents' classification waste, the status of community waste classification management is evaluated.

Indicators of management objects: In addition to the residents' constituent attributes, the internal driving factors are mainly identified based on the theory of planned behavior and consist of five variables: behavior attitude, subjective norm, perceived behavior control, intention and behavior [25]. The classification attitude of residents is their evaluation of the behavior of garbage classification, which is related to factors such as the residents' own attributes and their understanding of garbage classification. Subjective norm refers to the social pressure from friends and family when residents decide whether to implement domestic waste sorting behavior [27]. From the norm activation theory, it can be known that residents' personal norms also have an impact on behavior. Personal norms are internalized from social norms, and responsibility attribution is the main factor influencing personal norms [28,29]. Therefore, this article incorporates personal norms and responsibility attribution into social norms. Perceived behavior control is the related factors that residents perceive to have a positive or negative effect on their classification behavior, including the residents' internal factors such as willpower, ability, etc., and external factors such as time, space and the completeness of classification facilities. The indicators of corporate participation in governance are mainly considered from the types of corporate participation, operation methods and technology types.

**Table 1.** Evaluation index system of the synergy between mandatory classification management of MSW and public behavior.

Primary Indicator	Secondary Indicator	Tertiary Indicator
Government and agency A1	Classification process management B1	Normative of container setting and maintenance C1 Collect vehicle compliance C2 Standardization of the collection process C3 Transport operation standardization C4 Clarity of where the garbage goes C5
	publicity and education B2	publicity household number C6 Number of publicity activities C7 Publicize equipment completeness C8
	Supervision B3	Performance of instructors C9 Full-process compliance supervision C10
	Assessment and management B4	Incentive coverage of residents C11 Garbage separation assessment public C12 Garbage separation assessment C13
enterprises A2	Participate in the type B5	Single enterprise integrated management C14 Multi-enterprise joint management C15
	Enterprise operation mode B6	Government + Enterprise Model C16 Enterprise independent management model C17
	Technical types B7	Intelligent classification trash can C18 APP online service C19 Digital operation management of each link C20 Closed classification transportation C21 End processing technology C22
community residents A3	The classification of intention B8	Behavioral attitude C23 Subjective norm—personal norm C24 Subjective norm—attribution of responsibility C25 Subjective norm—social pressure C26 Perceived behavioral control—time, personal ability limits C27 Perceived behavioral control—infrastructure C28 Perceived behavioral control—publicity and education C29 Perceived behavior control—reward and punishment regulation C30
	Classification of behavior B9	Garbage classification participation C31 Garbage classification satisfaction C32 Garbage classification awareness C33

### 2.3. Entropy Method

The entropy weight method is used to determine the weight value of each main evaluation index, which reflects the relative importance of each evaluation index in the system [30]. Calculation process:

Firstly, to calculate the sample index weight:

$$P_{ij} = \frac{y_{ij}}{\sum_{i=1}^m y_{ij}} \quad (1)$$

where  $m$  is the total number of samples,  $P_{ij}$  represents the proportion of the indicator  $i$  in  $j$  system,  $y_{ij}$  denotes the value of indicator  $i$  in  $j$  system.

Secondly, to calculate the entropy of  $j$  indicator:

$$e_j = -k \sum_{i=1}^m p_{ij} \ln p_{ij} \quad (2)$$

where  $e_j$  expresses entropy information of the indicator  $j$ . the constant  $k$  is related to the sample  $m$ :  $k = 1 / \ln m$ . If  $p_{ij}$  is 0, let  $p_{ij} \ln p_{ij} = 0$ .

Finally, the exponential weight is calculated.

$$w_j = \frac{1 - e_j}{\sum_{j=1}^n (1 - e_j)} \quad (3)$$

where  $w_j$  is the weight of the indicator in the garbage classification management system.

#### 2.4. Coupling and Coordination Model

Combining the coupling degree with the system cooperation degree model can intuitively reflect the cooperation degree of multiple systems in the development state [31]. The calculation process is as follows:

$$T_i = \sum_{k=1}^n w_{ik} \times U_{ik} \quad i, k = 1, 2, 3 \dots, n. \quad (4)$$

$$T = \sum T_i \quad i = 1, 2, 3 \dots, n. \quad (5)$$

where  $w_{ik}$  is the weight of the  $k$  factor in  $i$  system,  $U_{ik}$  denotes the comprehensive values of the  $k$  factor in the  $i$  system,  $T_i$  represents the comprehensive scores of the  $i$  system, and  $T$  represents the comprehensive scores of the whole system.

Calculate the coupling degree of multidimensional system.

$$C = \sqrt[i]{\frac{U_1 \times U_2 \times \dots \times U_i}{\left(\frac{U_1 + U_2 + \dots + U_i}{i}\right)^i}} \quad (6)$$

where  $U_i$  represents the comprehensive values of the  $i$  system,  $C$  is the coupling degree of multiple indicators in the index system ( $0 \leq C \leq 1$ ), which reflects the degree of interaction between indicators. The larger the value of  $C$ , the greater the coupling degree and the better the coupling effect between systems.

Calculating the coupling cooperation degree, the coupling degree can only reflect the degree of mutual cooperative coupling between two subsystems in the system and cannot evaluate the mutual cooperative effect of the whole system [32,33], so the cooperative evaluation function is introduced:

$$D = \sqrt{C \times T} \quad (7)$$

where  $D$  is the degree of cooperative development ( $0 \leq D \leq 1$ ), which measures the degree of cooperation among indicators in the management process. According to the coupling level judgment standard [34,35], the system coordination level is classified, as shown in Table 2.

**Table 2.** Criteria for evaluation of coupling coordination degree.

Coordination Level	D Value Range	Coupling Coordination Type
disorder	$0 \leq D \leq 0.1$	Extreme maladjustment
	$0.1 < D \leq 0.2$	Severe maladjustment
	$0.2 < D \leq 0.3$	Moderate maladjustment
	$0.3 < D \leq 0.4$	Mild maladjustment
Between disorders and coordinate	$0.4 < D \leq 0.5$	On the verge of maladjustment
	$0.5 < D \leq 0.6$	Grudging coordination
coordinate	$0.6 < D \leq 0.7$	Primary coordination
	$0.7 < D \leq 0.8$	Intermediate coordination
	$0.8 < D \leq 0.9$	Good coordination
	$0.9 < D \leq 1$	High quality coordination

### 3. Data Collection

Beijing is among the earliest cities in China to carry out waste sorting and has rich management experience. Compared with the strengthening of management measures, classification behavior of residents lags behind. In 2019, the satisfaction survey report of garbage classification demonstration areas showed that the awareness rate of garbage classification of Beijing residents reached 96.4%, but the participation rate of garbage classification was only 43.4%, and only about 7% of the residents achieved complete standard garbage classification. Non-demonstration areas were more lagging behind. Therefore, this article takes Beijing, China as an example, to study the synergy between waste sorting management and residents' behavior.

The data relied on a questionnaire survey, interview and field research. Select interviews and field research methods to collect information on government waste classification management and enterprise participation in governance. Information collection is mainly divided into three steps: 1. Conduct unstructured interviews with street government staff in the sample area to collect relevant information on the government's scoring standards, management plans, and the status quo of the community. 2. The members of the research team conducted on-site inspections of the infrastructure, publicity and education, supervision and management in the sample area. Then conduct interviews with the property and sanitation workers in the community to understand the daily management status of the community. 3. Compare the interview content with the management information provided by the government, and pass experts' scoring quantifies the data. The scoring table adopts Likert5 scale (1 = worst management level, 5 = highest management level).

Through a questionnaire survey, the data of classifying psychological factors and behavioral intentions of residents in two types of districts were collected. The questionnaire comprised two sections: part 1 contained questions about citizens' profile. Waste classification behavior related questions made up part 2 of the questionnaire (Appendix A). The questionnaire adopted Likert5 scale, in which "5" represented the maximum agree and "1" represented the maximum disagree. Finally, the Delphi method is used to process the collected government, corporate and resident's data to determine the weight of each indicator.

Data collected between October 2019 and March 2020. In order to study the synergy between management levels and residents' behavior, the demonstration communities and non-demonstration communities with different management levels were selected for investigation. As of July 2019, Beijing has created a total of 224 demonstration areas, accounting for about 60% of the city's total communities. Therefore, the two types of communities are collected at a ratio of 2:1. The survey area is divided into four areas: Dongcheng District, Chaoyang District, Shijingshan District and Tongzhou District. A total of 659 questionnaires were distributed, and a total of 621 questionnaires were collected, with an effective rate of 94.23%. The stratified sampling and random sampling methods were used to investigate the two types of community residents, property, street government staff and corresponding community sanitation workers. Among them, Dongcheng District, Chaoyang District, Shijingshan District and Tongzhou District each select 2 streets, each street selects 4–6 communities, and an average of 80 questionnaires are distributed. Since Dongcheng District has achieved full coverage of the demonstration area, samples from non-demonstration areas come from Chaoyang District, Shijingshan District, and Tongzhou District, with 204 samples in total. The demonstration area samples come from four areas, a total of 408 copies.

### 4. Result and Discussion

#### 4.1. Reliability and Validity Test

In the questionnaire survey, the internal consistency test is used to evaluate the stability of each observed variable, and the overall reliability of the questionnaire is judged by the combination reliability above 0.6. Cronbach's Alpha coefficient of behavior attitude, responsibility attribution, personal norm and perceived behavior control are all greater

than 0.6, and the overall confidence of the questionnaire is 0.832, which indicates that the questionnaire has high reliability. Kaiser-Meyer-Olkin (KMO) test and Bartlett spherical test are used as the criteria of correlation and independence test between variables. KMO value of each variable are greater than the threshold condition of 0.5 and the significance of Bartlett test is less than 0.001, so the model scale as a whole has good convergence validity.

#### 4.2. The Status of Residents' Participation in Garbage Classification

See Appendix B for the survey results of government management and enterprise participation. Among the management factors, publicity coverage and publicity facilities are relatively the best. The garbage sorting facilities have basically achieved full coverage, and the sorting facilities in the demonstration area are more standardized and diversified. The management of supervision, guidance, assessment, rewards and punishments is relatively weak. The whole chain participation, technology diversification and digitalization of enterprises need to be developed.

Residents' classification behavior scores are shown in Table 3. On the whole, the index of behavior attitude is greater, the attribution of responsibility and participation in classification are relatively inferior. In the demonstration area, only 7.75% of the residents regularly classify garbage every time, and 21.81% of the residents never classify garbage. Nearly half (41.18%) of residents in the non-demonstration area throw garbage without classification. However, the awareness rate of residents in demonstration areas is generally very high, reaching 100%, and nearly 40% (38.48%) of residents who are "familiar with waste sorting". The awareness rate of residents in non-demonstration areas is also as high as 96.57%.

**Table 3.** Status of household garbage classification.

Variable	Specific Indicators	Demonstration Area	Non-Demonstration Area
Behavior attitude	Classification evaluation	4.06	4.01
	Cognitive environment	4.03	3.88
Subjective norms	Personal norm	3.89	3.90
	Attribution of responsibility	2.63	2.58
	social pressure	3.78	3.52
Perceptual behavioral control	Time, personal ability limits	3.14	2.98
	Infrastructure	3.73	3.53
	Propaganda and education	3.97	3.88
	Reward and Punishment Regulation	3.65	3.58
Classification of behavior	Participation	2.52	1.97
	Satisfaction	3.97	3.23
	Awareness	4.02	3.85

It can be seen that Beijing residents have a sharp awareness of the compulsory classification of domestic waste, but their awareness of the responsible body is vague and their participation initiative is weak. So, the coordination degree between garbage classification management and behavior needs to be strengthened urgently.

#### 4.3. The Classification of Domestic Waste Management and Behavior Correlation

Through SPSS22.0, the correlation analysis on the influencing factors of the synergy between domestic waste classification management and residents' behavior (see Table 4). The results show that the correlation between residents' behavior and responsibility attribution, reward and punishment measures is not significant. The reasons are as follows: the government plays a strong role in the process of promoting garbage classification in



Beijing, but the residents' own sense of responsibility is still weak. At the same time, there is a lack of reward and punishment measures, its effect is not obvious.

**Table 4.** Correlation comparison of residents' behaviors and influencing factors.

Variables	Independent Variable Factor	Demonstration Area		Non-Demonstration Area	
		Coefficient of Correlation	Significant	Coefficient of Correlation	Significant
Behavior attitude	Evaluation of garbage classification behavior	0.228 **	0.000	0.357 **	0.000
	Cognition of the importance of garbage classification	0.320 **	0.000	0.361 **	0.000
Personal norms	The influence of moral sense on residents	−0.033	0.504	0.045	0.525
	The impact of reputation on residents	0.111 *	0.025	0.109	0.120
attribution of responsibility	Responsibility of household waste management	0.098 *	0.049	0.099	0.157
social pressure	The influence of the residents of the community on the residents	0.165 **	0.001	0.289 **	0.000
	The influence of family and friends on the classification of residents	0.024	0.622	0.043	0.545
time, personal ability limits	Garbage classification is not time consuming and energy consuming	0.026	0.599	0.152 *	0.030
	Garbage sorting does not take up much space	0.083	0.093	0.203 **	0.004
	The standard of garbage classification is easy to master	0.182 **	0.000	0.296 **	0.000
infrastructure	There is a garbage mixed transport problem	0.122 *	0.014	0.131	0.061
	Convenience of garbage classification	0.141 **	0.004	0.159 **	0.023
	The technical level of equipment and service for garbage sorting	0.077	0.119	0.090	0.200
publicity and education	The level of community publicity measures	0.208 **	0.000	0.308 **	0.000
	Residents' satisfaction with community publicity	0.180 **	0.000	0.219 **	0.002
Reward and Punishment Regulation	Material rewards	−0.036	0.465	0.091	0.091
	Honorary title and other incentive methods	0.014	0.936	0.074	0.291
	Constraint methods such as fines	−0.004	0.936	0.106	0.131

Note: \* indicates significant at the level of 0.05 (bilateral); \*\* indicates significant (bilateral) at the level of 0.01.

The significant correlation between the management of the demonstration area and residents' garbage sorting behavior is in descending order: environmental awareness > classification evaluation > publicity guidance > classification rule difficulty > community publicity satisfaction > influence of community residents > convenience of garbage classification > garbage transportation situation > personal reputation > attribution of responsibility.

The order of non-demonstration areas according to relevance is: environmental cognition > classification evaluation > publicity guidance > classification rule difficulty >

influence of community residents > community publicity satisfaction > space occupied by garbage sorting > energy spent on garbage sorting > convenience of garbage classification.

It can be seen that classification attitude is the most significant influencing factor. Convenience and publicity guidance are also more important, but the influence of social pressure, personal norms and awareness of consequences are relatively weak. The management measures have not been effectively linked to the image, reputation and consequences of violations. Thus, reward and punishment measures need to be further strengthened. Non-demonstration areas need to pay more attention to demonstration function and strengthen publicity and education.

#### 4.4. Classification Management of Domestic Waste and Behavioral Synergy

According to the field investigation result, the evaluation index of Beijing municipal solid waste classification management and the evaluation index of residents' garbage classification behavior are obtained. The index weight is determined by the entropy method, and then the coupling synergy degree of government-enterprise-residents three-dimensional system is obtained.

##### 4.4.1. The Synergy between Government Participation in Governance and Residents' Garbage Classification Behavior

Respective calculations of four main influencing factors of government management: waste classification process management, publicity and training, supervision and the coordination degree between assessment measures and residents' waste classification behavior (Table 5).

**Table 5.** Synergy degree between government management indicators and residents' classification.

Government Management Indicators	Demonstration Area			Non-Demonstration Area	
	Dongcheng District	Chaoyang District	Shijingshan District	Tongzhou District	Other Communities
Classification process management	0.68	0.63	0.62	0.62	0.53
publicity and education	0.67	0.63	0.62	0.61	0.46
Supervision	0.66	0.61	0.61	0.60	0.40
Assessment and management	0.66	0.62	0.61	0.60	0.46

The coordination degree between government management and household waste classification performance in the demonstration area is in the state of primary coordination (0.60–0.68). Synergy degree of non-demonstration area is on the verge of maladjustment and Grudging coordination (0.40–0.53). Overall, there is still abundant room for improvement in the synergy between government domestic waste management and residents' classification behavior. Among them, the coordination degree between classification process management, publicity and training indicators and household garbage classification behavior is relatively high, and the supervision and assessment efforts have yet to be strengthened.

##### 4.4.2. The Synergistic of Enterprises' Participation in Governance and Residents' Garbage Classification Behavior

It can be seen from Table 6 that in the demonstration area, the level of synergy between the indicators of enterprises participating in governance and the classification performance of residents is primary coordination, while in the non-demonstration area, it is on the verge of maladjustment. On the whole, the degree of enterprise participation is insufficient, so we should enhance the intensity of enterprise participation, the introduction of market mechanism and the diversification of enterprise participation types, and promote the classification and recycling of resources in the whole chain.

**Table 6.** Synergy degree of enterprise participation in governance and residents' classification.

Secondary Indicators of Enterprise Participation	Demonstration Area				Non-Demonstration Area
	Dongcheng District	Chaoyang District	Shijingshan District	Tongzhou District	Other Communities
Participate in the type	0.68	0.63	0.62	0.61	0.49
The way they operate	0.75	0.70	0.68	0.68	0.49
Technical types	0.69	0.64	0.64	0.65	0.45

#### 4.4.3. The Synergy between the Tertiary Indicators of Government Management and Residents' Garbage Classification

In order to reveal the synergy of government management indicators more deeply, the synergy of the three-level management indicators was measured (Table 7). The overall coordination degree between government management and residents' behavior in the demonstration area is on the verge of maladjustment-intermediate coordination in Table 7. Among them, the coordination degree between the three-level indicators under the classification process management and the residents' garbage classification participation in the demonstration area is on the verge of maladjustment and grudging coordination (0.45–0.54). The coordination degree between the transportation operation standardization and residents' garbage classification behavior is the best, which is grudging coordination (0.51–0.54). The coordination of garbage destination and behavior is low, showing on the verge of maladjustment (0.45–0.48). The synergy in non-demonstration areas is all less than 0.5, which is in a state of slight imbalance and on the verge of imbalance. It shows that the unclear destination of classified garbage is a significant factor affecting residents' participation in behavior. The whole process of garbage classification and collection should be further standardized, and the destination of classified garbage should be clearly defined.

**Table 7.** Synergy degree between three-level indicators of government management and the classified participation of residents.

Secondary Indicator	Tertiary Indicator	Demonstration Area				Non-Demonstration Area
		Dongcheng District	Chaoyang District	Shijingshan District	Tongzhou District	Other Communities
Classification process management	Normative of container setting and maintenance	0.51	0.51	0.50	0.48	0.43
	Collect vehicle compliance	0.52	0.50	0.50	0.49	0.46
	Standardization of the collection process	0.51	0.48	0.48	0.47	0.39
	Transport operation standardization	0.54	0.52	0.52	0.51	0.40
	Clarity of where the garbage goes	0.48	0.46	0.47	0.45	0.33
publicity and education	publicity household number	0.54	0.52	0.53	0.51	0.37
	Number of publicity activities	0.55	0.51	0.51	0.491	0.33
	Publicize equipment completeness	0.66	0.63	0.62	0.58	0.39
Supervision	Performance of instructors	0.57	0.53	0.56	0.56	0.34
	Full-process compliance supervision	0.72	0.67	0.67	0.62	0.35

Table 7. Cont.

Secondary Indicator	Tertiary Indicator	Demonstration Area				Non-Demonstration Area
		Dongcheng District	Chaoyang District	Shijingshan District	Tongzhou District	Other Communities
Assessment and management	Incentive coverage of residents	0.60	0.59	0.56	0.56	0.39
	Garbage separation assessment public	0.58	0.56	0.54	0.54	0.38
	Garbage separation assessment	0.58	0.54	0.53	0.52	0.34

In the publicity and training management, the coordination between the completeness of publicity facilities and the participation of residents in waste classification in demonstration areas is relatively good, basically showing a primary coordination state (0.58–0.66). Under the supervision and management indicators, the coordination level of the whole process compliance supervision is in the state of primary coordination and intermediate coordination (0.62–0.72), which is relatively higher than other indicators. The coordination degree between the assessment management indicators and the participation degree of residents' garbage classification is in a state of slight maladjustment-grudging coordination.

The results show that the demonstration area has been improved in the whole process and compliance management, supervision and guidance of garbage classification. The implementation of publicity and education is relatively strong, and the overall publicity facilities are relatively complete, but the publicity frequency, intensity and coverage are insufficient, and there is an imbalance between communities. There are some problems in the assessment and supervision, such as the low effectiveness of residents' behavior change, the weak intensity of rewards and punishments and the low effectiveness of classified instructors. It needs to be further strengthened, explored and expanded.

#### 4.4.4. The Synergy between the Tertiary Indicators of Enterprise Participation and the Participation Level of Residents' Garbage Classification

As shown in Table 8, the cooperation degree between enterprises and residents involved in waste classification in the demonstration area is low, ranging from 0.33 to 0.68, which is between mild maladjustment and primary coordination. The cooperation degree of enterprises in non-demonstration areas is lower, in the range of 0.22–0.39, showing moderate maladjustment or mild maladjustment. In the enterprise operation mode, the synergy between the independent operation mode and the participation in household garbage classification is relatively high, indicating that the market-oriented enterprise participation is more in line with the development law of the renewable resources industry. The efficiency of enterprise integrated management is relatively high, but the overall synergy is low, and further development is needed. The degree of collaboration among the indicators of technology types is relatively low, and the application of waste sorting and recycling in digitization and new technologies is still in the initial stage.

**Table 8.** Synergy degree between the three-level indicators of enterprise participation in governance and the classified participation of residents.

Secondary Indicator	Tertiary Indicator	Demonstration Area				Non-Demonstration Area
		Dongcheng District	Chaoyang District	Shijingshan District	Tongzhou District	Other Communities
Participate in the type	Single enterprise integrated management	0.62	0.51	0.49	0.50	0.37
	Multi-enterprise joint management	0.56	0.48	0.45	0.46	0.29
Enterprise operation mode	Government + enterprise model	0.64	0.54	0.52	0.56	0.39
	Enterprise independent management model	0.68	0.57	0.55	0.59	0.34
Technical types	Intelligent classification trash can	0.43	0.38	0.35	0.41	0.24
	APP online service	0.40	0.34	0.33	0.34	0.22
	Digital operation management of each link	0.53	0.41	0.42	0.47	0.27
	Closed classification transportation	0.54	0.43	0.45	0.48	0.28
	End processing technology	0.52	0.46	0.45	0.48	0.29

#### 4.5. Discussion

The main psychological factors of residents' garbage classification behavior are: behavior attitude, subjective norms and perceived behavior control, which are consistent with previous studies [17,19–21]. Garbage classification evaluation and environmental cognition are the most important as the ideological basis of residents' behavior. Residents have a high awareness and recognition of garbage classification and recycling, but their own sense of responsibility is significantly lagging behind. Although the management method enhances the environmental attitude of the actors, it fails to strengthen the sense of responsibility and has not been closely linked to personal norms, image credibility and illegal consequences. Thus, the correlation between supervision and guidance, rewards and punishments and residents' behavior are low. It is necessary to strengthen the psychological feelings of residents such as responsibility attribution, personal norms and perceived behavioral control.

The coordination degree of management level, enterprise participation and residents' behavior in demonstration area was significantly higher than that in non-demonstration area. Therefore, the mandatory management level is proportional to the synergy of residents' behaviors, and the input intensity of management level should be increased in the later stage for the weak links [19]. The synergy between government and enterprises' three-level indicators and household garbage classification participation is relatively lower than that of comprehensive indicators. It shows that the comprehensive implementation of various management measures by the government and enterprises has a significant superposition effect on improving residents' garbage classification behavior and intention, and this has also been proposed in previous studies [26,36].

Overall, the synergy between government waste management and residents' participation is on the verge of imbalance or primary coordination, and there is still much room for improvement. In the management measures, garbage classification process management and behavior coordination degree are high. The current classification process management pays more attention to the standardization of transportation operations. The standardization of the sorting collection process and the unclear direction of garbage sorting have low coordination with residents' behavior, and the whole process management needs to be improved. It is suggested to further expand the implementation of compulsory

classification management, standardize the supervision of the whole process of garbage classification and collection, develop the renewable resources industry, and clarify the direction of classified garbage. The coordination degree of publicity and education is relatively high, but there are differences between communities. It is still necessary to strengthen publicity efforts, means and publicity facilities, and innovate in perspective and method [37]. For example, improve the relevance of education. For young people, put garbage classification public service ads and related knowledge in daily activity venues such as subway ports and bus stop signs; issuing free gifts with classified knowledge for the elderly; collaborate with schools to cultivate students' garbage classification habits in the form of classroom education; strengthen the publicity and education and management of enterprises in accordance with the law, improve the acceptance of classification knowledge of enterprise employees and owners.

The coordination degree of supervision and assessment indicators is low. Such management should focus on the improvement of residents' sense of responsibility and the change of public habits, and establish a system of garbage classification performance linked to residents' honor and credit. Strengthening the cognition of the connection between behavior and violation consequences [10]. At the same time, according to the actual situation of each area, focusing on different management methods and efforts to strengthen cooperation benefits [12]. Communities in the initial stage can start with weak management indicators to improve the construction according to the construction process of the demonstration area. Focus on demonstration effect, strengthen the management of classification process, such as the standardization of infrastructure, classification collection of vehicle compliance and rationalization of transportation mode. The assessment management mechanism should be improved and the mixed transportation of domestic waste after classification should be emphatically.

The coordination degree of corporate participation in governance and residents' behavior is between the state of imbalance and intermediate coordination. Among the types of participation, compared with the classification and recycling model of multiple companies, the integration of enterprises to undertake community business has a better degree of coordination. In general, it is necessary to increase the intensity and types of enterprise participation and promote the construction of a full-chain resource system with diversified participation [38]. In the operation mode, government purchases of services and residents' behavior are more synergistic. Market-oriented enterprises are more in line with the development of renewable resources industry, which is conducive to the role of market regulation. The synergy between the three-level indicators and residents' behaviors under the technical type is low, indicating that the current domestic waste management is still in the preliminary attempt stage in the application of new technologies such as intelligence, digital management and service. The government can vigorously support innovative waste classification and treatment companies, actively mobilize the enthusiasm of enterprises to participate in governance. Improve infrastructure supply and improve the convenience of residents' classification, thereby improving the efficiency of government management.

## 5. Conclusions

In this paper, the subject-object-process model is introduced into the field of garbage classification for the first time. Combined with the three dimensions of government, enterprises and residents, the synergy between management subjects and objects in the garbage classification system is studied to make up for the gap between garbage classification management and residents' behavior. Taking Beijing, China as an example, this paper conducts an empirical test on the model and finds that:

There are differences in the synergy between the management level and residents' garbage classification behavior in the demonstration area and the non-demonstration area. In the demonstration area, the synergy between the government management level and residents is 0.60–0.68, the synergy between enterprises' participation in governance and residents' behavior is 0.61–0.75. The synergy degree of government management,

enterprise participation and residents' behavior in non-demonstration area is 0.40–0.53 and 0.45–0.49, respectively. The higher the level of garbage classification management, the higher the level of coordination between management and behavior.

The synergy between the secondary indicators of government and enterprise management and household garbage classification behavior is relatively high, between 0.40 and 0.74, and the synergy between the tertiary indicators is between 0.22 and 0.68, which is relatively low. Therefore, the joint role of government and enterprise multi-factor management helps to improve the synergy between its management and residents' behavior. The main psychological influencing factors of household garbage classification behavior are behavioral attitude, subjective norm and perceived behavioral control. Management tools can start from these influencing factors to improve their synergy.

Although this study constructs a collaborative model of garbage classification management and residents' behavior based on subject-object-process. It compares the degree of coordination between management and behavior and provides an idea for the study of sustainable management and public behavior coordination. However, due to the availability of data, the model proposed in this paper only takes Beijing, China, as an example for empirical test. In future research, relevant data will be collected to test the impact of the model on other developing and developed countries.

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## Appendix A

**Table A1.** Questionnaire of Domestic Waste Classification Behavior.

1. Classified treatment of domestic waste plays an important and positive role in improving urban environment
2. It is everyone's duty to classify domestic garbage
3. I am willing to take the initiative to classify domestic garbage from myself
4. Support the government to implement the compulsory classification management of domestic garbage
5. Waste classification is helpful to solve the problem of environmental pollution in cities now
6. Improper disposal of domestic garbage will affect residents' health and spread diseases.
7. The exemplary behavior of garbage classification of nearby residents will encourage me to carry out garbage classification
8. The exemplary behavior of garbage sorting by family and friends will motivate me to sort garbage
9. Failure to classify garbage will affect personal image and reputation
10. Everyone should be responsible for the garbage he produces and minimize its pollution.
11. Even when no one is there, I will feel guilty if I don't classify the garbage according to the regulations.
12. The effective implementation of domestic waste classification should not be the responsibility of the government
13. Residents should be the main force in garbage sorting
14. Garbage Sort is not a waste of time and energy
15. The difficulty of domestic waste classification standard is very important to my classification behavior

**Table A1.** *Cont.*

16. Domestic waste sorting at home does not require a lot of space
17. Community supervision and guidance is very important for me to implement household waste classification
18. The education and publicity of garbage classification in the community is very important to my classification behavior
19. I am very satisfied with the current publicity of garbage classification in the community
20. Cash incentives can motivate me to classify garbage
21. Reputation awards such as "Green Pioneer" can motivate me to classify garbage
22. The convenience of waste sorting makes us more willing to participate in waste sorting
23. After I classify the garbage, whether the garbage direction is clear is very important for my implementation of household garbage classification
24. App booking door-to-door recycling or intelligent garbage sorting can promote my garbage sorting

**Appendix B****Table A2.** General Situation Table of Domestic Waste Classification Management at Sample Points.

Primary Indicator	Secondary Indicator	Tertiary Indicator	Demonstration Area	Non-Demonstration Area
Government and agency	Classification process management	Normative of container setting and maintenance	3.40	2.00
		Public notice, site setting, environmental sanitation, collection and transportation vehicles and other operations	3.35	1.50
	Public management	Publicity household number	3.63	1.00
		Number of publicity activities	3.00	1.00
		Publicize equipment completeness	4.38	1.00
	Supervision	Performance of instructors	1.88	0.50
		Compliance supervision of the whole process	3.18	0.50
	Assessment and management	Incentive coverage of residents	2.63	0.50
		Garbage separation assessment public	1.25	0.25
		Garbage separation assessment	2.75	0.75
enterprises	Participate in the type	Single Enterprise Integrated Management	3.45	1.00
		A number of enterprises jointly receive and transport processing	3.40	1.00
	The way they operate	Government + Enterprise Model	3.25	0.50
		Enterprise independent management model	3.50	1.00
	Technical types	Intelligent classification trash can	3.80	0.50
		APP online service	3.00	0.50
		Digital operation management of each link	2.50	0.50
		Closed Classification Transportation Technology	3.25	0.50
		Classification end processing technology	3.00	0.50



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