Status Quo Analysis and Optimization of the Classification Policy for Municipal Waste in Nanjing

Zeyu Yin[1*], Lili Feng[2], Wenjing Xin[3], Sixian Yu[4]

*b18160523@njupt.edu.cn[1], 1843934920@qq.com[2], norahxin@163.com[3], 1031658798@qq.com[4]

School of Applied Technology, Nanjing University of Posts and Telecommunications, Nanjing 210042, China[1]
Logistics and E-commerce College, Zhejiang Wanli University, Ningbo 315100, China[2]
School of Humanities and Foreign Languages, Qingdao University of Technology, Qingdao 266520, China[3]
College of Philosophy, Law & Political Science, Shanghai Normal University, Shanghai 201418, China[4]

Abstract—This article takes the waste classification policies promulgated in Nanjing over the years as its research object and categorizes it into different phases such as the collection of opinion, the pilot implementation, and the enforcement according to its characteristics in development. The quantitative analysis method is employed to analyze the policy subjects, objectives, tools and contents. The result shows that the current classification policy for municipal waste in Nanjing is inadequate in policy and regulation system, industrialization construction and advancing supervision. Based on these aspects, this article proposes some improvement suggestions and wishes to solve the above problems and provide reference suggestions for formulating and implementing the follow-up policies.

Keywords: waste classification; policy analysis; policy evolution; industry chain

1. INTRODUCTION

As China's municipalization process enters into a faster track, an ever-growing amount of waste generated from domestic life and industrial production process result in increasing demand for waste classification and disposal. According to the National Bureau of Statistics statistics, the total amount of municipal solid waste removal and transportation in China in 2019 has reached 242.06 million tons, with a remarkable increase of 84.02 million tons over the prior decade (see Figure 1). Bearing such a huge amount, China now ranks as one of the top waste-producing nations in the world. Effective waste disposal contributes to reducing pollution, conservation of land resources, and the promotion of sustainable ecological

development. In order to deal with and solve the problem of municipal waste, the promotion of accurate classification of municipal waste has now become an issue of urgency in the context of China's municipal governance.

Waste classification refers to a series of activities involving classified waste storage, operation, transportation, and finally transformation into public resources in accordance with specific regulations or standards. China's municipal waste classification policy can be traced back to 1992. The "*Regulations on the Administration of City Appearance and Environmental Sanitation*" promulgated by the State Council first put forward waste classification requirements in the form of a policy document, thus launching China's continuous exploration and experimentation of municipal waste classification [1]. Local governments also actively responded to the state's call with a large number of local policies following suit. One typical example is Jiangsu, which is one of the pioneering provinces to establish and implement municipal waste classification policies, issued the "*Tenth Five-Year Plan for Ecological Construction and Environmental Protection in Jiangsu Province*" and "*Regarding the Implementation of municipal Domestic Waste Disposal, and Charging System to Promote the Industrialization of Waste Treatment*" as early as 2002 to 2003. These documents put forward conceptual opinions on the construction of waste treatment, waste classification, and industrialization of domestic waste. As the capital city of Jiangsu Province, Nanjing issued the "*Notice on the Implementation of the Classification and Management of Municipal Solid Waste Collection*" as early as 2000. It was also the first particular document on the classification of municipal waste in Jiangsu.
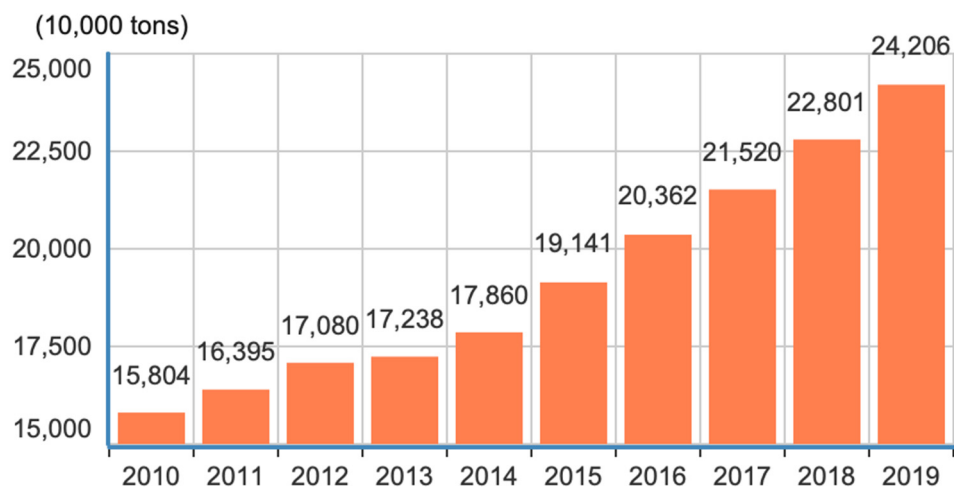

Figure 1. The total amount of domestic waste collected and transported from 2010 to 2019

There are still some shortcomings after the development and evolution of China's municipal waste classification policy for more than two decades. Although local policies vary greatly in different areas, the overall ideas and measures are roughly the same. The sampling of representative provinces and cities for analysis is helpful to understand and summarize the development history, core content, and shortcomings of China's municipal waste classification policy, from which improvement measures could be proposed, and headways could be made

in the study for the scientific development of China's municipal waste classification with a theoretical support for its feasibility and effectiveness [2].

2. METHODS AND MATERIALS

In order to ensure the samples selected are representative and advanced, this article first aims at Jiangsu Province, using the government websites and the Peking University magic database as the platform for policy collection. Then using "waste classification" as the keyword to search local laws, regulations, and working documents, and removing duplicate documents, expired documents, and irrelevant documents. Finally, we count 105 published policy documents in Jiangsu in total. Among them, Suzhou and Nanjing rank the top two, which have 28 and 22 respectively. However, as the capital and the first city to promote waste classification in Jiangsu, taking Nanjing as the analysis case is more typical. In order to ensure authenticity and credibility, the data involved in this article are based on the coding analysis of the policy text and reports from the National Bureau of Statistics.

In order to avoid the subjectivity and uncertainty of qualitative analysis, this paper uses the method of quantitative analysis to conduct in-depth research on the policy text. It is first to categorize the policy-making process into three different phases, which are the collection of opinion, the pilot implementation, and the enforcement according to its characteristics and issued time. Then systematically classification out the policy subjects, objectives, tools, and contents appearing in the policy text. Finally, summarizing the government' s preference in policy-making and presenting existing problems and improvement measures.

3. POLICY CHANGE PHASES

This article collects 22 policy documents for municipal waste in Nanjing for centralized analysis. Combined with each document's characteristics and issued time, we summarize the policy-making process as the opinion collection, the pilot implementation, and the enforcement [3]. Each phase and specific policies included are shown in Figure 2.

Phase	Number	Year	Policy Name
Opinion collection （2000-2010）	1	2000	*Regarding the Implementation of municipal Domestic Waste Disposal*
Pilot implementation （2011-2014）	2	2011	*Nanjing Municipal Domestic Waste Classification Pilot Program*
	3	2011	*Notice on organizing the visit to "Green Treasure-City waste classification Education Exhibition"*
	...	...	...
	8	2014	*Opinions on the implementation of waste*

			classification in Nanjing in 2014
	9	2014	*Implementation Plan for the Classification of Domestic Waste in Nanjing*
Enforcement （Since 2015）	10	2015	*Implementation Plan for Nanjing to Build a National Demonstration City of Domestic Waste Classification*
	11	2018	*Work plan for waste classification of party and government offices in Nanjing municipal area*
	...	...	...
	21	2020	*Nanjing Municipal Domestic Waste Management Regulations*
	22	2020	*Notice on Carrying out Ten Actions for Waste Classification of Nanjing Catering Enterprises*

Figure 2. Phase changes in Nanjing Municipal Waste Classification Policy

3.1 The opinion collection phase (2000-2010)

In order to implement the "Administrative Measures for municipal Living waste", "Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste", and other policies issued by the Central Government, the Nanjing Government promulgated the "Regarding the Implementation of municipal Domestic Waste Disposal" in 2000. This document responds to the released central signals and encourages the public to participate in waste classification. It puts forward opinions on publicity, promotion, and overall leadership of waste classification in cities to understand its feasibility and recognition, and it is also the earliest particular document on municipal waste classification issued by Jiangsu Province. At this stage, there were no other issued particular documents about waste classification. Nanjing Government only mentioned it as one of the issues in waste disposal and city environment policies. Moreover, the policy at this stage is too conceptual and lacks specific measures, which is reflected in the fact that there are many overall requirements, but the classification standards, regulations, and measures have not been perfected, and pilot projects have not been carried out in advance. As a result, there is not enough feedback on the policy effect and follow-up formulation, resulting in the failure of the policy implementation.

3.2 The pilot implementation phase (2011-2014)

In the background of the unsatisfactory effect of the previous policy implementation, the state has successively issued "*Guidelines for Domestic Waste Treatment Technology*", "*Municipal Appearance and Environmental Sanitation Management Regulations*", and other outline guidance documents to further improve the municipal waste classification framework system

and promote the work process. Against this background, Nanjing issued the "*Nanjing Municipal Domestic Waste Classification Pilot Program*" in 2011, which launched pilot works in Suojin Street, Yueyahu Street, Xinglong Street, and Jiangdong Street. This is the first time that Nanjing has issued a particular document to set up a waste classification pilot area. The document has formulated more specific rules and regulations, and classification methods, which have instructive significance for presenting and formulating follow-up policies. The later policies issued in the pilot implementation phase are mostly based on this, further complementing the rules and regulations, expanding the scope of the pilot, and strengthen publicity. After good feedback in the preliminary pilot work, the Nanjing municipal Management Bureau had issued the "*Notice on the Implementation Opinions of Nanjing Municipal Waste classification Expansion Pilot Work*" in 2012 to increase the coverage of waste classification.

3.3 The enforcement phase (Since 2015)

Due to insufficient funds, imperfect supervision system and infrastructure construction, waste disposal efficiency are low, and waste classification had been developed slowly. Until 2015, several central policies and regulations have been continuously issued. Among them, the "*Thirteenth Five-Year Plan--National municipal Domestic Waste Harmless Treatment Facilities Construction Plan*" marks the official start of the comprehensive waste classification. The "*Implementation Plan for the Domestic Waste Classification System*"requires the trials of waste classification in key cities. And the "*Notice on Comprehensively Carrying Out Waste classification Work in Cities at the Prefectural Level and Above*" requires that major cities should mandate waste classification work, which marks the municipal waste classification policies have officially transformed from pilot to mandatory. In response to national policies, Nanjing had issued the "*Implementation Plan for Nanjing to Build a National Demonstration City of Domestic Waste Classification*" in 2015. This document established a comprehensive incentive assessment mechanism and created an integral management system, exchange services system, and transportation management system. While maintaining the original promotion efforts, it also promulgated detailed regulations and a clear organizational division of labor to enforce the waste classification policies. In the enforcement phase, the policies promulgated by the government are more specific, and the degree of enforcement is more strict. At this point, the era of "national waste classification" and "compulsory classification" has begun[3].

4. QUANTITATIVE ANALYSIS OF POLICY TEXTS

A comprehensive analysis of the policy text can help understand the feasibility and accuracy of specific policies and guide the subsequent formulation of the following relevant policies scientifically and comprehensively. Based on the four dimensions of policy subjects, policy objectives, policy tools, and policy contents, this paper carries on the quantitative analysis to the 22 policy documents and summarizes their changes in three different phases. The results are as follows:

4.1 Policy subjects

Briefly speaking, policy subjects can be defined as individuals, groups, and organizations that participate in policy formulation or implementation [4]. Based on the statistics of 22 policy documents, this paper concludes that the main policy subjects from high to low are the government, community, enterprise, school, and individual. Among them, the government, as the central policymaker and implementer, runs through the entire process of municipal waste classification and management. However, It is challenging to complete the extensive municipal waste classification work of promotion and supervision by the government alone. As an enormous social life community composed of a specific population in a particular area, the community is a grassroots unit for social governance. Therefore, it is often necessary for communities to coordinate with the government to take up the responsibility of waste management and supervision in their own jurisdictions. In 2011, Nanjing held the "Green Treasure-City-wide Waste classification Education Exhibition" activity, which calls on primary and middle schools to visit and organize waste classification-related activities and bring waste classification publicity and promotion obligations into schools. In the various policy documents issued since then, the government is no longer a single policy subject, and communities, enterprises, and schools often appear as auxiliary implementers or pilot units. In the "*Notice on Carrying out Ten Actions for Waste Classification of Nanjing Catering Enterprises*" issued in 2020, the government had taken the company as a single subject to formulate standards to promote the implementation of the responsibilities of each district and the primary responsibility of catering enterprises.

In general, with the changing phases of Nanjing's municipal waste classification policies, the main policy subject has gradually changed from a single subject dominated by the government to multiple subjects that cooperate with the government, communities, enterprises, and schools. As one of the main subjects in policies, individuals have rarely appeared in local laws and regulations. The government often just formulates norms and guidelines and lets communities, enterprises, schools, or other subordinate units supervise and manage individuals.

4.2 Policy objectives

Waste is a valuable resource misplaced. Following the principles of waste reduction, recycling and harmlessness, implementing the waste classification work, and guiding citizens to form an environmental-friendly lifestyle are conducive to improve the city environment and recycling of resources, and strengthen national literacy and social civilization. The first particular waste classification document issued by Nanjing in 2000 had clearly stated that "gradually achieving harmlessness, reduction, recycling, and industrialization of waste disposal" is the ultimate objective. Among them, harmlessness refers to reducing the adverse effects on the environment and human bodies during the waste disposal process; reduction refers to reduce the resource consumption and waste generation in production, circulation, and consumption links, including source reduction and end-point reduction; recycling refers to take appropriate measures to realize the reuse of resources such as materials and energy in waste [5]; industrialization refers to the creation of a waste classification industrial chain, which includes jobs like classification and distribution in front-end, collection and transportation in middle-end, and treatment and disposal in back-end.

In each phase, waste reduction, recycling and harmlessness are the primary policy objectives of the government. Since China currently does not have sufficient experience in waste classification and the relevant industrial chain still takes time to build, there are no particular documents for the industrialization of waste classification issued. In addition to the "Four objectives", some other policy objectives that appear frequently include advancing waste classification work, implementing the spirit of regulations, setting examples, and improving the environment.

4.3 Policy tools

As an integral part of policies, policy tools are the means to achieve the expected policy goals. To some extent, they can be interchanged with policies. This article draws on Howlett and Ramesh's research method, which divides policy tools into compulsory, voluntary, and mixed types according to the degree of interference by state organs [6]. Among them, compulsory policy tools are directly enforced by the government on target population or companies; voluntary policy tools have little or no government intervention and complete predetermined tasks voluntarily; mixed policy tools have the features of both voluntary policy tools and compulsory policy tools.

With the changes in policy phases, the government's preferred policy tools have gradually changed from voluntary to mixed and compulsory. According to statistics, among the 22 documents issued by Nanjing, 9 are voluntary tools, 9 are compulsory tools, and 4 are mixed tools. The policy tools introduced in the opinion collection phase and the pilot implementation phase are mainly voluntary. Due to previous policy measures' unsatisfactory effect, such as encouraging voluntary public participation and pilot implementation on a small scale, the government began to issue compulsory policies to force people to sort and dispose of waste during the implementation phase. However, in recent years, the government has been coordinating various policy tools. The policies introduced are mainly focused on compulsory policy tools and supplemented by mixed and voluntary policy tools.

4.4 Policy contents

Based on the policy text, this article lists 24 main policy contents and counts them appear in each policy document. The final policy contents code is shown in Figure 3. The most frequent and accounted policy contents are propaganda promotion, supervision and examination, and strengthen leadership, at 86%, 77%, and 64%, respectively. Others include clear goals, encouraging classification, clear standards, collection and transportation, set up facilities are also above 50%. The complaints reports, competition activities, personnel publicity, and technology research are less than 20%. It can be seen that in the entire process of formulating the municipal waste classification policies, the Nanjing Government attaches the most importance to the promotion and supervision of waste classification but pays less attention to conduct researches and obtain feedback.

From the perspective of each phase, the top three policy contents in the opinion collection phase and the pilot implementation phase are propaganda promotion, strengthening leadership, and encouraging classification. The top three in the enforcement phase are supervision and examination, propaganda promotion, and clear standards. It can be seen that the government prefers to formulate policies about promoting and encouraging waste classification in the early

stage and focus on enforcing waste classification and constructing a management system in the later stage.

Policy content	Frequency	Percentage	Policy content	Frequency	Percentage
Propaganda Promotion	19	86%	Incentive System	9	41%
Supervision and Examination	17	77%	Financial Investment	9	41%
Strengthen leadership	14	64%	Mandatory Classification	7	32%
Clear Goals	13	59%	Pilot Implementation	7	32%
Encourage Classification	13	59%	Skills Training	7	32%
Clear Standards	12	55%	Recycling and Reuse	6	27%
Collection and Transportation	12	55%	Set an Example	5	23%
Set up Facilities	12	55%	Rewards and Punishments	5	23%
Ideological Education	10	45%	Complaints Reports	3	14%
Coordinated Operation	10	45%	Competition Activities	3	14%
Job Responsibilities	9	41%	Personnel Publicity	2	9%
Formulate Regulations	9	41%	Technology Research	2	9%

Figure 3. The Content Coding Table of Nanjing Municipal Waste Classification Policy

5. EXISTING PROBLEMS

5.1 Imperfect policy and regulation system

Political factors always dominate the actions of local governments. The main existing political problems in Nanjing's municipal waste classification policies are the unbalanced policy structure and imperfect policies and regulations. Although Nanjing is one of the cities that introduced waste classification policies earlier, it is still not as good as some cities like Xiamen, Shenzhen, Ningbo, Shanghai, Beijing, and Guangdong. For example, Xiamen completed the full coverage of residential waste classification in 2018. It ranked first in the country for five consecutive quarters in the assessment scores of 46 critical cities for waste classification by the Ministry of Housing and municipal-Rural Development. However, Nanjing still plans to complete a timing and fixed-point delivery in 60% of residential areas and realizes classified delivery in 40% of residential areas until 2020. It is attributed to Nanjing's imperfect issued policies and regulations, which still have much room for improvement compared with other advanced provinces and cities. In addition, the current policy contents of municipal waste classification in Nanjing pay less attention to scientific research, opinion collection, and rewards and punishments. The policy objectives are less focused on industrialization. Furthermore, the policy subjects seldom formulate a personal code of conduct. In order to improve this situation, the government should focus on countermeasures against weak links.

5.2 Weak industrialization construction

The classification and treatment of municipal waste require close coordination of multiple links. In order to form a complete closed-loop of waste collection industry chain from production, collection, transportation, and disposal, it is particularly significant to accelerate the integration and construction of industrial chain and make good use of front-end, middle-end, and back-end of waste classification. The entire waste classification work will not proceed if one of the links fails to provide sufficient technical support. At present, due to the lack of infrastructure and low investment in research and capital, China still has not built a sound industrialization system for waste classification. From the front-end, the waste collection system in most regions is immature. These areas often lack infrastructure and adequate supervision and only adopt mixed collection methods for centralized waste processing; From the mid-end, the biggest problem is the shortage of municipal waste disposal vehicles. On the one hand, it is easy to dispel residents' enthusiasm for waste classification. On the other hand, it is easy to make it challenging to carry out waste classification and disposal on a large scale; From the back-end, the current structure of municipal waste disposal is not reasonable, which relies heavily on landfill and incineration. These methods are incredibly harmful to the environment and cannot achieve better reduction, recycling, and harmlessness.

5.3 Difficulties in advancing supervision

In the political background of a single centralized system, local government power is the result of the central government's grant or entrustment [7]. There is an apparent relationship of obedience and being obeyed at all levels of government, between the central and local governments; units and individuals; higher and lower levels. In this way, a policy

implementation mode of issuing instructions from top to bottom is formed. Therefore, grassroots units often need to be consistent with the higher-level government in the governance process and seldom make changes according to local conditions [8]. As a result, it is easier to cause chaos in implementation at the lower level if the higher-level policy subjects are not strong enough or the policy formulation is not perfect. In addition, waste classification requires the participation of multiple subjects instead of the government's willpower alone. It requires autonomous participation and public response at all levels. Although there are many propaganda promotion policies for municipal waste classification, the public's awareness of it is still weak. On the one hand, top-down policy promotion is difficult to cultivate the awareness and habits of waste classification in the short term, and it is difficult for people to understand and implement waste classification quickly and accurately; On the other hand, many regions just promoted the waste classification policies but did not implement it. They cannot supervise a large number of grassroots personnel effectively or are too rude and straightforward in policy implementation, resulting in increasing the burden on residents and causing residents' resistance to waste classification.

6. IMPROVEMENT SUGGESTIONS

6.1 Optimizing the policy structure

The government should, while maintaining the implementation of existing policies, investigate shortcomings and weaknesses, such as issuing regulations to stimulate investment in scientific research and industrialization of waste classification, and improving individual-oriented management policy, as long as completing the relevant laws, regulations and policy systems to ensure the effective promotion and implementation of municipal waste classification from the legislation [9]. In addition, when formulating policies, the government can thoroughly draw experience from the policies formulated by other countries and regions with sophisticated experience in waste classification and make adjustments to local conditions while absorbing experience. Local governments also need to play a more active role in coordination and balance the distribution of policy subjects, policy content, policy objectives, and policy tools to avoid the unidirectional and one-sided nature of a single policy and achieve better policy implementation effects.

6.2 Intensifying the industrial chain

The industrial chain is an overall system responsible for connecting all industrial sectors, with its core lying in the interconnection of the internal group structure and a particular structural system and value-connotation characteristics. At the current stage, the development of all walks of life in our country is inseparable from the construction of related industrial chains [10]. The construction of the waste classification industry chain helps solve problems from the source; the integration of the industry chain is conducive to the realization of resource information sharing, timely adjustment of strategies, the realization of value appreciation, and assisting in the construction of reduction, recycling, harmlessness, and industrialization. To build an effective waste classification industry chain, we must learn from and refer to excellent precedents at home and abroad. At the early stage, the government will provide certain funds and policy support to attract enterprises to participate in technology research and

development and operation, and then through healthy competition to achieve various technologies in the industry chain. The improvement of efficiency will finally complete the market-oriented operation of the waste classification industry chain. The marketization of the waste classification industry chain will help to receive and attract talents, make up for various weak links, and realize the organic combination of front, middle, and back ends of waste classification so that that waste classification can create a more excellent value.

6.3 Invigorating technological innovation

In order to promote the transformation of municipal waste from rough unified treatment to refined classification management, it is indispensable to promote technological innovation. In all aspects of waste disposal, priority should be given to the research and development and the transformation and application of most state-of-the-art technologies. First of all, efforts should be given to strengthening the construction of infrastructure and building of systems bearing in mind the aim of providing a hardware foundation for technological innovation in waste classification; secondly, it is the duty of the government to provide vigorous support and bold encouragement for technological innovation, by incorporating it into policy-making, to ensure the effective conduct of scientific research; Thirdly, it is critical to upgrade the integration of various industrial fields, to vitalize local governments, enterprises, universities, and scientific research institutes in order to fuse the hotspots, namely smart cities, blockchain, the Internet of Things, big data, Cloud computing, artificial intelligence, etc., focusing on the recycling and utilization of municipal waste classification with technical breakthroughs. For example, for the front-end disposal of waste classification, the municipal solid waste classification management information system can be established to dynamically monitor the output of household waste in various regions, residents' disposal habits, and illegal discharge in real-time to improve the efficiency of waste classification; for the back-end waste Disposal, the recyclable waste can be recycled, the non-recyclable waste can be incinerated to generate electricity, and the domestic waste can be "turned into treasure" by high-tech means.

6.4 Comprehensive application of new media

The promotion of waste classification policies is inseparable from effective publicity. Although several forward-looking policy documents were issued to regulate waste classification publicity, the results achieved are under the weather. Retrieval of information from social software, mobile media, and video accounts in new media is on the rise. Full use of these media resources to publicize waste classification should be made by the government by means of WeChat official accounts, Sina Weibo, Douyin short videos, and etc. It is urgent to popularize waste classification knowledge, display the progress gained in waste classification, and even attract users to participate in discussions on how to improve the waste classification. For example, the topic of "Which type of trash are you" once ranked top hot searches on Weibo, while sparking discussion among the masses, there was also a lot of publicity and popular science on waste classification. The government can also interact with netizens via internet comments to promptly extract opinions and feedback on the waste classification from the general public in order to ameliorate the policy-making. In addition, the government should also encourage communities, enterprises, schools, and various units to actively carry out activities with the theme of "waste classification" in their daily lives, encourage citizens to participate in waste classification actively, help create an atmosphere for

waste classification, and popularize waste classification—knowledge to promote residents' environmental awareness.

6.5 Stimulating grassroots supervision

The practical implementation of the municipal waste classification policy is an inalienable constituent of the social duty of every residents. In order to ensure the effective implementation of relevant policies and promote civil management, on the one hand, the government must continuously stimulate the enthusiasm of target groups. Other than conventional methods such as guiding, propagating, and educating, the government should also set up rewards and punishment measures and formulate a waste classification scoring system to encourage incentives. For those who consciously abide by the waste classification, awards shall be granted, with the aim to create a waste classification role model, on the other hand, attention should be paid to grass-root regulations and the perfection of basic level governance capabilities. In addition to necessary compulsory measures in the policy implementation, more material and workforce should be added at the grassroots level, the construction of facilities should be improved, with more appointments of waste classification supervisors, and the awareness and professionalism of the law enforcement personnel should be improved.

7. CONCLUSIONS

This article considers that waste classification is an important policy issue related to social people's livelihood and sustainable development, and it is also an indispensable part of municipal governance. Based on it can realize the harmlessness, reduction, recycling and industrialization of domestic waste, it is inevitable for the central and local governments to promote compulsory waste classification vigorously. Through the quantitative analysis of policies in Nanjing, the result shows that the existing problems including an imperfect policy and regulation system, weak industrialization construction, and difficulties in advancing supervision. This article suggests that the government optimize the policy structure, intensify the industrial chain, invigorate technological innovation, use new media, and stimulate grassroots supervision.

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