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Brief Report

Investigation and Suggestions regarding Residents' Understanding of Waste Classification in Chinese Prefecture-Level Cities—A Case Study of Maanshan City, Anhui Province, China

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Abstract: The implementation of waste-sorting policy is conducive to improving residents' working and living environments, and has positive implications for promoting green development and building in China. As one of the main factors in the implementation of waste-sorting policy, residents' awareness of and behavior regarding waste sorting and disposal affects its promotion, while policies, incentives and infrastructure will affect residents' enthusiasm for implementing waste sorting. Taking Maanshan City in Anhui Province as a case study, this paper discusses the current state of progress towards ecological civilization in China; the influence of policy promotion on residents' perception of it; the correlation between residents' age and their understanding of waste classification; and the correlation between residents' enthusiasm, policies and green infrastructure; and puts forward some suggestions for how to enhance green infrastructure and improve residents' perceptions of waste classification in the future.

Keywords: waste classification; Chinese prefecture-level city; classification consciousness; ecological civilization; residents' enthusiasm

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1. Introduction

With the rapid progress of urbanization and modernization in China, the urban population has increased rapidly, and its material quality of life and consumption level have continuously increased, and the output of municipal solid waste has also shown a trend of increasing year by year [1–3]. Landfill and waste incineration consume resources and produce substantial greenhouse gases, which exacerbates environmental issues [4–6]. As an enhancement of the traditional methods of waste collection and disposal, waste classification has strong implications on livelihoods and sustainable development. Through waste classification management and the reuse of resources, the mechanisms of waste disposal can be optimized and the quality of a living environment can be improved [7,8].

The starting point of and the key to effective waste classification is the residents of the area in question. Their willingness to adopt domestic waste classification policies and their approach to it are not simply their personal attitudes, but are also major factors affecting the social environment [9]. Therefore, investigation of residents' understanding of waste classification is an effective means to judge the implementation of waste classification policies [10,11].

Li et al. [12] used the full, extended VBN theory to examine residents' attitudes towards municipal solid waste classification; that is, the higher a waste product's bio value, the more likely residents were to appropriately classify it. Liu et al. [13] investigated the influence of morality and law on urban residents' willingness to sort waste, and found that the

perceived efficacy of recycling directly affected attitudes and behavior pertaining to it, and that this was also positively correlated with respondents' level of education and being under 40 years old. Wu et al. [14] used data text mined from Sina Weibo to identify the key factors affecting residents' willingness to participate in waste sorting, and found that residents' positive attitudes were mainly caused by public environmental awareness and government incentives stimulated by publicity and education, while negative emotions came from inadequate infrastructure and unsuitable waste sorting arrangements. Bai et al. [15] studied the data of four randomly selected major cities in China through the ordered Probit model, and came to the conclusion that the proportion of residents who are willing to pay for waste sorting is high, but the amount they are willing to pay is fairly low.

Based on the analysis of the survey data, this paper takes Maanshan City, Anhui Province, China as a case study, explores the progress of residents' understanding of waste classification as part of the waste classification policies of Chinese prefecture-level cities, and puts forward some thoughts and relevant suggestions for the improvement and development of future policies.

2. Survey Objects and Methods

Urban residents of Maanshan City (Yushan District and Huashan District) were selected as the research subjects, and stratified sampling was used to conduct an in-depth investigation by combining online and offline methods. Maanshan, a city in the center of the Yangtze River Delta, is located in Nanjing and Hefei metropolitan areas, between 117°53′–118°52′ east longitude and 31°24′–32°02′ north latitude. Maanshan was chosen because it is a prefecture-level city and one of the 297 cities with widely implemented policies [16]. In addition, Maanshan City has improved its waste sorting policy according to the principle of moderate advance, which has played a role in leading research. The study of Maanshan City can serve as a reference for understanding the future development of other cities [17]. A total of 1504 questionnaires were collected, and after removing invalid questionnaires, such as those with contradictory responses, the number of valid questionnaires reached 1350, with a recovery rate of 89.76%. In order to protect privacy, this study did not ask for the respondents' names, ID cards or other private information. The sample population does not include minors under the age of 16, as they are considered as having no or limited capacity for civil conduct; adults over the age of 18 and minors over the age of 16 whose main source of livelihood is their own labor income were included, as they are considered to have full capacity for civil conduct. After data collection, Origin 2021, Stata 16.0 and SPSS 27 were used to produce images and analyze the data. The influence of policy promotion on residents' initial perception, the correlation between residents' age and their understanding of waste classification, and the correlation between residents' enthusiasm, policy and green development were analyzed and discussed.

The following operations were used to avoid possible survey bias: all the interviewees were interviewed offline, and those among the respondents able to use social media to complete the questionnaire did so online, via a QR code (This is referred to as online collection). People who were not competent with social media used paper questionnaires, and staff then manually input these data. In addition, the online questionnaire stipulated that any one computer/smart phone could only be used once. In order to avoid filling errors, the respondents could enter the questionnaire again to modify the submitted contents and only keep the last submitted data during the time from submitting the questionnaire to the completion of the data export (24:00 on the same day). This online and offline questionnaire collection method served to improve the efficiency of data entry and the accuracy of the data, and to prevent repeat entries.

3. Basic Characteristics of The Respondents

3.1. Geographical Distribution

According to the government's public information, the population ratio between Yushan District and Huashan District is about 44.11:55.89 [18]. The geographical distribu-

tion of the respondents should be strictly controlled to make them more suitable for the population distribution in various places when investigating. The ratio of the number of valid questionnaires collected in Yushan District and Huashan District is 44.07:55.93.

3.2. Gender Distribution

A total of 691 valid questionnaires from male respondents and 659 valid questionnaires from female respondents were collected; thus, the gender ratio was 104.86 (for every 100 females). According to public data, the gender ratio of the total population in China is 105.07 (for every 100 females) [19] and that of the permanent population in Maanshan is 104.71 (for every 100 females) [18]. The gender distribution essentially conforms to the gender ratio between the country and the city, and the obtained results are scientific and reasonable.

4. Analysis and Discussion

4.1. Influence of Policy Promotion on Residents' Perception

Residents' understanding of the waste classification policy was the most comprehensive in 2016–2019 (49.78%), followed by 2011–2015 (31.56%), and the number of people who were familiar with waste classification policy before and after 2010 was the lowest. This is positively correlated with the point at which residents first learned about waste classification, which indicates that government policies can positively guide residents' approaches to waste classification. With the increasing publicity, frequency and intensity of government policies related to waste classification, residents' understanding of the main policies of waste classification has gradually improved, and the government and residents have continuously attached importance to the green development.

4.2. Correlation between Residents' Understanding of Waste Classification and Their Age

Residents were assessed on their understanding of waste classification. Among those who passed the assessment, young people (16–40 years old) accounted for the most, comprising 42.33%, followed by mature people (41–60 years old; 33.42%), and people over 60 accounted for only 24.25%. The survey subjects' general knowledge of waste classification showed a downward trend with the increase of age. The means of obtaining information was the key reason for the substantial difference in understanding of waste classification among different age groups. The main channel for people aged 16–40 to obtain information is the internet, and the tools for this are mainly smart phones and computers. Those aged 41–60 years obtain information through the internet and televised news, and occasionally newspapers; the main ways for people over 60 years are watching television, reading newspapers and listening to the radio.

Because online networks can be used to obtain information more widely and rapidly, it is more effective to use the internet to learn about waste classification. Although the internet is gradually becoming one of the main ways for the new generation of residents to obtain information, most residents still use traditional media to obtain information. Therefore, it should be the main method of publicity and promotion in the future, in order to fully integrate traditional media with online media and to reap the combined the benefits of the excellent quality of traditional media and the reach of online media.

4.3. Correlation between Residents' Enthusiasm (RE), Policies (P) and Ecological Civilization (EC)

Table 1 summarizes the respondents' single-choice responses regarding the extent of understanding of waste classification policy (P), the extent of ecological civilization (EC) in China and the level of enthusiasm towards waste classification (RE).

Table 1. Questions, Options and Number of People with Selected Options.

Questions	Options	Number
Recognition degree of waste classification construction in Maanshan city (P)	Have great achievements (Strongly positive)	732
	There are some achievements (Moderately positive)	599
	No results (Not positive)	9
	Unwilling to answer (No evaluation)	10
Possibility of actively participating in waste sorting (RE)	Self-disciplined waste sorting (Strongly positive)	706
	Semi-autonomous waste sorting (Moderately positive)	579
	Refuse to classify waste (Not positive)	60
	Unwilling to answer (No evaluation)	5
Current level of ecological civilization in China (EC)	Make great progress (Strongly positive)	624
	There is some progress (Moderately positive)	678
	No progress (Not positive)	10
	Unwilling to answer (No evaluation)	38

4.3.1. Reliability Analysis and Validity Analysis

The Cronbach α coefficient was used as the measurement index. It can be seen from Table 2 that the reliability coefficient value is 0.953 > 0.9, which shows that the reliability quality of the research data is very high. KMO and Bartlett tests were used to verify the validity, and the KMO value is 0.731, ranging from 0.7 to 0.8, reflecting good validity (Table 3). In addition, the communality values of all research items are higher than 0.4.

Table 2. Reliability Analysis of Scale.

Name	Corrected Item—Total Correlation (CITC)	Cronbach's α if Item Deleted	Cronbach's α Coefficient
RE	0.943	0.898	0.953
P	0.897	0.937	
EC	0.874	0.957	

Table 3. Validity Analysis of Scale.

KMO	Bartlett Test		
	Approx. Chi-Squared	df	*p* Value
0.731	4604.582	3	0.000

4.3.2. Correlation Analysis

The Pearson correlation coefficient is used to study the correlation between RE and P, RE and EC. The correlation coefficient value between RE and P is 0.921, and that between RE and EC is 0.885, and both of them are significant ($p < 0.01$), so there is a significant positive correlation between RE, P and EC.

4.3.3. Regression Analysis and Path Analysis

After the data were centralized, P and EC were taken as independent variables, and RE was taken as a dependent variable for linear regression analysis (Table 4). The model formula is:

$$RE = -0.000 + 0.648 \times P + 0.361 \times EC \quad (1)$$

The square value of model R is 0.897, that is, P and EC can explain the 89.7% change of RE. The model passed the F test ($F = 5883.882$, $p = 0.000 < 0.05$), which showed that at least one of P and EC would have an influence on RE. The regression coefficient of P is 0.648 ($t = 38.728$, $p = 0.000 < 0.01$), and that of EC is 0.361 ($t = 25.289$, $p = 0.000 < 0.01$), that is, both P and EC have significant positive effects on RE.

Table 4. Results of Linear Regression Analysis (n = 1350).

	Unstandardized Coefficients		Standardized Coefficients	t	p	VIF
	B	Std. Error	Beta			
Constant	−0.000	0.005	-	−0.000	1.000	-
P	0.648	0.017	0.599	38.728	0.000 **	3.133
EC	0.361	0.014	0.391	25.289	0.000 **	3.133
R^2			0.897			
Adjusted R Square			0.897			
F			F(2,1347) = 5883.882, p = 0.000			
D-W Value			0.093			

Dependent Variable: RE; ** $p < 0.01$.

As can be seen from Table 4 above, when P affects RE, the normalized path coefficient value is 0.599 > 0, which is significant (z = 38.768, p = 0.000 < 0.01), and when EC affects RE, the normalized path coefficient value is 0.391 > 0, which is significant (z = 25.320, p = 0.001). Table 5 shows the covariance relationship between the variables. The standardized path coefficient between EC and P is 0.298 > 0, and this path has a significance of 0.01 (z = 23.384, p = 0.000 < 0.01). It can be seen that there is a significant positive covariance correlation between EC and P. According to the above contents, the path diagram is obtained (Figure 1).

Table 5. Covariance Table of Variables.

X	Y	Unstandardized Estimated Coefficient	Std. Error	z	p	Std. Estimate
EC	P	0.298	0.013	23.384	0.000	0.825

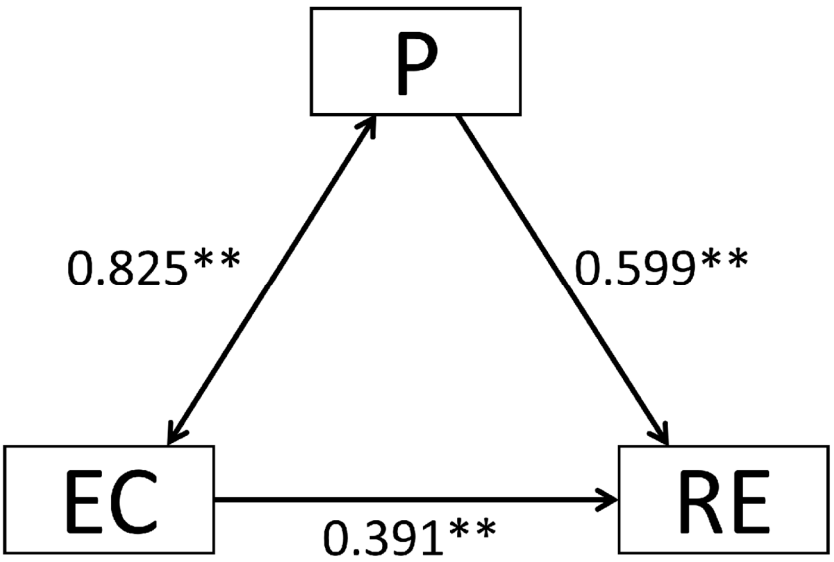

Figure 1. Path analysis diagram of the correlation between residents' enthusiasm (RE), policies (P) and ecological civilization (EC), ** $p < 0.01$.

5. Conclusions and Suggestions

Waste classification is of immense significance for building a modern environmental governance system and promoting environmental governance in China [20]. Taking residents' awareness of waste classification as an example, this research focuses on the factors influencing residents' understanding of waste classification. The results show that: 1. Most residents' understanding of waste classification mainly comes from the frequency of the government's promotion of waste classification policies and the means of promotion.

2. In terms of age division, young and middle-aged residents have a better understanding of waste classification than the elderly because of their ability to obtain and adopt new information via new media platforms. Therefore, we should increase publicity and education regarding waste classification for the elderly in a way that is appropriate for them. 3. In terms of influence, residents' understanding of waste classification policy (P) and the extent of progress towards ecological civilization in China (EC) have a significant positive influence on their approach to waste classification. The P and the EC have a mutual influence on each other. The suggestions are as follows:

1. Expand publicity to improve residents' cognition.

Residents are the main actors in waste classification, and their attitudes and behaviors influence the outcomes of waste classification policy, so it is particularly important to enhance the understanding of waste classification [21]. We should enhance the appreciation of individuals of the importance of proper waste classification, improve the supervision and feedback mechanisms of waste classification, and develop waste classification infrastructure that is comprehensive and integrates recycling. The most feasible way to promote the publicity, popularization and understanding of waste classification policies is to incorporate science and technology, and fully integrate traditional and online media.

At present, the dissemination of relevant policies mainly depends on the government network and TV advertisements. The government can use the network platform to popularize concepts, open official accounts, record relevant videos or write popular science articles, and dispel the limitations of time, space and outreach regarding waste classification education. It should be noted that the interest and the popularity of this content should be optimized in order to encourage people to accept the information. At the same time, in order to better promote the information to children and the elderly, the local government should make in-depth field visits and formulate effective publicity mechanisms according to local conditions.

2. Accelerate the scientific and modern waste sorting facilities.

Popularizing waste classification and fully developing and utilizing waste resources will be the focus of waste classification in the future. As a carrier of waste recycling, waste bins play a vital role in the waste classification and recycling system. Therefore, it is a potential option to post posters of classification instructions next to waste bins to assist residents in classification, or to set up a billboard near waste bins to attract residents' attention by using the slogans in the billboard. With the development of science and technology, intelligent waste bins will emerge as the times require. Users only need to input the waste product's name or display the waste under a camera, and the intelligent waste bin can automatically indicate the waste category and open the corresponding box cover, which reduces the difficulty in remembering categories and improves the classification accuracy.

3. Improve the process of waste classification system

Another reason for citizens' low enthusiasm for participation comes from inadequate government management processes—after waste is classified into waste bins, it is mixed and transported again by waste trucks; after the waste classification is completed, the disposal method is landfill; proper recycling infrastructure is not currently in place. These phenomena have greatly affected the enthusiasm of citizens. Although there are no obvious cases mentioned above in Maanshan, there are still problems in the waste management system, such as low efficiency of packaging and transfer in waste transfer stations, no classification requirements for waste in some areas, and inadequate penalties for littering. Therefore, there is an urgent need to develop relevant recycling policies in strict accordance with the corresponding norms and standards, maximize its efficiency, improve the urban environment, and increase penalties for non-compliance. It is also necessary to optimize the suitability of facilities for waste sorting, continually improve the storage and transportation system for waste sorting, and optimize the waste-sorting process through the supervision of administrative departments.

It should be emphasized that this study only analyzes two significant determinants of residents' enthusiasm, making it a preliminary study. In the follow-up study, we should explore a wider range of determinants, in order to understand the potential causes of each factor and the more complex interaction mechanism, so as to provide a reference for the Chinese government to implement more effective policies. For example, government policies can be differentiated according to target groups, but this requires in-depth research in order to determine the optimal means of differentiation.

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References

1. Ding, Y.; Zhao, J.; Liu, J.W.; Zhou, J.; Cheng, L.; Zhao, J.; Shao, Z.; Iris, Ç.; Pan, B.; Li, X.; et al. A review of China's municipal solid waste (MSW) and comparison with international regions: Management and technologies in treatment and resource utilization. *J. Clean. Prod.* **2021**, *293*, 126144.
2. Kurniawan, T.A.; Liang, X.; O'Callaghan, E.; Goh, H.; Othman, M.H.; Avtar, R.; Kusworo, T.D. Transformation of solid waste management in China: Moving towards sustainability through digitalization-based circular economy. *Sustainability* **2022**, *14*, 2374. [CrossRef]
3. Nanda, S.; Berruti, F. Municipal solid waste management and landfilling technologies: A review. *Environ. Chem. Lett.* **2021**, *19*, 1433–1456. [CrossRef]
4. Lee, R.P.; Meyer, B.; Huang, Q.; Voss, R. Sustainable waste management for zero waste cities in China: Potential, challenges and opportunities. *Clean Energy* **2020**, *4*, 169–201.
5. Kehinde, O.; Ramonu, O.J.; Babaremu, K.O.; Justin, L.D. Plastic wastes: Environmental hazard and instrument for wealth creation in Nigeria. *Heliyon* **2020**, *6*, e05131. [CrossRef]
6. Pan, D.; Su, F.; Liu, C.; Guo, Z. Research progress for plastic waste management and manufacture of value-added products. *Adv. Compos. Hybrid Mater.* **2020**, *3*, 443–461. [CrossRef]
7. Yang, M.; Chen, L.; Wang, J.; Msigwa, G.; Osman, A.I.; Fawzy, S.; Rooney, D.W.; Yap, P.S. Circular economy strategies for combating climate change and other environmental issues. *Environ. Chem. Lett.* **2023**, *21*, 55–80. [CrossRef]
8. Awasthi, S.K.; Sarsaiya, S.; Kumar, V.; Chaturvedi, P.; Sindhu, R.; Binod, P.; Zhang, Z.; Pandey, A.; Awasthi, M.K. Processing of municipal solid waste resources for a circular economy in China: An overview. *Fuel* **2022**, *317*, 123478. [CrossRef]
9. Fu, Y.; Zhu, J. Green design and recycling systems for solving the dilemma of disposable chopsticks waste caused by online food delivery: A review. *BioResources* **2021**, *16*, 8640. [CrossRef]
10. Zhang, S.; Hu, D.; Lin, T.; Li, W.; Zhao, R.; Yang, H.; Pei, Y.; Jiang, L. Determinants affecting residents' waste classification intention and behavior: A study based on TPB and ABC methodology. *J. Environ. Manag.* **2021**, *290*, 112591. [CrossRef] [PubMed]
11. Almulhim, A.I.; Abubakar, I.R. Understanding public environmental awareness and attitudes toward circular economy transition in Saudi Arabia. *Sustainability* **2021**, *13*, 10157. [CrossRef]
12. Li, L.; Yue, G.; Xinquan, G.; Yingmei, Y.; Hua, C.; Jianping, H.; Jian, Z. Exploring the residents' intention to separate MSW in Beijing and understanding the reasons: An explanation by extended VBN theory. *Sustain. Cities Soc.* **2018**, *37*, 637–648. [CrossRef]
13. Liu, C.; Jing, Q.; Cong, J.; Zhang, W. How do integrity level and economic punishment affect residents' willingness and behavior to separate household waste? New evidence from 1293 questionnaires in Jinan. *J. Clean. Prod.* **2022**, *365*, 132713. [CrossRef]
14. Wu, W.; Zhang, M. Exploring the motivations and obstacles of the public's waste classification participation: Evidence from Sina Weibo. *J. Mater. Cycles Waste Manag.* **2023**, *25*, 2049–2062.
15. Bai, R.; Lin, B. Are residents willing to pay for waste recycling: Evidence from a survey in Chinese first-tier cities. *Environ. Impact Assess. Rev.* **2022**, *95*, 106789. [CrossRef]

16. Xinhua News Agency. China Will Basically Achieve Full Coverage of Waste Classification by the End of 2025 [EB/OL]. Chinese Government Network. 24 May 2023. Available online: https://www.gov.cn/govweb/lianbo/bumen/202305/content_6875926.htm (accessed on 26 May 2023).
17. Maanshan Civilization Network. Maanshan: Strive to Basically Achieve Full Coverage of Domestic Waste Classification by the End of Next Year [EB/OL]. China Civilization Network. 15 October 2021. Available online: http://mas.wenming.cn/wmcj/202110/t20211015_7367379.shtml (accessed on 4 May 2023).
18. Dangtu County Bureau of Statistics. Bulletin of the Seventh National Population Census of Maanshan City [EB/OL]. Dangtu County People's Government. 24 May 2021. Available online: https://www.dangtu.gov.cn/xxgk/openness/detail/content/60bf1f3fd1da9beb078b4567.html (accessed on 4 May 2023).
19. National Bureau of Statistics. Bulletin of the Seventh National Census [EB/OL]. Chinese Government Network. 11 May 2021. Available online: http://www.gov.cn/guoqing/2021-05/13/content_5606149.htm (accessed on 4 May 2023).
20. Chen, S.; Liu, N. Research on Citizen Participation in Government Ecological Environment Governance Based on the Research Perspective of "Dual Carbon Target". *J. Environ. Public Health* **2022**, *2022*, 5062620. [PubMed]
21. Wang, S.; Wang, J.; Yang, S.; Li, J.; Zhou, K. From intention to behavior: Comprehending residents' waste sorting intention and behavior formation process. *Waste Manag.* **2020**, *113*, 41–50. [PubMed]