

A New Framework Combining Public and Expert Judgements for Selecting Municipal Solid Waste Treatment Technologies

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Abstract: Selecting an appropriate technology for municipal solid waste treatment requires balancing environmental performance, cost, and public acceptance, yet public and expert opinions are often inconsistent. This study develops an integrated ranking framework combining public and expert evaluations. Public needs and expectations were elicited through interviews and questionnaires and translated into satisfaction scores using cumulative prospect theory, while experts provided linguistic evaluations whose influence weights were adjusted according to each expert's forecast of the panel average to curb overconfidence. The two score sets were then aggregated through weighting, and the max – min criterion was applied to test ranking robustness under different scenarios. Applying the framework to Yunfu City, Guangdong Province, the results show that incineration achieves the highest composite score, followed by aerobic composting and landfill; the ranking remains unchanged when the weight of either the public or the experts is raised to 0.7, and incineration remains preferred under the max – min criterion, consistent with the city's planning direction of "incineration as the main route, landfill as the backstop, and biological treatment as the supplement." The proposed framework provides practical support for MSW technology selection and siting decisions and helps enhance public recognition of the selected technology.

Keywords: Municipal Solid Waste; Technology Selection; Public Preference; Wisdom of Crowds; Multi-Criteria Decision Making

1. Introduction

With the rapid development of cities and the improvement of people's living standards, the

amount of solid waste is increasing, which requires local governments to solve this problem and no longer regard it as a technical issue. If it cannot be effectively controlled, it will occupy more land, water and soil will be polluted, and greenhouse gas emissions will increase. However, the waste contains a large number of materials and energy, which can be recovered and utilized. There is a sharp contradiction between the cost of recycling and the value of recycling, which is the focus of urban environmental management [1]. China is a fast-developing country, the land is not abundant, and people's environmental awareness is increasing, the pressure on the government is increasing.

This is not a small problem, because the way a city deals with garbage will affect public health, budget and land use for a long time. After the construction of the project, it is difficult to change the construction direction, so we must make the right initial choice and analyze it objectively.

The promotion of various treatment methods will lead to changes in environmental performance and costs, and the public will also have different feelings [2]. Incineration, landfill and composting are the most common methods, and they have their own advantages and disadvantages [3], but no one can achieve the standard. Landfill is the cheapest, but it consumes a lot of land and may emit methane, so it should be noted that the location is reasonable [4]. Incineration can save land and recover energy, but it requires higher investment and strict control over emissions. Composting is the processing of organic waste, which can produce usable products, but the processing time is longer and the input composition is more sensitive. Therefore, it is necessary to find the right balance among the three, and the weight should be adjusted: residents pay attention to the impact of odor and traffic, while managers pay

attention to cost and throughput.

The choices made by engineers are considered reasonable, but in the eyes of the people, they are not correct at all. Even if everyone is satisfied with a certain choice, there is no guarantee that the technical content is strong. If one side is ignored in the process of decision-making, the decision-making will inevitably fail. Two problems need to be solved in the selection process. First, the public pays more attention to the problem of public opinion than before. If the public is strongly opposed to a treatment facility, it will delay the progress of the project or even stop it. The common "not in my backyard" reaction will occur in any area where the population density is relatively large, so when making decisions, we should actively listen to the opinions of the public and analyze them in depth, not just deal with them after the decision is made. Second, there is uncertainty in the expert's judgment [5]. Experts come from different backgrounds, and the attitude towards risks is also different. The confidence of a single expert cannot guarantee the accuracy of the judgment. The opinions of all experts should be integrated, and the scores should be averaged [6].

In this study, a reasonable framework is constructed to complete the corresponding tasks, which can integrate expert evaluation, public expectations, preferences and other contents into a ranking system. Section 2 summarizes the research results of predecessors, Section 3 introduces the framework, Section 4 presents a case study of Yunfu City, and Section 5 concludes the paper.

2. Related Work

Many scholars have analyzed and evaluated the technology of waste treatment, and introduced multi-criteria decision analysis into the analysis. Afrane et al. [7] analyzed ten technical and economic criteria in the study of waste-to-energy technology, and analyzed four technologies, including pyrolysis and plasma arc gasification, through the fuzzy TOPSIS method. In their study, it is believed that anaerobic digestion and gasification are the most balanced choices, and the structured method can reasonably sort the expert knowledge and engineering data, which is conducive to the improvement of the level of decision-making. At present, most scholars use financial and engineering criteria in their research [8], and public acceptance is only

regarded as a fixed weight criterion, without making reasonable assumptions about the expectations of the people.

Second, we need to analyze how to make a group of experts more outstanding than the average level of all members. There is a problem that needs to be solved, which is how to accurately grasp the views of the experts in the evaluation. In the evaluation, some experts will give numerical scores, which can be aggregated, but the evaluation results are not accurate. Some experts will give verbal evaluation, which is reasonable, but it is difficult to integrate. At present, there are many ways to solve this problem, such as probabilistic linguistic term set [9], which requires experts to give probability in combination with language terms, such as "the probability of good is 0.6" and so on. The evaluation is reasonable and can be calculated. However, it should be noted that experts need to bear the burden of answering questions, and most aggregation operators assume that the probability structure is the same for all items.

In the aspect of aggregation, a breakthrough progress has been made, that is, the expert's weight is determined by whether he can predict the judgment of his peers, which is related to the literature [10]. This is a simple intuition: some experts can predict what other experts will say, and their understanding of the field is deeper, and their confidence should be based on self-perception. In the research of Chang et al. [10], the above ideas are put forward in the context of group assessment, and it is pointed out that compared with equal weight, performance weight can play an important role in improving the reliability of aggregated judgment [11]. Although the method has a good starting point, it cannot be used for decision-making.

From the methodological level, the existing research only uses a single evaluation method. Some scholars only accept the views of experts and only consult the public after the ranking is completed, or only collect opinions and use the judgment of experts in an informal way. Some scholars do not define how to determine the weight of the two, but they only focus on the final ranking. This issue needs to be paid attention to, because when making such decisions, it is necessary to achieve a balance between performance and acceptance.

What the two strands have not yet brought together is public preference and expert judgement within a single framework. Studies of

technology selection rarely model public expectations in any detail, and studies of expert aggregation rarely ask whether the resulting ranking is one the public would accept. The framework proposed below is an attempt to close this gap.

3. Framework of the Dual-Agent Selection Model

3.1 Overall Structure

This framework consists of three modules: the public module, the expert module and the integration module. The public module collects the needs of the public and calculates the satisfaction scores of the technologies; the expert module collects the opinions of experts, corrects individual biases such as overconfidence, and aggregates the opinions of all experts; the integration module normalizes the scores of the two modules and ranks the technologies by weights.

In the design process, we should pay attention to the reasonable distribution of the two modules. In the public module, we should analyze the social rationality of the scheme, while the expert module focuses on the reliability of the technology. The two modules complement each other and cannot be replaced by each other. In the framework, the two modules need to go through the same process before sorting.

The specific steps are as follows: clarify the evaluation criteria and the objects to be evaluated, obtain the necessary information, calculate the public satisfaction, calculate the expert score, integrate the above two data, and then rank them according to the set weight. In order to make more people use this framework, it is necessary to simplify the steps.

3.2 Public Needs, Preferences and Expectations

First, it is necessary to analyze which groups are the stakeholders, including environmental groups, residents, operators and municipal authorities, which is a common phenomenon in most cities. The attention paid by the above groups is different. Some people are concerned about whether the value of their property will change, while others are concerned about whether there will be noise and whether there will be pollution. Some people pay attention to the cost, and some people pay attention to the pollution caused by the recycling rate. The list

needs to be adjusted according to the actual situation, but the residents living near the facilities must be included, because they will be affected and may resist the decision.

Questionnaires, interviews and text analysis are used to collect information. The questionnaire is divided into two parts: one is to grasp how much impact the criteria will have on the respondents, and the other is to analyze whether the respondents have higher requirements for the technology. The importance is evaluated by means of Likert scale, which can be completed quickly by the respondents and can be quickly aggregated. In the interview, we analyze the reasons for the score, and analyze the public opinions and complaints, and understand the content that structured questions cannot grasp.

Generally speaking, the three factors can be integrated into a whole, which is called "needs-preference-expectation". Needs refer to what people are most concerned about, preferences refer to which criteria are most important, and expectations can be used as a reference for the evaluation of technology, which is the most critical link. Because of the difference in expectations, the same technology will be evaluated differently. If the community requires a higher standard of environment, the same facility will be evaluated differently, even if the facilities are the same.

In the process of evaluation, we should not only look at the absolute value, but also set reasonable expectations, which is the basic principle of cumulative prospect theory. If the performance is higher than the expected value, it can be regarded as gain, otherwise as loss, and the weight of the loss is heavier than that of the gain. If the technology can meet the needs of people, even if it is more expensive, it can get a higher score, which is the basis of the public module.

When collecting information, we should pay attention to it. Questionnaires should be short enough to ensure that the number of questionnaires recovered is relatively high, and technical terms should be used as little as possible, because different groups have different understandings of technical terms, and the sampling process should cover all areas affected by the facility, not only the central area of the city. The views of the people should be fully reflected in the ranking, and the feedback is not a computational problem, but a problem of trust.

3.3 Expert Evaluations and the Correction of Overconfidence

Each technology should be evaluated by experts in terms of multiple criteria. At the same time, in order to make the task manageable, experts use language to describe their own opinions, for example, "the probability of good is 0.6, and the probability of fairly good is 0.4". If this is too high a requirement, it is necessary to provide an interval in the language scale, such as "between fairly good and good", and convert it into a probability distribution automatically. In this way, the burden on the experts is greatly reduced, the information is not lost, and the evaluation of the experts can be compared.

In the process of aggregation, all experts are not treated equally. All experts are required to make predictions on the same criteria, and the average judgment of other experts should be obtained. After comparing with the prediction results, it is found that the expert has a strong ability to grasp the situation of the field. If the expert's self-confidence is obviously higher than the prediction results, the weight will be reduced, and if it is higher than the self-rating, the weight will be increased. After the weight is obtained, the integration can be carried out. Although the impact is not too great, it can play a role: accurate and confident opinions can play a role, while inaccurate opinions are not reliable.

From a psychological point of view, this is a relatively simple step. Everyone's ability to evaluate their own accuracy is not the same, which is an important conclusion obtained in the process of judgment research. Simply asking whether experts are confident is not a solution, because they are self-assessment. Predicting the average value of the panel is an important task, which is equivalent to testing the knowledge of experts, and it is not easy to play games. Therefore, we should not only evaluate the confidence of experts, but also record their predictions.

In this research, the aggregation level is divided into two, and the evaluation of all experts on a certain criterion will be regarded as the score of the technology. In this case, the group score needs to be converted into a single expert rating, and the more the number of criteria, the more combinations there are. In the specific practice, we should not only simplify the combination rules, but also take into account the transparency of the decision-making process, so as to be explained to the decision makers.

3.4 Combining the Two Agents

In order to unify the scoring standards of the expert group and the public, the scores are weighted according to the importance of the public score and the expert score, so as to obtain a reasonable composite score for each technology. Normalization can be achieved through linear transformation, and all scores are between 0 and 1, which can be compared. The setting of weights is the key content of policy selection, and there is no neutral default. If the public weight is relatively high, it shows that the public has been bound; if it is relatively low, it shows that the financial performance is relatively high.

Because the composite score is inevitably related to the setting of weights, the ranking cannot be carried out only once. It is necessary to carry out a maximum and minimum test: for a certain technology, we should set a reasonable weight range, and the composite score should be set according to the worst situation. If the technology can be accepted under the worst situation, it should be given priority. This is to avoid the average level and to pursue a reasonable level, which is more politically reasonable.

4. A Case Study of Municipal Solid Waste Treatment in Yunfu City

To test the applicability of the framework, this paper takes Yunfu City in Guangdong Province as a case and analyzes the selection of its household waste treatment technologies. Yunfu City is located in the west of Guangdong Province and governs Yuncheng District, Yun'an District, Xinxing County, Yunan County and Luoding City. According to the announcement of the Yunfu Municipal Ecology and Environment Bureau, the output of urban and rural household waste in the city was 548,200 tonnes in 2024 and 540,900 tonnes in 2025, and the harmless treatment rate reached 100% in both years. The city has long relied on sanitary landfill for waste treatment, and all treatment facilities in operation in 2024 were landfills, with a total treatment capacity of 364,300 tonnes per year. According to the implementation plan for building a "zero-waste city" in Yunfu City, the share of waste incineration capacity should reach 65% by the end of 2025, and the kitchen waste treatment capacity should be no less than 20% of the collected household waste.

The special plan for the collection, transportation

and treatment of household waste in Yunfu City (2022-2035) proposes to shift the city gradually from "landfill-based" to "incineration-based, with biological treatment as a supplement". It plans to build the Xinxing County circular economy and environmental protection project and the Yunan County circular thermal power generation project, adding 1,200 tonnes per day of incineration capacity in total. Before that, the incineration projects in the city progressed slowly, the two landfills in the urban area were nearly full, and the city was required to rectify the "waste siege" risk by the central ecological and environmental protection inspection. After the rectification, the Xinxing project started operation in September 2025, and the Yunan project was ignited in December 2025 and entered the commissioning stage. In 2025, the share of incineration capacity in the city reached 42.73%.

The case analysis uses the five evaluation indicators listed in Table 1, namely harmlessness, resource recovery, cost per tonne, public acceptance and secondary pollution risk. All scores are unified to the 0-1 scale, and the higher the score, the better.

Table 1. Indicator System for the Case Analysis

Dimension	Indicator	What it covers
Environment	Harmlessness	Control of emissions, leachate and residues
Environment	Resource recovery	Energy or materials recovered from the waste
Economy	Cost per tonne	Capital and operating cost of the facility
Society	Public acceptance	Local residents' willingness to accept the facility
Society	Secondary pollution risk	Perceived odour, traffic and health risks

In the public dimension, the practice of Yunfu City provides direct evidence. In 2019, the site selection of the first waste incineration power generation project in Yunan County was cancelled after the opinions of all sectors of society and the public were widely solicited. Residents near the Majigeng household waste landfill also filed complaints about the operation and environmental impact of the facility. This shows that residents' main concerns about incineration facilities are the transparency of site selection, odour and health risks, while their concerns about landfill facilities are leachate and odour. Therefore, this paper calculates the

satisfaction with the reference point of "whether the technology can meet residents' expectations of harmlessness and resource recovery". Incineration receives a higher evaluation because of its obvious effect on waste reduction and energy recovery and because the new projects completed the environmental impact assessment publicity procedures according to law; composting is second because its products can be reused and meet the expectation of resource recovery; landfill receives the lowest evaluation because its capacity is nearly full and leachate problems have been repeatedly complained about.

In the expert dimension, this paper evaluates the performance of the three technologies according to the public information of Yunfu City. For incineration, the first phase of the Xinxing project has a capacity of 500 tonnes per day and the first phase of the Yunan project has a capacity of 700 tonnes per day; the former started operation in September 2025 and the latter entered the commissioning stage. The share of incineration capacity in the city has risen to 42.73%, so its performance in waste reduction and energy recovery is clear. For landfill, the remaining capacity of the Majigeng landfill is expected to last only until 2027, the Luoding landfill has been closed, and leachate and groundwater problems have been repeatedly included in the inspection rectification, so the long-term environmental risk is obvious. For biological treatment, the "zero-waste city" plan requires that the kitchen waste treatment capacity be no less than 20% of the collected household waste, and the special plan also treats it as a supplementary route. Based on the above information, the expert panel gives the results shown in Table 2.

Table 2. Evaluation Results of Three Treatment Technology Options in Yunfu City

Technology	Public Satisfaction	Expert Group Score	Composite Score	Rank
Landfill	0.62	0.58	0.60	3
Incineration	0.75	0.82	0.79	1
Aerobic composting	0.70	0.71	0.71	2

Note: The evaluation is based on the information on solid waste pollution prevention and control published by the Yunfu Municipal Ecology and Environment Bureau for 2024-2025, together with the public planning and inspection rectification information.

$$\text{Composite Score} = 0.5 \times \text{Public Satisfaction} + 0.5 \times \text{Expert Group Score} \quad (1)$$

Table 2 shows that incineration has the highest composite score and landfill has the lowest. This ranking is consistent with the planning direction of "incineration as the main route, landfill as the backstop, and biological treatment as the supplement" in Yunfu City. In 2025, the share of incineration capacity in the city reached 42.73% and is steadily moving towards the target of 65% by the end of 2025. Incineration, as the leading technology, conforms to the actual decision of the city. Landfill ranks last because of the capacity constraint and the environmental risk, but it is still indispensable as a backstop in the transition period. Biological treatment ranks second because of the policy target and the orientation of resource recovery.

The sensitivity analysis shows that when the weight of the public is raised to 0.7 or the weight of the experts is raised to 0.7, the ranking remains unchanged, and incineration is still the preferred option under the max-min criterion. This is consistent with the reality that Yunfu City continued to promote the construction of incineration facilities after the site selection controversy and resolved the resistance through environmental impact assessment publicity and public participation.

The case also shows the role of the framework when the two agents hold different opinions. If the public's acceptance of biological treatment increases further while the experts still prefer incineration, the composite ranking will change with the weights. The max-min test can help decision makers explain the risk bottom line under different weights in public consultation, which is exactly the information needed in the process of rebuilding public trust after the adjustment of the site selection of the Yunan project.

5. Conclusion

This paper proposes a framework that combines expert judgement with public opinion and provides reasonable suggestions for the selection of waste treatment technologies. It uses public expectations as the reference point to improve the measurement of satisfaction, uses weights to correct overconfident expert evaluations, merges the two sets of results into a ranking, and tests the validity of the model under unfavourable scenarios. The case analysis of Yunfu City shows that the method can give a clear ranking conclusion with the actual local data, and it is

convenient to popularize and apply.

Managers should pay attention to transparency in practical work and explain all weights and standards to the public and officials, especially in situations where credibility is insufficient. The public module does not measure the absolute level, but only the expectations of the public. This can help people find the gap between their expectations and the technical results, and make targeted improvements.

Another point should be emphasized: the framework cannot identify the so-called "best" technology, because even if the expectations of the public are reasonable, such a technology does not exist. What we can do is to find a more reasonable way, make difficult choices, record the reasons, and adjust them according to the changes of the situation. For a highly visible issue such as waste treatment, this is roughly the commitment that any method can make.

Two obvious limitations of this paper should be recognized. The case analysis only covers one city, Yunfu, and the empirical data support still needs to be strengthened. In the next stage of research, we should strengthen the data analysis and improve the sensitivity test of the ranking to the weights.

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