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Collaborative governance of municipal solid waste in urban agglomerations: The case of Yangtze River Delta

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As the by-product of modern life, the accelerating amount of municipal solid waste remains a wicked environmental and social problem that burdens megacities or populated cities in large. Apart from enhancing dexterity and proficiency in the intracity handling of waste, efficient and effective management needs to go beyond administrative boundaries and seek regional cooperation. Previous studies featuring Chinese regional waste management have paid scant attention to such endeavors. A SWOT analysis of the strengths and weaknesses of provinces and municipalities within the Yangtze River Delta, one of the country's top urban agglomerations, justifies the opportunities for further intra-region collaboration. This research analyzed the status quo of waste management in the region and laid out the enabling institutions, challenges, and policy suggestions for enhanced collaborations.

KEYWORDS

collaborative governance, municipal solid waste management, SWOT analysis, urban governance, Yangtze River Delta, China

Introduction

Waste generation is increasing at a higher growth rate due to rapid urbanization, industrialization, and improved community living standards. This phenomenon occurred primarily in China and other emerging economies (Zhang et al., 2010; Guerrero et al., 2013). For example, national statistics show that in 2019 alone, 196 large and medium-sized cities in China reported generating about 1.8 billion tons of solid waste¹. The increased volume of solid waste threatens the cities' sustainable development due to land scarcity issues and has thus attracted the lavish attention of local governments. The waste problem pressures megacities and large cities that usually generate more waste per capita. At the same time, efficient waste management is conducive to achieving the Carbon Peak and Carbon Neutral Targets (Li et al., 2021). The entire process of solid waste

¹ Data source: 2020 Annual Report on Prevention and Control of Environmental Pollution by Solid Waste in Large and medium Cities of China.

management produces greenhouse gas emissions and affects cities' energy consumption and carbon cycle, including collection, transportation, compost, digestion, incineration, and landfill (Zhou et al., 2015). It is estimated that approximately 4,984.71 kg CO₂ will be produced per 8,500 ton of fully treated solid waste (Nabavi-Pelesaraei et al., 2017). Improving solid waste disposal efficiency can recover valuable recyclable materials and mitigate adverse environmental impacts (Gundupalli et al., 2017).

This study discusses the potential for collaborative governance of municipal solid waste among different provinces and municipalities in the Yangtze River Delta to achieve higher levels of management efficiency and effectiveness. The Yangtze River Delta covers 41 cities in Jiangsu, Zhejiang, and Anhui provinces and the Shanghai municipality, covering an area of 3,58,000 square kilometers. It is an essential engine for China's economic transformation and upgrading and a model for regional coordination. The region has become the sixth-largest urban agglomeration in the world (Xu and Yin, 2021). However, due to the economic growth and population increase, solid waste generation in the Yangtze River Delta is enormous and increasing annually (Zhou et al., 2022), causing severe social and environmental problems. The imbalance of solid waste production and disposal capacity among cities has affected the daily operations of cities and sometimes led to the illegal dumping of solid waste across regions. In recent years, although the central governments have repeatedly proposed to build collaborative governance institutions for solid waste in the Yangtze River Delta, local governments lack the motivation to break the limits of administrative divisions and seek cooperation. Up to now, the integrated management of solid waste in the Yangtze River Delta is only at the level of oral consensus. Formal institutions for the joint prevention and disposal of solid waste have not been established.

In this paper, we conduct a SWOT analysis of solid waste governance in different types of cities, i.e., central and non-central. Then, we analyze the necessity, feasibility, and current difficulties of collaborative governance in the region, exploring the policy measures and discussing enabling institutions for collaborative governance.

Strength, weakness, opportunity, and threat analysis of waste management in different types of cities

Waste management in the Yangtze River Delta

Cities in the Yangtze River Delta generate huge amounts of waste every year. The types of solid waste are extensive, including general industrial, hazardous, and domestic waste (Gupta et al.,

2015). Industrial, hazardous, and domestic waste, respectively, account for about 9%, 17%, and 21% of the national total². There are also disparities within the region. Notable features are: Waste generation of industrial solid waste in Jiangsu and Anhui Provinces accounts for a high proportion of the regional total (about 40% respectively); The output of hazardous waste in the four administrative areas is relatively small, but the regional distribution is highly uneven; Shanghai's annual domestic waste output exceeds that of Anhui, accounting for about 20 percent of the regional total (Figure 1).

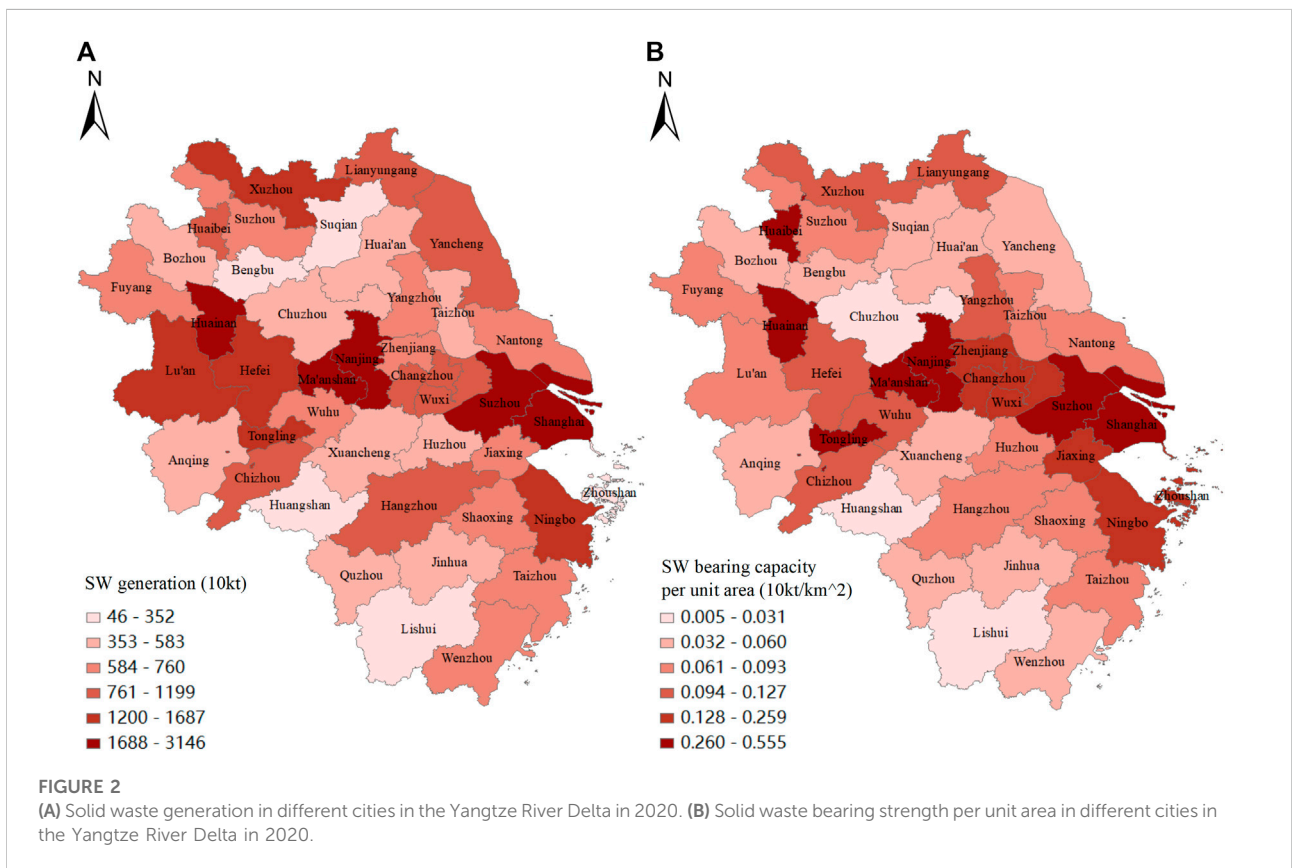
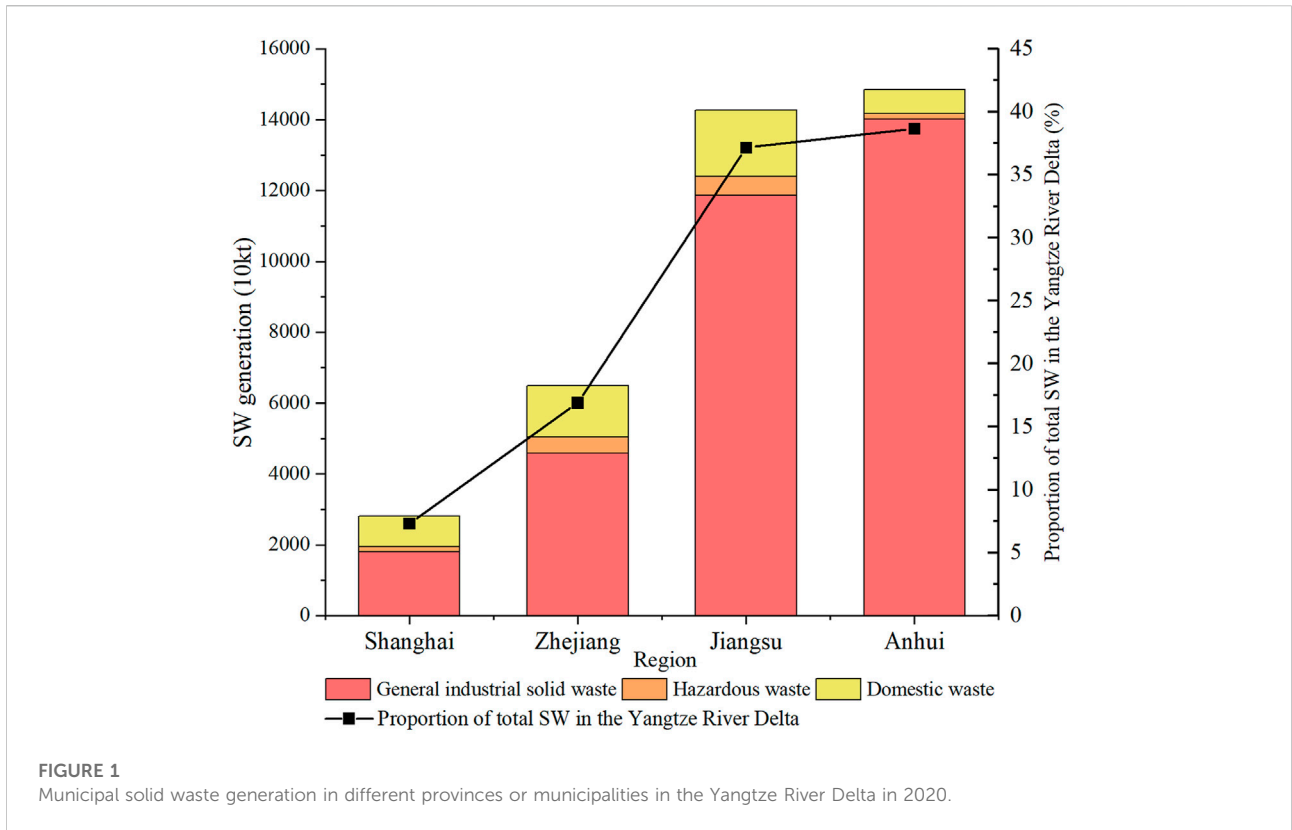
There are also divergence in solid waste generation and solid waste bearing capacity per unit area among cities. Some cities are faced with severe difficulties in solid waste management due to their high waste output and high bearing strength per unit area, such as Shanghai, Nanjing, Suzhou, Ma'anshan (Figure 2).

With-region comparison of the current status of waste disposal reveals a severe imbalance between the region's solid waste generation and disposal capacities. Taking hazardous waste, for example, according to the data published by the Departments of Ecology and Environment in four administrative regions, Shanghai's hazardous waste disposal capacity is lower than its annual generation, with a gap of about 3,30,000 tons. At the same time, Anhui, Zhejiang, and Jiangsu have far more hazardous waste disposal capacity than the annual output, with a surplus capacity of about 3.42 million tons, 6.7 million tons, and 8.14 million tons, respectively (Figure 3).

Solid waste management in different cities has different characteristics (Kurniawan et al., 2021). The Yangtze River Delta urban agglomeration includes many cities, among which the difference in industrial development is large (Zhang et al., 2018; Ye et al., 2019; Xue et al., 2020), and solid waste management also presents different characteristics. Scholars divide the constituent cities of the region into central cities and surrounding cities, leading cities and other cities, or central cities and other cities judging by the industrial evolution, price spillover, and population flow and migration (Wang et al., 2020; Niu et al., 2020; Lan et al., 2021). Based on these existing typologies, this research divides central and non-central cities by comparing the cities' solid waste generation and disposal capacity. If the solid waste generation exceeds its disposal capacity, the city is considered a central city; otherwise, it is considered a non-central city. The classification of central and non-central cities is based on the current situation. They are interchangeable in the future, provided that the gaps in generation and disposal capacities change.

Central and non-central cities have advantages and disadvantages in solid waste management and face different development situations. This research provides a comparative

² Data source: China Statistical Yearbook 2020.



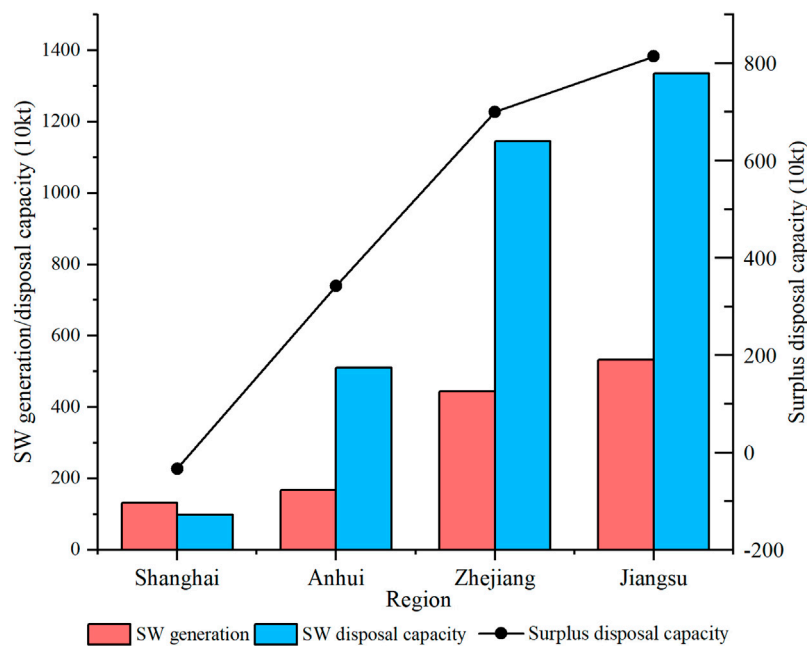


FIGURE 3
Municipal solid waste generation and disposal capacities in different provinces or municipalities in the Yangtze River Delta in 2020.

analysis using the Strength, Weakness, Opportunity, and Threat (SWOT) matrix as an analysis framework. This analysis method adopts a systematic perspective to assess the object’s internal strengths and weaknesses and the external opportunities and threats to help the action subjects choose strategies (Chen et al., 2014; Phadermrod et al., 2019; Longhurst et al., 2020). Tables 1 and 2 present the analytical results of solid waste management in central and non-central cities in the Yangtze River Delta. Driven by mutual external conditions, i.e., the national zero-waste city strategy, the difference between central and non-central cities lies in internal advantages and disadvantages. Central cities are usually large cities and most probably the capital city. They share favorable policies, good governing capacity, and advanced technology, precisely the

disadvantage of non-central cities. By contrast, surplus solid waste disposal capacity and vast available land in non-central cities are also lacking in central cities. The complementarity between the advantages and disadvantages is the basis of the collaborative governance of solid waste in the Yangtze River Delta.

Towards an integrated regional waste management collaboration

The SWOT analysis indicates the region’s huge potential to move towards an integrated regional waste management collaboration. Firstly, the mismatch between the disposal

TABLE 1 SWOT analysis of solid waste management in central cities.

Strengths

- Strong policy support from local governments
- Adequate financial support
- Agglomeration of leading enterprises and strong technical expertise
- High level of social governance and rich experience in solid waste management
- Pronounced garbage classification effect and smooth process of solid waste management

Opportunities

- Special city status and more attention given by the upper-level government
- Reference of excellent experience available at home and abroad

Weaknesses

- High production of solid waste
- Limited land spaces for building new waste disposal facilities

Threats

- Strong awareness of NIMBY among residents

TABLE 2 SWOT analysis of solid waste management in non-central cities.

| Strengths | Weaknesses |
|---|---|
| <ul style="list-style-type: none"> • Relatively lower production of solid waste • Adequate solid waste disposal facilities • Abundantly available land resources | <ul style="list-style-type: none"> • Immature technology and rudimental disposal methods • Weak financial support for the solid waste disposal industry • Lack of operational policies and standards • Incomplete industrial chain and low utilization of solid waste resources • Unsound solid waste classification and recovery system |
| Opportunities | Threats |
| <ul style="list-style-type: none"> • Driving pressure of national environmental assessment • Spillover of technology and experience from central cities | <ul style="list-style-type: none"> • Frequent illegal dumping incidents of solid waste • Residents' NIMBY awareness |

demand and disposal capacity of solid waste in different cities is crucial in establishing a cooperative disposal institution. The volume of waste generated is closely related to the types and intensities of human activities in different cities (Das et al., 2021). The utilization and disposal capacity of solid waste is also confined by multiple factors such as city scale, technological level, and land use. Therefore, making a significant adjustment in a short time is challenging. The Not In My Back Yard (NIMBY) effect has also caused significant obstacles to implementing relevant projects (He et al., 2021). This mismatch leads to pressure on solid waste disposal in central cities, while waste disposal in non-central cities has surplus capacity. The central cities have been exerting their own strength to reduce solid waste in the region. For example, Shanghai has been actively building several solid waste utilization and disposal facilities, striving to build a terminal disposal pattern of “one master and multiple points” in the municipal area, and reducing source quantity by promoting green consumption and implementing waste classification, along with some solid waste transfer outsourcing to solve the problem. However, low land use efficiency, difficulty in promoting the site selection of facilities, and unstable cooperative relationships have become new dilemmas to be faced. If trans-regional treatment of solid waste can be achieved, it can solve the urgent need of central cities. Non-central cities also benefit from the improvement of solid waste disposal and resource utilization technologies. The collaboration also boosts their industrial development and local employment.

Secondly, waste treatment and utilization involve multiple streams and require a good separation of labor. The most appropriate disposal techniques for different kinds of solid waste exhibit noticeable differences (Aich and Ghosh, 2015). It is hardly possible for any single city to include all types of disposal facilities within its jurisdiction. Cities in the Yangtze River Delta share distinctive industrial structures (Zhang et al., 2019; Zhou et al., 2021) and may deploy treatment plants based on their comparative advantage. Also, transportation to specific areas for centralized disposal will bring economies of scale for small and scattered solid waste generation spots.

Lastly, it is conducive to establishing a joint prevention and control institution of solid waste and regulating the illegal behavior of trans-regional dumping with this scientific transfer institution. In recent years, there have been several illegal dumping cases of solid waste in the region and even formed a close collaboration black industry chain, which seriously polluted the ecological environment of the dumped sites. For example, in the case of Suzhou's Wujiang district in recent years, law enforcement officers have repeatedly intercepted large quantities of industrial solid waste and construction waste shipped from the nearby Qingpu district of Shanghai and Jiashan County in Zhejiang. Despite a strong crackdown on illegal dumping in the region, the very low cost of illegal dumping has made it more prevalent. Moreover, to save operating costs, some enterprises hand over solid waste to unqualified companies for disposal or directly dump it in other jurisdictions. As a result, some inter-provincial and inter-municipal adjacent areas have become vulnerable areas of illegal dumping.

Feasibility assessment

Cities in the region are very much prepared for such joint action. Firstly, laws and regulations in both environmental protection and regional documents of the Yangtze River Delta have proposed to promote the establishment of a trans-regional solid waste disposal institution. Specific provisions can be found in the Solid Waste Law, the Plan for the Integrated Development of the Yangtze River Delta, and documents of the Ministry of Environmental Protection and other ministries. These documents ensure its implementation through legality and authority.

Secondly, the experience of joint control of air pollution and river basin pollution in the Yangtze River Delta provides a cooperative foundation for the collaborative governance of solid waste. The region has made some valuable explorations on air and water pollution under the mode of trans-regional and multi-entity participation (Hu et al., 2014; Wang et al., 2020). In

this process, some scientific trans-regional cooperation measures have also been introduced, including leaders' joint meeting systems, regional environmental cooperation institutions, regional environmental cooperation agreements, and horizontal ecological compensation mechanisms. Although there are differences in specific management methods and technical means between solid waste management and the other two, the core problem of collaborative governance of municipal solid waste is still how to go beyond administrative boundaries and achieve cross-regional cooperation. Therefore, the experiences in joint control of air pollution and river basin pollution could provide references for the collaborative governance of solid waste. Meanwhile, the regular consultation and mutual assistance relationship established by local ecological and environmental protection departments in the long-term cooperation will also benefit regional waste management.

Finally, collaborative regional waste management has proved successful in other urban agglomerations globally. For example, Germany's Rhin-Ruhr urban agglomeration has established a waste exchange system, which summarizes the trading intention information of different regions to meet the demand and supply of solid waste in different markets. The Tokyo metropolitan area has developed an efficient solid waste disposal mode: The surrounding areas of Tokyo have formed a clear industrial chain of solid waste disposal, which jointly eliminates the solid waste generated in the region through the division of labor. There are also quite a few attempts domestically. For example, Sichuan and Chongqing have established a safelist for the trans-regional transfer of hazardous waste, which has improved the disposal capacity of hazardous waste in both places. Guangdong and Macao have also set up environmental protection groups to solve Macao's environmental problems.

However, despite those favoring factors, there are also challenges that policy designers might consider. The transregional disposal of solid waste brings about the transfer of environmental pollution and management risk. Local government leaders face the pressure of the increasingly stringent target responsibility system and performance evaluation system in environmental protection. The jurisdiction's environmental protection situation is closely related to their promotion (Wu et al., 2018), which will unavoidably affect their policy choices. This exacerbates the mismatch between supply and demand for solid waste disposal in the Yangtze River Delta: Governments in central cities such as Shanghai and Hangzhou are eager to release excess solid waste from their jurisdictions; Northern Anhui, Northern Jiangsu, and other places have vast inland hinterland and idle disposal capacity, but they are not willing to receive solid waste from other administrative areas. Administrative barriers make it difficult to form a consensus on bilateral cooperation between cities. Meanwhile, there is a big gap between the actual

cooperation situation and the policy assumption. Even though the restrictions on the trans-regional transfer of solid waste are gradually relaxed in the recently issued new policies, the local government's mindset has not changed in time, which is reflected in the fact that the approval and inspection process is complicated and time-consuming.

Actionable recommendations

Based on the analysis above, it is essential to establish institutions for the collaborative governance of solid waste in the Yangtze River Delta. Central cities have the opportunity to transfer the solid waste that cannot be disposed of to the non-central cities and the latter would get compensations in various forms. However, at the same time, we should choose the most efficient solid waste flow direction according to the structural differences of solid waste output and types in different cities and if necessary, relocate the disposal facilities or transfer advanced technologies among different cities. We have offered four actionable recommendations that may facilitate the collaborative governance of waste in the Yangtze River Delta.

Firstly, we need to strengthen the top-level design to provide organizational and institutional guarantees for the cooperative governance of solid waste. Under the background of the integrated development of the Yangtze River Delta, local governments should strengthen environmental cooperation and promote regional solid waste collaborative management by formulating regional policies, laws, and regulations. The Yangtze River Delta should also establish a robust organizational institution with precise functions and smooth operation to coordinate the work of solid waste cooperative management, which should cover all departments related to solid waste management in each city. Based on full consultation, each city's common goals and interests should be clarified, and regional cooperation agreements on solid waste management should be reached. At the same time, the Yangtze River Delta should establish a positive expert advice system. Domestic and overseas experts should be invited to conduct investigations and studies to provide decision-making references for government cooperation from a professional perspective.

Secondly, a reasonable ecological compensation institution needs to be developed. Ecological compensation is an essential means to adjust the relationship between stakeholders of environmental protection and has been widely used in many fields of environmental governance (Pan et al., 2017; Fu et al., 2018). The trans-regional disposal of solid waste is not only the market behavior of waste producers and disposers but also closely related to local environmental pollution and governance risks. Therefore, in addition to paying the specific disposal cost according to the market principle, the production government should also pay ecological compensation fees to the

disposal government for the adverse external effects such as exacerbating solid waste pollution, occupying the ecological environment resources, and causing NIMBY conflicts. Cities should establish a stable cooperative relationship. Governments should agree on compensation standards in advance based on careful consideration of short-term benefits and long-term development. They can use diversified compensation means, including special fund compensation, project compensation, and technology compensation. For the regional transfer of large-scale or multiple-type solid waste, specific cooperation matters can be negotiated case by case.

Thirdly, the local governments need to attach importance to the role of enterprises and promote technological innovation and industrialization development in the solid waste industry. Enterprises play the role of responsible persons (Yang et al., 2020) or contractors (Corvellec et al., 2012) in environmental protection and pollution prevention. Their market behaviors affect the quality and efficiency of solid waste disposal. Therefore, the government should promote the formation of a healthy market competition environment, encourage enterprises to improve their technical level and explore a more efficient business model of solid waste co-management. Local governments should overcome the dependence on low labor and environmental cost of small workshops, actively introduce or cultivate leading enterprises in the field of solid waste disposal by building industrial parks, strive to achieve breakthroughs in core technologies, and eventually improve the total level of solid waste disposal in the Yangtze River Delta. At the same time, it should also be noted that technological innovation may change the structure of coordinated solid waste management in the Yangtze River Delta and then timely change the disposal flow.

Lastly, both central and local governments need to take multiple measures to ensure the integration of solid waste governance with other industries. The suitable disposal of solid waste is a complex system involving multiple highly correlated processes. Therefore, unified standards and rules should be formulated at the beginning to ensure a smooth transition during the processes. Local governments could invest and build them proportionally for the site selection and construction of solid waste disposal facilities. They can also learn from the experience of the Superfund Law of the United States to create a green investment and financing system to ensure its operation in a market-oriented way. When COVID-19 has strongly impacted all industries (Donthu and Gustafsson, 2020), it is more important to give full play to the solid waste disposal industry's positive role in boosting the economy and stimulating employment. By extending the industrial chain, the solid waste raw materials after resource disposal can be put into

related industries for use, and ecotype and park-type resource recycling bases can be built to drive the industrial development of surrounding areas.

Conclusion

Municipal solid waste management is becoming an increasingly complicated task in large cities in the Yangtze River Delta. The SWOT analysis provides the legitimacy for formulating regional collaborative governance institutions on waste management. Potential future stances include the transformation in the legal (a safelist system for illegal dumping), political (an integrated regional waste management strategy), economical (a formal ecological compensation system for extra-territorial waste disposal), and technological (synergizing waste management with other emerging industries) aspects. The case has also sought to serve as an instructive example to other urban agglomerations during the process of urbanization.

Author contributions

JZ: conceptualization, writing-review and editing, funding acquisition, supervision. MZ: methodology, investigation, writing original draft.

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