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Case Report

Sustainable Municipal Solid Waste Disposal in the Belt and Road Initiative: A Preliminary Proposal for Chengdu City

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Abstract: The Chinese green Belt and Road initiative is promoted. This study takes Chengdu as a key hub under the Belt and Road initiative. The municipal solid waste disposal is the point to control pollution and move toward sustainability. Hence, sustainable municipal solid waste disposal needs to be studied. The prior studies are absent in the planning scenarios analysis. This study proposes a case study to propose three planning scenarios for waste disposal to enhance its sustainability. Scenario 1 represents the current waste disposal mode in Chengdu; Scenario 2 considers all the wastes being incinerated; and Scenario 3 focuses on the incorporation of three disposal methods, i.e., anaerobic digestion, incineration, and landfilling. These three scenarios are assessed based on their greenhouse gas emissions, costs, and public acceptance, to determine the optimality for future managerial practice. Results indicated that Scenario 3 has the highest overall efficiency, yet is challenging in terms of economic feasibility. The limitations of the study are also discussed.

Keywords: municipal solid waste; GHG emissions; scenario; waste disposal

1. Introduction

The Belt and Road Initiative is a proposition of China for strengthening partnerships among countries along the land-based "Silk Road Economic Belt" and the oceangoing "Maritime Silk Road", through which 65 countries with about 16.0% of the world's GDP, as well as a population of 4.4 billion are bound together [1,2]. Under the Belt and Road Initiative, emphasis has been placed on economic collaboration between countries in building an open, encompassing, green and shared economic mode [3]. The green economic growth calls for urban transition in response to the crisis of climate change [4]. Currently, the greenhouse gas emissions (GHGs) generated from municipal waste disposal accounts for 3% of worldwide emissions [5]. While striving for economic development and urbanization, countries also face the urgent issues of designing proper municipal solid waste (MSW) disposal plans and uncovering potential ways to reduce emissions [6]. Landfilling, incineration, and biological treatment (anaerobic digestion) are currently the most common ways of MSW disposal [7–9]. As conditions vary among countries, a dilemma usually occurs in the selection of disposal ways [10]. For example, the investment and operational costs of incineration and anaerobic digestion are generally higher than that of landfilling, but the latter contributes abundant landfill gases (LFGs) and leachate, which makes it difficult with respect to the reduction of GHGs and may even cause secondary environmental pollutions [11–13]. Therefore, it is essential to preferentially consider coordination among the economy, environment, and society when formulating an MSW disposal plan to increase its sustainability.

Legislation is a requisite to guide MSW management. For example, "The Law of the People's Republic of China on the Prevention and Control of Environmental Pollution Caused by Solid Waste" is the key legislation in China on solid waste management [14], which stipulates that local government should formulate and promulgate specific measures for waste supervision and administration, including the establishment of collection, transport and treatment facilities [15,16]. This ensures the importance of analyzing the possible status quo of waste disposal to build appropriate planning scenarios for future management practices.

This study proposes three scenarios and assesses their GHGs, costs, and public acceptance, to select the optimal planning scenario for the promotion of sustainable waste disposal. A case study of Chengdu, a megacity in China and a key hub under the Belt and Road Initiative, was conducted to verify the scenario analysis. Chengdu, due to its economic, logistic, and technological advances, has been indicated as the best-performing city in Southwest China, which has immense potential to add value to the Belt and Road Initiative [17,18]. Due to its rapid urbanization, the amount of municipal solid wastes being generated rises by 5% each year [19], which brings intense challenges on the waste disposal and its associated GHGs reduction. Urban Management Bureau of Chengdu (UMBC) is responsible for the MSW collection and transportation, but there is neither meticulous source separation nor sorting for the waste before landfilling or incineration. The MSW is distinguished by the chemical properties of the involved constituent components, which is divided into organics and inorganics [20]. According to the investigation by UMBC, the organics reaches up to 76.5% of the total MSW, including food residue, wood waste, paper, textiles, plastics, and rubber [21]. Especially, food residue from households accounts for 59.7% of the organics, which shows great potential in energy recovery by using anaerobic digestion (AD) [22]. This study aims not only to provide insight into the design of MSW disposal plans for Chengdu city, but also gives a template of MSW disposal for countries under the Belt and Road Initiative to combat against climate change.

2. Literature Review

Recent studies on MSW disposal have mainly focused on its optimization, with most of the studies centered on the optimization of its economic performance. For example, Li et al. [23] developed an interval-based possibilistic programming (IBPP) model by taking uncertainties in costs of MSW collection, transportation, and disposal into account, to minimize the total cost of MSW disposal systems and the associated environmental impacts. By considering the economic uncertainties, including waste transportation and operational cost, Zhu and Huang [24] constructed a waste management privatization model to compare the service efficiency of different contract-out plans. Dai et al. [25] developed a two-stage support-vector-regression model to optimize the MSW disposal system in the city of Beijing by minimizing the net system cost. Economopoulou et al. [26] established restricted conditions based on the study area (the Attica Region in Greece) and constructed an optimized model with the aim of capital investment minimization of waste management. Similarly, Asefi and Lim [27] utilized a geographic information system (GIS) to optimize a MSW disposal system with consideration of its operations cost minimization. Das and Bhattacharyya [28] constructed a mixed integer program to optimize MSW collection and transportation routes, to increase its economic efficiency. On the same basis, Yadav et al. [29] developed an interval-valued facility location model with the aim of minimizing MSW transportation cost.

With the crisis of climate change looming, sustainable development has gained increasing attention. Reduction of GHGs is a significant indicator that drives sustainable waste management [30]. From such a perspective, many studies have been conducted to optimize MSW disposal systems by taking GHGs assessment into account. Wittmaier et al. [31] took Northern Germany as a case area and analyzed the GHGs generated from waste incineration and the associated energy recovery by using life cycle assessment (LCA). Similar research methods were applied in studies by Liamsanguan and

Gheewala [32] and Cifrian et al. [33]. In the former study, the environmental benefits of MSW disposal combined landfilling with incineration were assessed in terms of GHGs and energy consumption, whereas the latter evaluated the potential emissions reductions, including recycling, composting, incineration, and landfilling. Based on this, Zhao et al. [34] used a combined LCA and life cycle costing (LCC) method to analyze the GHGs and economic performance of the MSW disposal of Tianjin City, ultimately to develop an eco-efficiency indicator evaluation system. Lu et al. [35] developed an inexact dynamic optimization model (IDOM) and obtained a trade-off solution between MSW disposal cost and GHGs. Similarly, Mavrotas et al. [36] constructed a planning model with the aim of minimizing GHGs and economic cost to optimize the capacity expansion of treatment units and the involved waste flows. Hanandeh et al. [37] designed different scenarios based on various waste management ways, including landfilling, composting, recycling, and anaerobic digestion, to assess the potential reduction of GHGs in each scenario. Pin et al. [38] further integrated the aforementioned MSW disposal scenarios into three scenarios, namely recycling, composting, and incineration, to select the best scenario based upon the greatest potential reduction of GHGs.

Prior studies have focused on the optimization of sequential MSW disposal systems, indicated from waste generation to the final disposal [39,40]. This study deliberately narrows down the systems boundary by only taking the disposal design into account, since countries under the Belt and Road Initiative have not formulated the appropriate plan to reduce the stocks of waste [41]. Moreover, the facilities for waste disposal are generally operated independently, without developing possible linkages among them [11,42]. This may result in inefficiency of energy recovery in waste disposal. This study takes Chengdu as a typical case area, to propose three possible waste disposal planning scenarios based upon interactions among the AD plant, incineration plant, and landfill disposal center. The three scenarios were then assessed and compared based on their GHGs, operational costs, and public acceptance, and the optimum scenario was selected to provide a template for waste management in developing countries covered by the Belt and Road Initiative.

3. Method and Data

3.1. Scenario Development

Three scenarios were proposed in the study, of which Scenario 1 is the benchmark scenario indicating the current waste disposal in the city of Chengdu, which involves a maximum of 52% of the wastes sent for landfill disposal, and the rest for incineration [19], as shown in Figure 1a. Since Chengdu has not implemented a system of waste classification and collection, the waste is in a mixed composition [43]. In this case, there is no difference on the composition between the waste for landfill disposal and the waste for incineration. The data indicated that 52% of the wastes were sent for landfill disposal is actually determined by the disposal capacity.

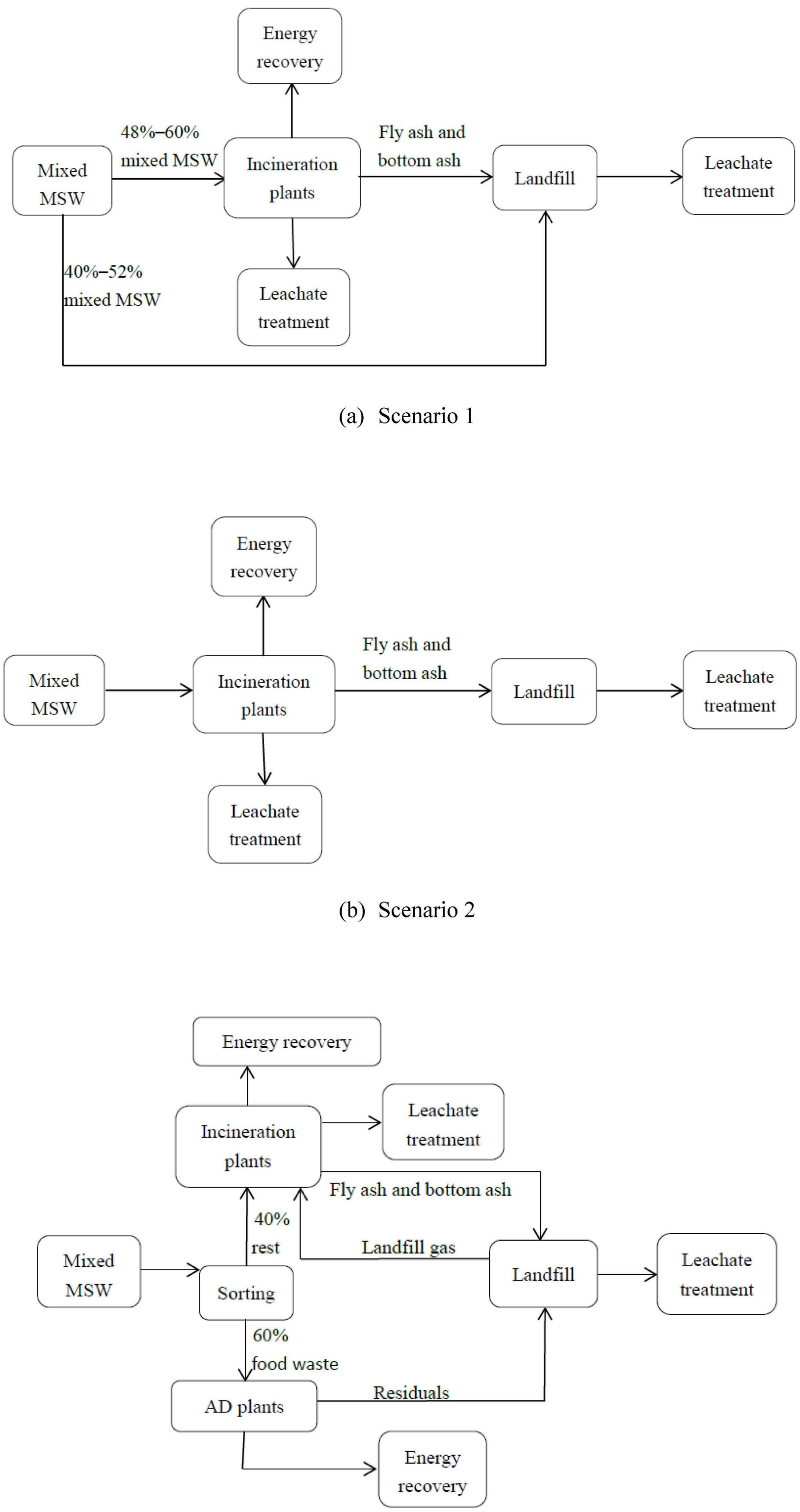
Scenario 2 considers all the MSW to be incinerated, because of its efficient waste reduction, with the residuals (fly and bottom ash) disposed via landfilling, as shown in Figure 1b. It is a planning scenario which reflects Chengdu's governmental policy-making on waste treatment. Since landfill disposal is limited by the site selection, the local government has decided to establish more incineration plants to reinforce the performance of waste reduction [44]. According to the "Urban Planning of Chengdu City (2016–2035)", all the MSW is preferred treatment by incineration instead of landfilling during the planning period [19]. Thus, Scenario 2 is proposed by taking an extreme condition into account, i.e., all the wastes sent for incineration are assumed as not being sorted, but remained as a mixed composition. Meanwhile, due to the high moisture content and low calorific value, the MSW cannot be incinerated completely without adding combustion improvers [42]. In such a case, MSW is piled up 3–7 days in storage bunkers for drying before incineration, through which a large amount of fresh leachate (20% by MSW weight) is produced [45]. Table 1 shows the variation of waste composition before and after stacking, in terms of the investigation by UMBC. It is clear that the mass proportion of food waste decreases significantly from 66.53% to 59.72%, whilst others fluctuate slightly. This further verifies that food waste contributes the most of fresh leachate because of dewatering during the period of stacking in the bunkers. The growth of the proportions of other compositions, i.e., paper, textiles, and wood, results from reduction of the total mass of mixed wastes after leachate discharging.

Table 1. Variation of waste composition before and after stacking.

	Composition (%)				
	Paper	**Textile**	**Food**	**Wood**	**Rest**
Waste before stacking	8.516	2.983	66.533	3.015	18.953
Waste stacking for 3–7 days	10.140	3.406	59.722	3.262	23.500

In Scenario 3, the MSW is classified into organic and inorganic. The organic part, e.g., food waste, is subjected to AD for biogas generation in order for further energy recovery. The inorganic MSW is handled through incineration, with the residuals disposed via landfilling. The LFGs is recovered and transported to the incineration plant where it is used to evaporate the waste leachate.

The study applies the inventory of greenhouse gases emissions proposed by the Intergovernmental Panel on Climate Change (IPCC) to assess the GHGs in different scenarios of waste disposal. Moreover, the study has incorporated 'triple bottom line' (economic, environmental, and social) into the selection of waste disposal plans to enhance its sustainability, instead of only taking GHGs reduction into account. The triple bottom line is a concept developed by Elkington, which offers a framework that simultaneously considers balances between economic, environmental, and social issues in business operations [46]. It has been widely used to evaluate sustainability performance in various fields, such as supply chain optimization, green buildings design, location of waste disposal facilities, etc. [47–49]. In this context, the marginal cost of per unit GHGs reduction by using the cost-benefit analysis is to analyze the economic sustainability among the three proposed scenarios. The social sustainability is indicated by the public acceptance to the facilities of waste disposal. As the three perspectives may have their inherent importance on the selection of disposal plan, a multi-attribute decision-making approach specifically by using a 'binary dominant matrix' is conducted to determine the optimal scenario for managerial practice with the best economic, environmental, and social performance.



(a) Scenario 1

(b) Scenario 2

(c) Scenario 3

Figure 1. Setups of the three defined scenarios.

3.2. GHG Emissions Assessment

In this study, the direct GHGs from MSW incineration, AD, and landfill disposal were assessed, as illustrated by the CO_2 equivalents.

3.2.1. GHG Emissions from Incineration

CO_2, CH_4, and N_2O are considered as the major components of the GHGs generated by waste incineration, which are given as follows [50]:

$$\begin{aligned} I_{GHG} &= I_{CO_2} + I_{CH_4} \times 25 + I_{N_2O} \times 298 \\ &= Q_I \times CCW \times EF \times \tfrac{44}{12} + Q_I \times EF_{CH_4} \times 10^{-6} \times 25 \\ &\quad + Q_I \times EF_{N_2O} \times 10^{-6} \times 298 \end{aligned} \tag{1}$$

where I_{GHG} is the annual GHGs in CO_2 equivalents from MSW incineration, tons; I_{CO_2} is the annual CO_2 emissions from MSW incineration, tons; I_{CH_4} is the annual CH_4 emissions from MSW incineration, tons; I_{N_2O} is the annual N_2O emissions from MSW incineration, tons; Q_I is the waste incinerated annually, tons; CCW is the carbon content of the MSW, in %; EF is the oxidation efficiency of the MSW, in %; EF_{CH_4} is the emissions factor of CH_4, kg CH_4·kg^{-1} MSW; and EF_{N_2O} is the emissions factor of N_2O, kg N_2O·kg^{-1} MSW.

MSW incineration provides power through energy recovery, which may decrease the GHG emissions compared to conventional power generation, i.e., thermal power [51]. Thus, SI_{GHG} can be expressed as follows:

$$SI_{GHG} = Q_I \times ERF_I \times EF_{ep} \tag{2}$$

where ERF_I is the power recovered per amount of waste incinerated, MWh ton^{-1}; and EF_{ep} is the emissions factor of the power generation, tons of CO_2 equivalent·MWh^{-1}.

Fly ash and bottom ash are the typical by-products of incineration, which may contribute to GHGs, calculated as follows:

$$RI_{GHG} = Q_I \times PR_i \times EFT_i \tag{3}$$

where RI_{GHG} is the annual GHGs in CO_2 equivalents from the incineration residuals per annum, tons; PR_i is the ratio of bottom ash produced, in %; and EFT_i is the emissions factor of the residuals treatment.

3.2.2. GHG Emissions from Landfill Disposal

GHG emissions from landfill disposal may be composed of the LFGs and emissions from the leachate treatment. The main components of LFGs are CH_4 and CO_2, which account for over 90% of the total LFGs [52]. Only the GHGs based on the CH_4 levels are focused in this study and given as follows [50]:

$$\begin{aligned} L_{CH_4} &= \left(MSW_Q \times L_0 - R\right) \times (1 - OX) \times 25 \\ &= \left\{MSW_Q \times \left[MCF \times \sum_i (DOC_i \times W_i) \times DOC_F \times F \times 16/12\right] - R\right\} \\ &\quad \times (1 - OX) \times 25 \end{aligned} \tag{4}$$

where L_{CH_4} is the CH_4 emissions from annual waste landfill disposal, tons of CO_2 equivalents; MSW_Q is the amount of waste disposed in landfills annually, tons; L_0 is the CH_4 generation potential; R is the amount of CH_4 recovered, tons; OX is the oxidation factor; MCF is the CH_4 correction factor; DOC_i is the component of degradable organic carbon, in %; W_i is the ith waste component in MSW, in %; DOC_F is the degradable organic carbon, in %; and F is the proportion of CH_4 in LFG, in %.

Leachate treatment is a significant source of CH_4 and N_2O emissions, and the associated GHGs are measured as follows [53]:

$$LT_{GHG} = Q_l \times \left(EF_{tp} + E_c \times EF_{ep}\right) \tag{5}$$

where LT_{GHG} is the annual GHGs from the leachate treatment, tons of CO_2 equivalents; Q_l is the amount of leachate treated per annum, m^3; EP_{tp} is the emissions factor; E_c is the energy consumption of leachate treatment, MWh/m^3; and EP_{ep} is the emissions factor of the electricity consumption, $t\ CO_2 \cdot MWh^{-1}$.

3.2.3. GHG Emissions from Anaerobic Digestion

AD is commonly applied in organic waste treatment and may contribute to biogases, including CH_4 and CO_2, which is determined as follows:

$$AD_{GHG} = (Q_{AD} \times PR_{gas} \times \frac{R_{CH_4}}{0.0224}) \times 44 \quad (6)$$

where AD_{GHG} is the annual GHG emissions from AD, tons; Q_{AD} is the amount of waste treated via AD per annum, tons; PR_{gas} is the biogas produced, $m^3 \cdot t^{-1}$; and R_{CH_4} is the proportion of CH_4 in the biogas, in %.

3.3. Economic Assessment

Economic feasibility is estimated by the cost-benefit analysis (CBA) to inspect the construction costs, operational costs, and revenues in the different scenarios. CBA is an analytical approach that measures the economic value of a project through the quantification of costs and possible benefits caused by investment decisions [54]. It has been widely employed to evaluate the economic feasibility of waste to energy projects [55]. As Scenario 1 is an actual operating management system, the construction cost has been excluded, and only the operational cost is considered. For Scenarios 2 and 3, construction costs for the incineration plant and AD plant are considered. Revenue for all three scenarios is defined as the revenue from electricity generation through energy recovery. The costs of the scenarios are measured as follows [56]:

$$\text{EAC} = \frac{C_t \times r}{1-(1+r)^{-t}} + O_t - R_t \quad (7)$$

where EAC is the annual cost, yuan; C_t is the annual investment, yuan; O_t is the annual operations and maintenance cost, yuan; R_t is the annual revenue, yuan; r is the discount rate (%); and t is the lifespan of the facility, years.

3.4. Data Source

The city of Chengdu was the study area in this investigation. The active data were mainly provided by the UMBC. The emissions factors were obtained from the Intergovernmental Panel on Climate Change (IPCC) [50] and the Guidelines for Provincial Level Greenhouse Gas Inventory [57], as shown in Table 2.

Table 2. Data for the parameters of the GHGs assessment and their sources.

Parameters	Data	Source
Incineration capacity (2016–2020; million tons)	2.08, 2.86, 2.96, 2.96, and 4.27, respectively	[19]
CCW (%)	20	[57]
EF (%)	95	[57]
EF_{CH4}	0.2	[50]
EF_{N2O}	47	[50]
E_{MSW} in Scenario 1 (2016–2020; MWh)	661,977	UMBC
E_{MSW} in Scenario 2 (2016–2020; MWh)	1,064,071, 1,123,169, 1,185,671, 1,251,885, and 1,321,503, respectively	[19]

Table 2. *Cont.*

Parameters	Data	Source
E_{MSW} in Scenario 3 (2016–2020; MWh)	428,055, 451,829, 476,972, 503,608, and 531,614, respectively	Field investigation
EF_{ep} (t $CO^2 \cdot MWh^{-1}$)	0.9229	[58]
MSW_Q in Scenario 1 (2016–2020; million tons)	1.359, 1.55, 1.752, 1.966, and 2.191, respectively	[19]
MSW_Q in Scenario 3 (2016–2020; million tons)	0.020, 0.021, 0.022, 0.024, and 0.025, respectively	[19]
MCF	1	[50]
DOC_F	0.5	[59]
F	0.35	[60]
R	0	Field investigation
OX	0.1	[57]
$Q_{l,y}$ (2016–2020; million tons)	0.5175, 0.705, 0.883, 0.885, and 0.885, respectively	Field investigation
E_{tp} (kg/m^3)	0.059	[59]
E_c (MWh/m^3)	0.014	[61]
PR_{gas} (m^3/t)	76.71	[62]
R_{CH4} (%)	61	Experiment
Construction investment for AD plants	90,644 USD/t	[63]
r	8%	[56]
Operating cost	9.35 USD/t (landfill), 26.82 USD/t (incineration), 45.03 USD/t (AD)	[42,63,64], respectively
Subsidy	12.64 USD/t (landfill), 28.44 USD/t (incineration), 27.46 USD/t (AD)	Field investigation [42,63], respectively
W_i (Paper, Textile, Food, Wood; %)	10.14, 3.406, 59.722, and 3.262, respectively	UMBC
DOC_i default value (Paper, Textile, Food, Wood; %)	40, 24, 15, and 43, respectively	[57]

4. Results and Discussion

4.1. Results

GHGs continuously increase during the period of 2016–2020 in all three scenarios shown in Figure 2. Among them, the most rapid increase in GHGs is observed in Scenario 1, with 33.76% more in 2020 than in 2016. This is possibly due to the limited capacity of the incineration plant in Scenario 1, thus, the newly-generated MSW may only be treated via direct landfilling, which leads to the excessively rapid increase in GHGs. In contrast, Scenario 3 has the smallest increase of GHGs. This result indicates that the incorporation of AD and the interaction of different treatment facilities may have potential in GHGs reduction. This postulation is also supported in a study by Rajaeifar et al. [65], who utilized LCA in the analysis of the MSW disposal system in Iran and discovered that the introduction of AD treatment could effectively reduce GHGs.

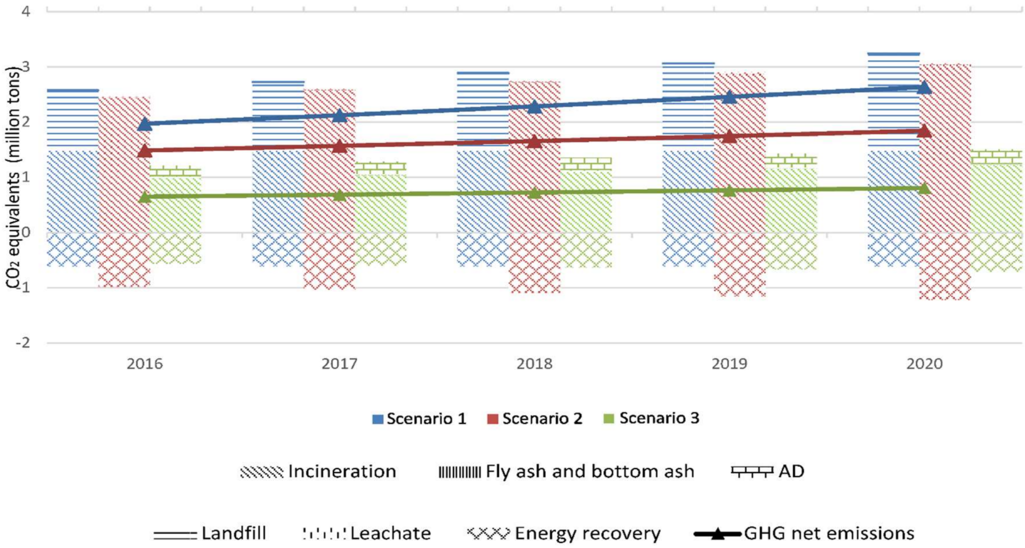


Figure 2. Trends in GHG emissions for the different scenarios.

While comparing the GHGs and the cost per ton of waste treatment, it is obvious that Scenario 1 has the highest emissions level but the lowest cost, as shown in Figure 3. The performance of Scenario 1 is mainly affected by the comparatively high emissions levels. However, the cost of landfilling is the lowest. Scenario 3 enables substantial reduction of GHGs, but the cost would be higher by up to eightfold. The higher cost is due to high construction investment and operational costs. This indicates that Scenario 3 is economically infeasible for management practice.

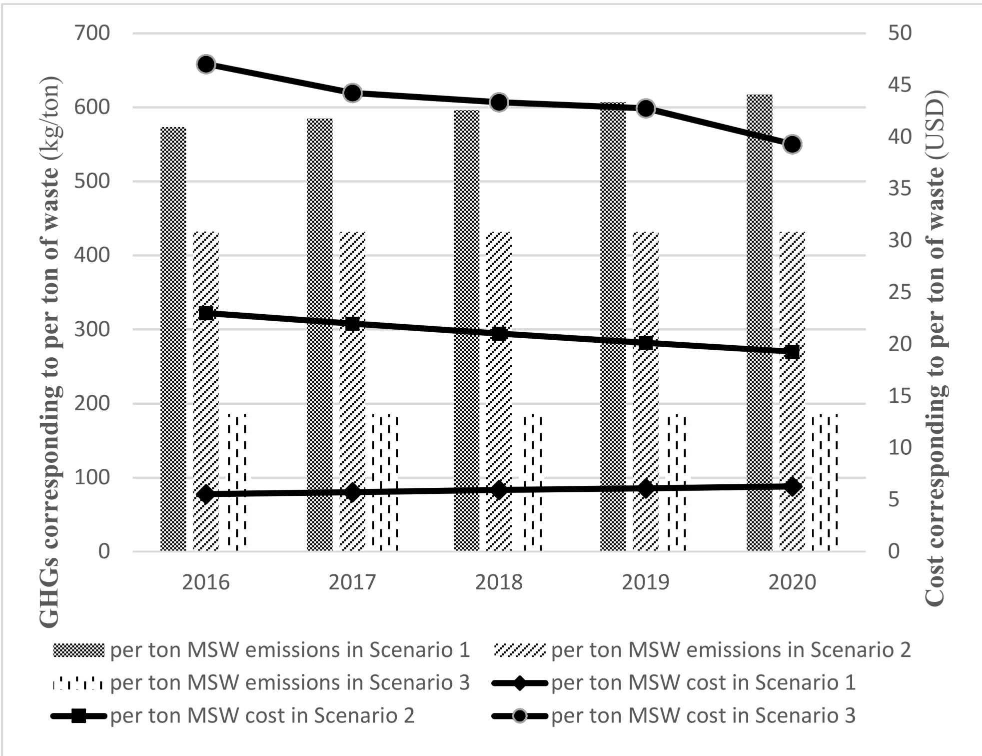


Figure 3. GHGs and costs per ton of waste for the different scenarios.

4.2. Discussion

The results clearly reflect that there might be a conflict between the GHGs reduction and cost consideration in implementation of the waste disposal plan. Public acceptance is also a significant factor that influences decision-making in the design of waste disposal systems [66–68]. For instance, there is widespread controversy regarding incineration in China, in terms of potential health and environmental risks [69]. A number of incineration projects have been postponed, or even cancelled, because of strong social resistance [70]. To select the optimal scenario for the management practice, normalization is conducted to ensure a common scale for comparison, as follows [30]:

$$A_{ij} = \frac{OBJ_{imin} - OBJ_{ij}}{OBJ_{imax} - OBJ_{imin}} \quad (8)$$

where A_{ij} is the normalized attributive value of objective i in scenario j; OBJ_{ij} is the actual value of objective i in scenario j; OBJ_{imin} is the minimum value of objective i among the three scenarios; and OBJ_{imax} is the maximum value of objective i among the three scenarios.

The objectives in this study are GHGs, operational costs, and public acceptance. A binary dominance matrix (BDM) is applied to assess the importance of the three objectives, which is a subjective weighting approach that lists all the criteria on both the vertical and horizontal axes in a matrix, and a value of 1 or 0 is assigned to each column generated by the intersection of the axes, in terms of the relative importance of a pair of criteria [71]. Compliance with green development proposed by the Belt and Road Initiative, it is assumed that the order of importance is ranked as GHGs, cost, and public acceptance, and the corresponding weights are given in Table 3.

Table 3. Weights by using the binary dominance matrix.

Indicator	GHGs	Cost	Public Acceptance	Score	Weight
GHGs	-	1	1	3	0.5
Cost	0	-	1	2	0.33
Public acceptance	0	0	-	1	0.17

Figure 4 shows that Scenario 3 obtains the highest score, due to its advantages in GHGs reduction and the high degree of public acceptance. Scenario 3 can be an optimal alternative system for solid waste disposal in the city of Chengdu. However, there are a number of uncertainties in its implementation. First, it is supposed that all the organic wastes are handled by AD in Scenario 3. In fact, complete separation between organic and inorganic waste has not been implemented in Chengdu, which may significantly impact the AD performance [19]. Second, the economic feasibility is also a challenge, owing to the large investment input for the AD plant, LFGs recovery, and leachate evaporation systems. Moreover, a network needs to be set up for the coordinative interactions among the involved facilities, e.g., the landfills may not be willing to provide the recovered LFGs to the incineration plant for further utilization.

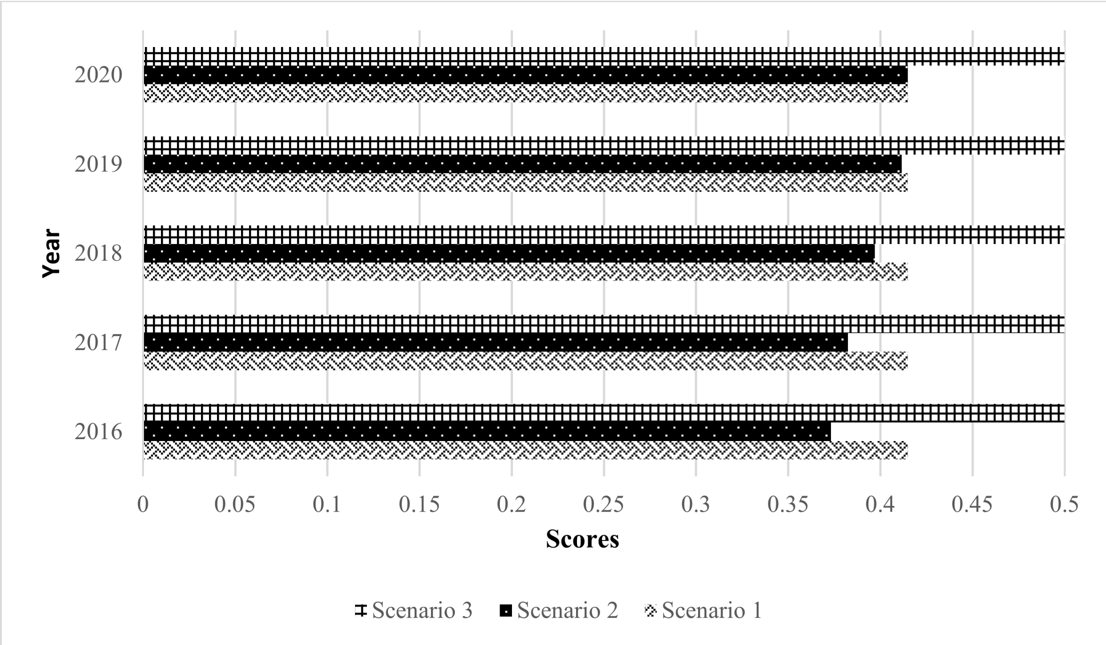


Figure 4. Evaluation results of the different scenarios.

To resolve the economic dilemma in Scenario 3, motivations may be adopted by the local government. For instance, the government may consider subsidies for investment in the key treatment facilities within the scenario, including the AD and incineration plants, as well as research and development subsidies to partially cover the external costs. However, the financial burden on the government owing to overreliance on subsidies must be avoided. Marketization mechanisms such as build-operate-transfer and public-private partnership may be introduced to attract social capital for investment in waste reuse and recycling to increase the back-end disposal efficiency.

5. Conclusions

Chengdu City in China is used to form the three different management planning scenarios for MSW disposal. Scenario 1 represents the current mode of MSW disposal in Chengdu City; Scenario 2 represents the planning of MSW disposal in the period of 2016–2035; and Scenario 3 represents an MSW disposal system that incorporates three treatment methods, i.e., AD, incineration, and landfilling. The three scenarios are compared in terms of their GHGs, costs, and public acceptance. The results indicate that Scenario 1 has the highest level of GHGs and the lowest cost, whereas Scenario 3 has the lowest GHGs and the highest cost. After taking public acceptance into account, Scenario 3 could be considered as the optimum system for MSW disposal.

However, there are still some limitations: (1) Uncertainty in systems boundary demarcations. The scenario design only considers the direct emissions of GHGs during the disposal stage, and indirect emissions during waste generation, collection, and transportation have not been included. (2) Uncertainty in the establishment of model parameters. For example, components of the landfilling waste and properties of the leachate may have impacts on GHGs. However, these factors have been omitted in this study. (3) Subjectivity in the weightings of GHGs, cost, and public acceptance. The emissions reduction target, level of economic development, and public awareness vary among different countries, which lead to differences in the weightings. The weightings used in this study serve only as a reference for the validation of the binary dominance matrix being used. Further studies are required to determine the method with which the weightings can be decided in a scientific manner according to varying conditions in different regions under the Belt and Road initiative.

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Author Contributions: Junhan Huang conducted the case study and proposed the scenario analysis. Rui Zhao was involved in conceptualizing the whole study and writing the whole study. Tao Huang collected the data. Xiaoqian Wang implemented the calculation process. Ming-Lang Tseng improved the whole structure of the study.

Conflicts of Interest: The authors declare no conflict of interest.

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