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Assessing Sustainable Municipal Solid Waste Management Factors for Johor-Bahru by Analytical Hierarchy Process

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Abstract: Management of solid waste involves collection, transportation, treatment and safe disposal to landfills. These activities create a lot of impacts to the environment and most of the time impose social and financial burden on authorities handling solid waste management as well as the community. Local authorities managing waste are confronted with problems, protests and resistance from the public because of difference of views and perceptions on impacts created by waste management plans. This paper assesses some environmental, social and economical impacts viewed by stakeholders in the city of Johor Bahru Malaysia. Analytical hierarchy process (AHP), a multi-criteria decision making analysis tool is used to evaluate the views of the stakeholders with the aid of super decision software. Stream ecology, flora and fauna, habitat depletion, land use and air quality are ranked higher for environmental factors/impacts. Public awareness health and safety, population size and cooperation from the public dominate the social factors. Regulation, landfill capacity, operation and maintenance cost and capital cost dominate economic factors/impacts. Four alternative disposal plans (landfilling, recycling, incineration, composting) were proposed and ranked according to the priorities of the stakeholders. Incineration and recycling were preferred to landfilling and composting disposal options.

Introduction

Solid waste generated in most developing countries are accompanied by harmful solid, liquid and air emissions to the environment as well as human health [1, 4]. This is due to inadequate provision of basic services such as sanitation facilities, transport infrastructure, waste collection and sanitary water supply [8]. The problem has made affected areas highly unsafe for habitation because of the effects of leachates and bad odours [3]. However, solid waste handling and management is a complex problem. The selection of treatment facilities requires the evaluation and integration of views and perceptions of all stakeholders (local authorities, communities, interest groups such as non-governmental organizations (NGOs) and international funding agencies [1. 6]. In the past, authorities and researchers decide on how best waste should be managed without involving stakeholders in the decision making process [1, 5, 6]. This led to objections and protests from affected communities. One of such a case is the protest against the installation of an incinerator in Selangor Malaysia [11]. To involve all stakeholders in the waste management decision making process, researchers have used various techniques or models [1, 12]. These models according to [12] are those based on multi-criteria decision making techniques such as analytical hierarchy process (AHP), those based on life cycle assessment (LCA and those based on cost benefit analysis (CBA). According to [1], "The most effective management of municipal solid waste has to relate to

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local environment, economic and social priorities". While LCA and CBA based techniques assess environmental and monetary aspects, AHP structure is designed in a way that environmental, social and economical aspects can be adequately accommodated [7]. However, a rank reversal is one of the main limitations of AHP although this depends on the mode of synthesis adopted. Recently this limitation is improved [14]. This paper assesses the views of stakeholders on the environmental social and economic impacts in selecting sustainable solid waste disposal plan for Johor Bahru. Analytical hierarchy process (AHP), one of the multi-criteria decision analysis (MCDA) concepts is therefore chosen to assess the perception of stakeholders on waste disposal plans proposed for the city. Studies show that AHP has the robustness to handle intangible such as preferences, likelihood, importance and interdependence of factors in which priorities are easily identified among views of stakeholders [13]. In addition, subjectivity in making judgments is controlled and decisions are reached through fair trade-offs and compromises for the benefits of all stakeholders.

Methodology

Data was obtained by the use of questionnaire (primary source). Agencies involved include three Municipalities of Johor Bahru, Pasir Gdang and Johor Bahru Tengah. Two more agencies were included in the questionnaire survey because of their direct role in solid waste control in the municipalities. These are Iskandar Malaysia Development Authority (IRDA) in charge of all infrastructural development and monitoring of generated solid waste; and Department of Environment Johor which regulate and supervises the environmental well being of main Johor city. Some of the impacts on solid waste disposal were identified through public opinion during meetings and interactions with the stakeholders. Other impacts used were obtained from literature [1, 5, 6, 8, 9, and 10]. These impacts/factors are structured according to AHP hierarchy methodology [7]. Here, the decision making inputs are discomposed into units and sub units, (goal, criteria, sub criteria and alternatives). Then these elements are pair-wise compared based on a 9 point weighting scale by Saaty in a matrix form. In each set of comparisons, there are n (n-1)/2 judgments [7]. Four alternatives are proposed to constitute the solid waste disposal alternatives (Fig. 1). Super decision software, (software for AHP computations) is used in computing the judgments of the stakeholders. The alternatives (landfilling, recycling, composting and incineration) are ranked according to the weights of the impacts. Priorities obtained from the weights of the stakeholder judgments are presented in Table 1. Fig. 1 shows the procedure of the assessment based on AHP structure: environmental impacts consist of noise, visibility, fauna and flora, stream ecology, air quality, land use, habitat deletion and vibration. Social impacts are public health and safety, traffic congestion, odour effects, population growth, housing type, employment, skills, cooperation and public awareness. Economic aspects are capital cost, operation & maintenance cost, recruitment & training cost, labour cost, income, bad debt, landfill capacity, regulation influence and incentives/disincentives.

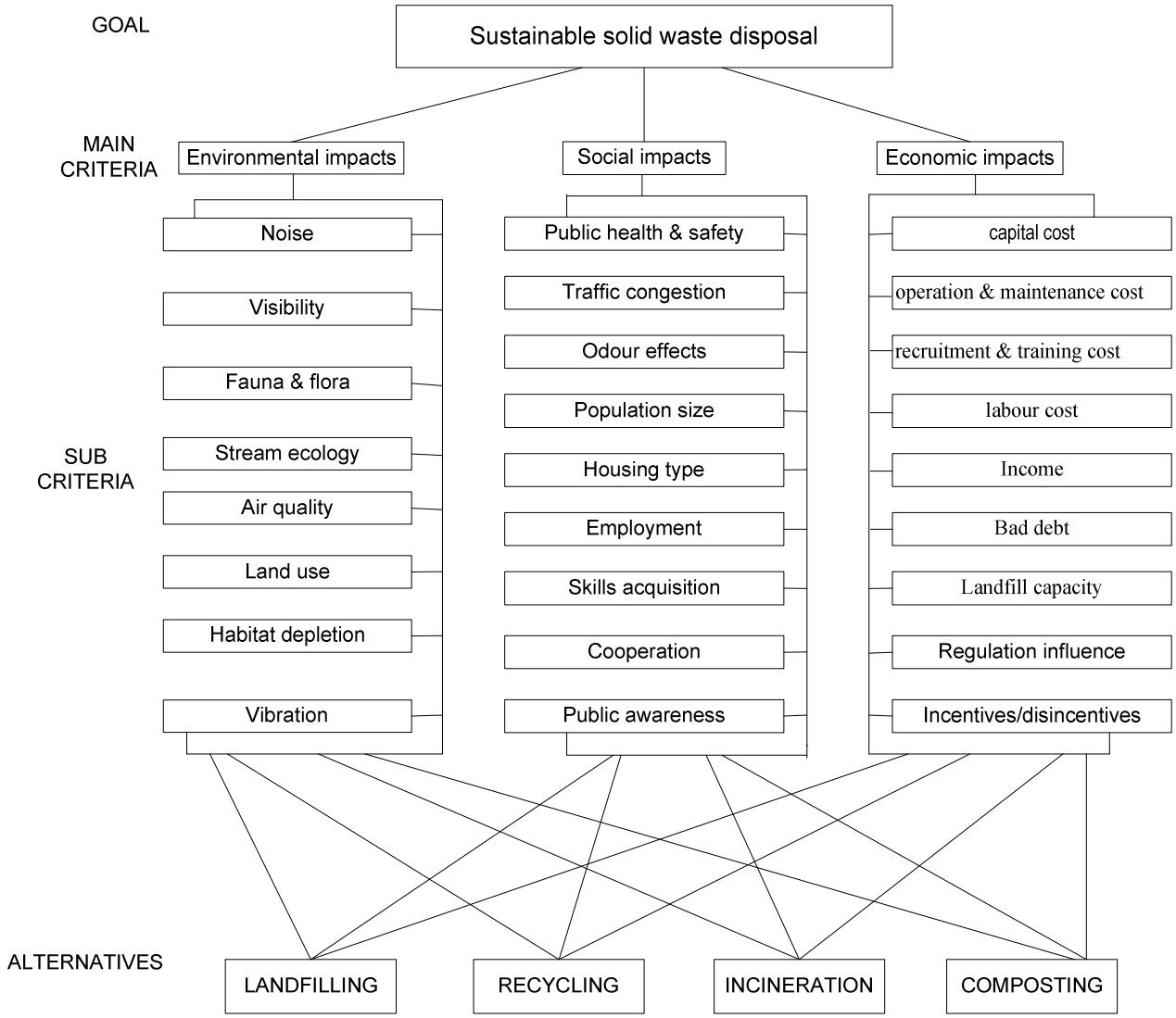


Fig. 1. Analytical hierarchy process of sustainable solid waste disposal plan for Johor Bahru

Discussion

Weighting of the stakeholder participation is obtained by aggregating the different weights associated to the management plans involving weights assigned by each stakeholder group to the treatment plans according to each criteria, the importance given to each criteria by each group of stakeholder and the share of each stakeholder group on the final decision process [1]. Table 1 shows impact categories assigned by the stakeholder groups. For environmental aspect, stream ecology, flora and fauna, habitat depletion, land use and air quality have greater influence than vibration, noise and visibility. This indicates that stakeholders have higher priorities in plants and animal species protection and preservation. Land affected by treatment plan is critical. For social factors, public awareness, public health and safety, cooperation and odour effects dominated traffic congestion, housing type and population growth (Table 1). The stakeholders pointed out the need educating the public on waste generation, life style, source separation, waste recycling and other benefits such as waste to energy benefits. In case of economic impacts, the need for implementing regulation on (waste generation, separation from source, monitoring and control of suitable disposal), cost of land for waste disposal, operation and maintenance of disposal plans, capital cost of investment, labour cost and recruitment and training cost to handle plants are dominant and considered most important. Bad debt, income and incentives/disincentives do not influence the views of the stakeholders much. This is likely because the government mostly appoints and supervises those individuals and bodies handling the wastes. For the ranking of the alternatives, incineration is ranked 1st, recycling 2nd, landfilling 3rd and finally composting 4th. Incineration and recycling are most preferred solid waste disposal plans (Table 2).

Table. 1. Priorities derived from the judgments of the stakeholders for the three groups of the criteria/impacts

Factors		Priorities
Environmental sub factors	A1Noise	0.03285
	A2 Visibility	0.05856
	A3 Fauna &Flora	0.18958
	A4 Stream Ecology	0.24621
	A5 Air Quality	0.10952
	A6 Land Use	0.16356
	A7 Habitat Depletion	0.17132
	A8 Vibration	0.02842
		1
Social sub factors	B1 Public Health & Safety	0.15611
	B2 Traffic Congestion	0.02975
	B3 Odour Effects	0.14489
	B4 Population size	0.09013
	B5 Housing Type	0.04975
	B6 Employment	0.08395
	B7 Skill Acquisition	0.10574
	B8 Cooperation	0.15124
	B9 Public Awareness	0.18845
		1
Economic sub factors	C1 Capital Cost	0.12121
	C2 Operation & Maintenance Cost	0.13327
	C3 Recruitment & Training Cost	0.08378
	C4 Labour Cost	0.11276
	C5 Income	0.07723
	C6 Bad Debt	0.04615
	C7 Landfill Capacity	0.16711
	C8 Regulation Influence	0.17831
	C9 Incentives/Disincentive	0.08019
		1

However, the utilization of the two or more plans requires a sanitary landfill for safe disposal of wastes and residues from the recycling and incineration plants. The preference of incineration over all options is informed by the recent development in the utilization of waste for energy. A typical ton of solid waste is reported to produce 525 kWh of electricity, ± 75 kWh [2]. However, the preference of more than one disposal option plan demonstrates the need for integrated approach to solving the problem of solid waste.

Table. 2. Synthesis of the model in ranking the alternatives

Alternatives	Priorities	Ranking
Landfilling	0.19751	3
Recycling	0.2604	2
Incinerating	0.35277	1
Composting	0.18932	4

Conclusion

Results for environmental impacts show that steam ecology, flora and fauna, habitat depletion, land use and air quality dominated the concerns of the stakeholders (Table 1). This shows a consciousness and worry on pollutions that are caused by leachates, wastewater, and emissions from automobiles and waste disposal facilities; as well as protection for natural habitats and biodiversity during the disposal of the solid waste. Educating the public on source separation of waste, waste reduction habits in (homes, schools and business centres) and recycling of the waste is seen to be significant. For economic factors, the need for implementing regulation on (waste generation, separation from source, monitoring and control of suitable disposal), cost of land for waste disposal, operation and maintenance of disposal plans, capital cost of investment, labour cost and recruitment and training cost to handle plants are dominant and considered most important. The synthesized results show that incineration and recycling are preferred followed by landfilling. Finally, this research has provided some tools of collective interaction and tradeoffs; and identified new feelings or concerns and attempted assessing them. It has also identified those social and economic impacts that affect stakeholders in decision making during the selection of an appropriate waste disposal option for Johor Bahru Malaysia.

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