DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR SITING OF HAZARDOUS WASTE DISPOSAL FACILITY IN MALAYSIA

Badriyah Zakaria*, Ramdzani Abdullah, Muhammad Firuz Ramli and Puziah Abd. Latiff

P.hD (GS19641)
5th Semester

i. Introduction

In the Ninth Malaysian Plan, more effort is taken on preventive measures to mitigate negative environmental effects at source, intensifying conservation efforts and sustainably managing natural resources (EPU, 2006, p 453). In keeping abreast with the socio-economic development, Malaysia has made its firm commitment in the issues related to environmental degradation especially in managing toxic and hazardous waste problems. This is proven in the Mid-Term Review of the Ninth Malaysian Plan, 2006-2010 of which the Environmental Quality Act 1974 (EQA 1974) was amended on 30th August 2007 to provide for mandatory jail sentence for illegal disposal of scheduled waste and to make the chief executive officer liable for the offence committed by the company.

No doubt hazardous wastes need to be disposed off in a secured manner in view of their characteristics such as toxicity, corrosivity, ignitability, reactivity and persistence. In Malaysia, hazardous waste is referred to as scheduled waste, a terminology used in EQA 1974 which covers a wide range of industrial waste that include not only hazardous and dangerous substances but also sludge generated by general manufacturing processes and wastewater treatment. The volume of scheduled wastes generated in Malaysia is increasing every year as industrial activity booms. Illegal dumping is an ongoing problem and incidents of illegal dumping make major news stories from time to time in the newspapers and other media. Scheduled waste management is given high priority in Malaysia's environmental programs and higher penalties are imposed if found guilty for illegal dumping activities.

The siting of hazardous waste disposal facilities is an important consideration in the context of hazardous waste management as it touches upon issues of economic efficiency, environmental soundness and social fairness. In fact, the siting of an increasing range of facilities, hazardous waste disposal facility in particular has become a major policy problem for all nations alike (Lesbirel and Shaw, 2007; Chang et al., 2006; Fredriksson, 1998). Whenever a facility for waste disposal either municipal solid wastes or hazardous wastes is being proposed, governments often encounter significant resistance and opposition towards the siting of such facility. Thus, a major principal of a site selection process is to assure that new facility is placed at intrinsically superior sites that by virtue of their natural features and land use setting will greatly safeguard public and the environment (Yesilnacar and Cetin, 2005; LaGrega, 2001). Review of the literatures indicated that site selection criteria should include environmental, social and economic considerations. Indeed for land disposal of hazardous waste, a number of criteria must be taken into considerations. However, early siting studies focus more on economic and environmental criteria for site selection. According to Lesbirel and Shaw (2007), the 1980s' literature review emphasized more on least-cost approaches to site selection. It cannot be denied that the political factors inherited in the siting decision of waste disposal facility for either municipal solid waste or hazardous waste. In general, landfill design, construction, maintenance and operation play a decisive role in the site selection of a hazardous waste disposal facility.

ii. Objective

The aim of the study is to develop a decision support system for siting hazardous waste disposal facility in Malaysia. The system should incorporate different kind of data sets, criteria of different weight values and accommodate the simulation of models in it. Thus to achieve this aim, several objectives are formulated as below:

1. To develop the criteria for siting hazardous waste disposal facility
2. To develop a prototype of decision support system to assist in preliminary siting of hazardous waste disposal facility
3. To determine candidate sites through simulation of models used in siting hazardous waste disposal facility

iii. Research Methodology

The methodology to be discussed here is merely related to the first objective. The focus of the study for this semester is to develop the criteria for siting a hazardous waste disposal facility in Malaysia. The Delphi method has been employed in this study to gather information on the site selection criteria for siting a fully integrated hazardous waste disposal in Malaysia. The Delphi technique aims to derive the benefit of the opinions of a group of experts while avoiding the disadvantages of "group think" and "group dynamics" where certain individuals dominate the discussion. The method consists of a structured series of repeated questions, usually in the form of a questionnaire, presented to the members of a group (Hatzichristos and Giaoutzi, 2006). Delphi surveys can be carried out by post, face to face, online or email and also through teleconferencing. For the purpose of this study, the survey will be conducted through emails which link to the specified website.

A two-round of Delphi survey will be employed in this study. All the emails correspondence of the selected experts in Malaysia are gathered in the database. The experts will be contacted either through phone calls or personal visits in order to get their consents for participation in the survey. This is to ensure that high rate of response from the target group. At a specified date, a set of questionnaire were emailed to each of the participant and a due date was given for the submission of a completed questionnaire. After a first round of survey, all the questions in the succeeding rounds are presented to each member of the group. This is the advantage of the Delphi survey whereby each of the members will get to know the results of the survey. The second round of the survey will be accompanied by information regarding the replies given by other participants, which remain anonymous. Each member of the group is therefore encouraged to re-consider his/her own views in the light of the replies given by other members in the group. The method provides the participants with the same opportunities to express their own views, thus avoiding errors inherent of group work. After two rounds of the surveys, the general view of the group is summarized as the average and not the majority of the expressed views.

The data obtained will be analysed using the SPSS software (also XLSTAT software) and the results are then presented in terms of mean rank for each category of Environmental (Hydrology and Hydro-geological Criteria), Economic and Social Factors. Those mean ranks are presented in descending orders for all criteria and sub-criteria.

iv. Result & Discussion

Kruskal-Wallis Tests are performed in order to produce mean ranks for all the variables under each categories based on its main criteria and sub-criteria. Those results are presented in the tables below for each category:

Table 1: Kruskal-Wallis Test for Hydrologic & Hydrogeological Criteria

HYDROLOGY & HYDROGEOLOGICAL CRITERIA	MEAN RANK
Surface Water	14.13
Envn Sensitive Land	14.13
Climate	12.50
Groundwater	12.50
Geology	12.50
Ecology & Biodiversity	9.25

HYDROLOGY & HYDROGEOLOGICAL SUBCRITERIA	MEAN RANK
Reservoirs	95.00
Wetlands/swamps	95.00
Infiltration	81.00
Flood prone areas & 100-yr floodplain	81.00
Drinking water supplies	81.00
Habitat for endangered species	81.00
Depth to groundwater	81.00
Groundwater flow velocity & direction	81.00
Recharge areas	81.00
Proximity to wells	81.00
Faults	74.00
Rainfall & precipitation	67.00
Public parks/ Forest reserves	67.00
Hydraulic conductivity	67.00
Groundwater quality	67.00
Conservation	67.00
Landslides	60.00
Sinkholes	60.00
Earthquakes (seismic activity)	53.00
Flora	53.00
Fauna	53.00
Habitat	53.00
Wind direction	46.00
Temperature	36.50
Underlying mines	32.25
Evaporation	29.50
Solution cavities	25.50
Depth to bedrock	22.50

Lithology	22.50
Karst areas	21.25

Table 2: Kruskal-Wallis Test for Engineering Criteria

ENGINEERING CRITERIA	MEAN RANK
Soils & Drainage	13.75
Physical site	13.00
Topography	11.63
Land Uses	11.63
Noise	2.50

ENGINEERING SUBCRITERIA	MEAN RANK
Residentials	36.00
River/stream	33.50
Soils formations	25.75
Artificial drainage	25.75
Zoning of activities	25.75
Slope	23.25
Development potential	23.25
Mining activities	17.38
Elevation	14.88
Industries	12.25
Agricultures	9.75

Table 3: Kruskal-Wallis Test for Economic Criteria

ECONOMIC CRITERIA	MEAN RANK
Road network &Transportation Corridor	14.50
Costs	14.50
Site Development	12.50
Utilities/Infrastructures	11.75
Logistics	11.75
Site	10.00

ECONOMIC SUBCRITERIA	MEAN RANK
Water	32.00
Electricity	32.00
Excavation	19.25
Grading	19.25
New roads	18.00
Proximity to major waste generators	29.38
Transport access	32.00
Availability of Utilities	19.25
Adjacent land uses & buffer zones	38.25
Investment	29.38
Operational costs	32.00
Acreage	25.75
Salvage value/benefit after closing	18.00

Table 4: Kruskal-Wallis Test for Social Criteria

SOCIAL CRITERIA	MEAN RANK
Risks/Potential Hazards	14.50
Population	12.13
Human Values	9.75
Heritage & Cultural Values	8.75
Land Acquisition	7.38

SOCIAL SUBCRITERIA	MEAN RANK
Proximity to residentials/dwellings	55.50
Proximity to public places	55.50
Toxic clouds	55.50
Fire & explosions	55.50
Environmental Health	48.88
Density	42.25
Public perception & participation	42.25
Individual Lands	32.00
Aesthetics	30.50
Cultural/Historical	26.88
State Lands	26.88
Landscape & Recreation	23.88
Archaeological	21.75
Architectural	18.75
Employment Opportunities	18.75
Visibility	18.75
Estate properties	13.00

v. Significance of Findings

Site selection is the most critical step in the entire decision making process of hazardous waste management. Thus, development of criteria that suit the Malaysian scenario is important to ensure site selection process has being carried out with the priority given to public health and the environment in particular. In addition, if public are well informed on the site selection, opposition and resistance can be minimized. This research will establish a reference for future investigation of site selection as well as provide useful feedback and inputs for site selection process. Results drawn will also give an insight of the effectiveness of the current procedure of the EIA pertaining to the site selection of the hazardous waste disposal management in Malaysia.

References

Fredriksson, P.G. (1998). The siting of hazardous waste facilities in Federal systems: The political economy of NIMBY. Environmental Resource Economics. 15: 75-87.

Hatzichristos, T., Giaoutzi, M. (2006). Landfill siting using GIS, fuzziy logic and the Delphi method. Int.J. Environmental Technology and Management, Vol.6, Nos. ½, 2006.

LeGrega, M.D. et al. (2001). Hazardous waste management. (2nd Ed.). McGraw-Hill International edition. McGraw-Hill series in water Resources and environmental engineering. Biological Science series. McGraw Hill Higher Education.. Singapore.

Lesbirel, S.H., D. Shaw. (2007). Facility Siting: Issues and Perspectives. Columbia Earthscape. An online resource on the global environment.

Yesilnacar, M.I., Cetin, H. (2005). Site selection for hazardous wastes: A case study from the GAP area, Turkey. Engineering Geology. 81:371-388.