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Improving the food waste composting facilities site selection for sustainable development using a hybrid modified MADM model

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ABSTRACT

With the growth of population and the development of urbanization, waste management has always been a critical global issue. Recently, more and more countries have found that food waste constitutes the majority of municipal waste, if they are disposed of properly, will bring more benefits in sustainable development. Regarding the issue of selecting and improving the location to make the disposal facility towards achieving the aspiration level for sustainable development, since it involves multiple and complicated interaction factors about environment, society, and economy which have to be considered properly in the decision-making process of mutual influence relationship. It is basically a multiple attribute decision making (MADM) issue, a difficult problem which has been obsessing the governments of many countries is widely studied and discussed. This study uses the new hybrid modified MADM model, as follows, first to build an influential network relation map (INRM) via DEMATEL technique, next to confirm the influential weightings via DANP (DEMATEL-based ANP), and then to construct a decision-making model via a hybrid modified VIKOR method to improve and select the location for remaining the best disposal facilities. Finally, an empirical case study is illustrated to demonstrate that the proposed model can be effective and useful. In finding the process of decision making, environmental pollution is the main concern of many people in the area, but actually it is the resistance by the general public that has to be considered with first priority.

1. Introduction

The quantity of waste being generated is increasing, even as the availability of land decreases (The World Bank, 2012; Demesouka et al., 2013). The council of the European Union announced in its Landfill Directive (Directive 31/99/EC) that the quantity of all organic substances taken to landfills must be reduced. Similar policy statements have also been issued elsewhere in the world, including Taiwan (Zhang and Matsuto, 2011; Swedish Government, 2012; Meyer-Kohlstock et al., 2013). It has been found that food waste makes up a considerable proportion of the total organic waste (FAO 2013; Eriksson et al., 2015; Schott and Cánovas, 2015). The high water content in food waste renders it susceptible to decay during collection, transport, and storage. This can lead to the emission of odorous compounds and have an adverse effect on the quality of leachate from landfill sites. It also introduces moisture and NaCl to the incineration process (Wang et al., 1999; Lee et al., 2007). Thus, many countries, such as Germany, Swiss, Korea, and Cuba, have adopted the policy of turning food waste into compost.

The Taiwanese government is planning to build 60 composting plants to accommodate the recovery and reuse of 2100 tons of food waste per day. It is expected that recyclable organic substance from municipal solid waste (MSW) could also be converted into compost. Compost is dark brown or black in appearance with a soil-like odor and stabilized compounds, which are useful in the control of plant disease and provide nutrients to stimulate plant growth.

Many previous papers in this field have focused on landfills and the means by which to select suitable locations for the disposal of hazardous waste or MSW (Adeli and Khorshiddoust, 2011; De Feo and De Gisi, 2014; Motlagh and Sayadi, 2015; Zavadskas et al., 2015). No previous study has focused on the optimal location for food waste sites, despite the importance of mitigating the

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problems specific to the disposal of organic materials (Eskandari et al., 2012).

Selecting sites for the final disposal of MSW plays a key role in the waste management lifecycle. Residents are prone to complaints of "Not In My Back Yard (NIMBY)", and selecting an inappropriate sites can greatly increase the costs of construction and operations. Most importantly, an inappropriate location can result in large-scale contamination in the surrounding environment.

In the process of selecting a disposal site, decision-makers must consider technological issues as well as the economic, environmental, and social consequences, many of which are mutually incompatible (Erkut and Newman, 1989).

Early works in this area focused on mathematical optimization models, to which was added the geographical information system (GIS) in the mid 1990s. At present, the most common tool is the quantitative Multiple Attribute Decision Making (MADM) model (Eiselt and Marianov, 2015; Soltani et al., 2015). Unfortunately, this model treats the various issues as discrete problems. In other words, it fails to account for the complex relationships among the various factors encountered in the real world.

Hybrid MADM models are widely used as decision support systems, particularly in areas requiring a balance among conflicting objectives at the environmental, economic, and societal levels (Zavadskas et al., 2016a,b). In this study, we applied the hybrid modified MADM model, referred to as the DEMATEL with DANP combining modified VIKOR model (DDANP-MV), to the problem of identifying the ideal location for food waste composting facilities.

The primary difficult in these decisions lies in the formulation of criteria by which to judge one location as better than another (Al-Jarrah and Abu-Qdais, 2006). For this proposal, we put together an expert team to build a hybrid modified MADM model. The DEMATEL technique was first used to identify influential relationships (interdependence) among the complex criteria in order to construct an influential network relation map (INRM). The DEMATEL-based Analytic Network Process (DANP) was then used to calculate the weights for each criterion. Finally, the modified VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR) method was used to evaluate preselected candidate locations for food-waste compost facilities.

The remainder of this article is organized as follows: Section 2 presents a review of the literature on establishing indicator frameworks. Section 3 describes the methodology of the DDANP-MV model. Section 4 presents a case study illustrating the use of the proposed model in selecting a site for a food-waste composting facility in Taiwan. Conclusions are drawn in Section 5.

2. Review on establishment of the indicator framework

Although many researchers have discussed the location of waste disposal facilities, there was no internationally recognized evaluation of public buildings. Different provisions/regulations have been made for the relevant bodies of different countries in the region. The issues covered by these provisions/regulations relating to social, cultural, technological, environmental, and geographical issues (Eskandari et al., 2012). This condition also made the choice of location decision complexity more prominent. One of the things that should be mentioned is that each type on regional waste disposal facilities all has its own particularity. Therefore, the special features of decision criteria should be put into consideration. There will be different decision criteria related to different countries or regions, even though they may be the same type of waste disposal facilities (Aragonés-Beltrán et al., 2010).

Therefore, we operated the assessment focusing on the evaluation criteria at this stage. The assessment focused on past experiences of researchers and decision-makers. The criteria proposed by different authors mainly included: technology, economy, environment, society, transportation cost (Khan and Faisal, 2008); natural factors (hydrogeology, geographical features and topography) and human factors (accessibilities, central cities, villages and land use); waste quantity and type of waste (Şener et al., 2006); assistant functions, freeways, the closest freeways, population, the demanded of new road contracture, influence, landscape, agricultural value, protection of natural habitat (distance) (Norese, 2006); economic (land, manpower and energy cost), basic facilities (usage of facilities, close to residential areas) and objectives of the law (Queiruga et al., 2008).

In this study, based on the review of the articles, who is in line with local conditions and regulations of the expert group conducted a questionnaire survey. As a result, a food waste composting facilities was proposed, consisting of 3 dimensions and 12 criteria as follows.

2.1. Environment dimension (A1)

The task of site selection for food waste composting facilities was complex, as different environmental, technical and regulatory issues must be properly considered, especially in environmental issues.

The selection of waste disposal facilities is the first issue related to the protection of natural resources and the environment. In fact, decision makers[1] and planners are increasingly focusing on regulating and following sustainable ways which different tactics can be integrated. This is helpful in selecting the most appropriate disposal facilities location.

2.1.1. B1 site topographic and geomorphic characteristic

Site topographic and geomorphic characteristic includes three parts: (1) upside, (2) inside, and (3) under the ground surface. When using the same way to utilize the land, the essential qualities of the land which like soil, hydrogeology, topography and climate, etc. It will determine which one is better than the other.

2.1.2. B2 Distance from residential areas

The study found that people are most concerned about the odor that is caused by the waste disposal facilities (Banar et al., 2010).

Therefore, many governments have the related criteria for regulatory indicators, which consider the distance between residential location of waste disposal facilities and residential areas with higher adaptability distance.

2.1.3. B3 Land use suitability

The land use problem is due to the limited amount of land. Therefore, it will focus on the optimal use of land and has a close relationship with land use planning. In the strategy of site selection, we should consider the land use conditions and related control regulations of the pre-selected location. Then select the appropriate locations to build the facilities.

2.1.4. B4 Distance from environmental sensitive areas

The difference in classification is not very large. Basically, the main purpose of classification is due to the environmental sensitive areas of human function. When the location of the waste treatment facility is selected, the preselected location in the environmentally sensitive area should be excluded.

[1] In here, the decision makers or planners are the main roles for evaluating the feasibility of waste disposal facilities, such as related government administration, or private developer.

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