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A comparison of the Analytic Hierarchy Process and the Analysis and Synthesis of Parameters under Information Deficiency method for assessing the sustainability of waste management scenarios

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A B S T R A C T

The selection of an appropriate Multi-Criteria Decision Analysis method or a combination thereof, is essential to support sustainability decision-making in the waste management sector. None of the methods is ideal, so that sometimes a combination of methods may be necessary. The aim of this study is to examine the ability the Analysis and Synthesis of Parameters under Information Deficiency method to be used in sustainable waste management, as never been used method in this sector. In order to do this, scenario ranking is done using the Analytic Hierarchy Process, and the results are compared with results obtained by the Analysis and Synthesis of Parameters under Information Deficiency method. Four waste treatment scenarios were developed based on the waste composition in city of Niš, and nine indicators were selected. The obtained results indicate that there is no significant difference in the scenario ranking, regardless of the method used, the Analytic Hierarchy Process or the Analysis and Synthesis of Parameters under Information Deficiency method. The best sustainable waste management scenario is the scenario which involves composting of organic waste and recycling of inorganic waste (39.3% ranking priority). This study has illustrated how the Analysis and Synthesis of Parameters under Information Deficiency method, that has a capability to work with a lack of information, which is often the case in waste management, can be applied to assessment sustainability of waste management scenario.

1. Introduction

The Multi-Criteria Decision Analysis (MCDA) is a commonly used method for assessing the sustainability of waste management. Environmental, economic and social sustainable development indicators are partially or completely conflicting and by nature very diverse and expressed in different units, probability or subjective evaluations. The benefit of the Multi-Criteria Decision Analysis in assessing a sustainable waste treatment scenario is that it allows the use of both qualitative and quantitative criteria, which can address different aspects of sustainable development indicators. It also allows the participation of different groups of decision-makers even with opposing goals in defining indicators and decision-making.

A decision-making problem involves alternatives, criteria, criteria weights and result evaluation (Wang et al., 2009). The

Abbreviations: AHP, Analytic Hierarchy Process; ANP, Analytical Network Process; ASPID, Analysis and Synthesis of Parameters under Information Deficiency; ELECTRE, Elimination and Choice Translating Reality; EVAMIX, Evaluation matrix; GAIA, Geometrical Analysis for Interactive Aid; GP, Goal Programming; HANP, Hierarchical Analytical Network Process; LCA, Life cycle assessment; MADA, Multi-Attribute Decision Analysis; MAUT, Multi-Attribute Utility Theory; MAVT, Multi-Attribute Value Theory; MCDA, Multi-Criteria Decision Analysis; MELCHIOR, Methode d'ELimination te de Choix Incluant les relation d'ORdre; MGI, Method of General Index; MOP, Multi-Objective Mathematical Programming; ORESTE, Organization, Rangement Et Synthese De Donnes Relationnelles; PROMETHEE, Preference Ranking Organization Method for Enrichment Evaluation; SMART, Simple Multi-Attribute Rating Technique; TOPSIS, Technique for Order Preference by Similarity to Ideal Solution; UTA, UTility Additive.

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corresponding decision-making process usually includes four main stages: alternatives formulation and criteria selection, criteria weighting, evaluation, and final treatment and aggregation. The preliminary step in MCDA is to formulate alternatives for a decision-making problem from a set of selected criteria and to normalize the original data of criteria. Secondly, criteria weights are determined to show the relative importance of criteria in MCDA. Then, acceptable alternatives are ranked by MCDA methods with criteria weights. Finally, the ranking of alternatives is ordered. If all ranking orders of alternatives in different MCDA methods are the same, the decision-making process ends (Wang et al., 2009).

1.1. Classification of multi-criteria decision making (MCDM) methods

Nowadays, there are plenty of different MCDA methods. Generally, they differ in type of decision criteria, type and number of alternatives, approach to compensation among decision criteria, and preference ordering (Azapagic and Perdan, 2005). Given the large number of different MCDA methods, the choice of an appropriate method is not an easy task. The choice of the method depends on the problem, the criteria used for assessing the sustainability (number and type of criteria, methods for criteria selection), possible alternatives (if any finite or infinite number), and on how the decision is made (individual or group decision-makers).

Different classifications of MCDA methodology can be found in the literature. One of the most extended classification approaches first differentiates between Multiple-Objective Decision-Making (MODM) methods working with an indefinite set of possible alternatives, and Multiple-Attribute Decision-Making (MADM) methods, suggesting a finite set of alternatives (Herva and Roca, 2013b). The same classification was done by Pohekar and Ramachandran (2004) in reviewing the application of MCDA methods to sustainable energy planning. Other authors have produced detailed classifications as shown in Table 1. Azapagic and Perdan (2005) classified the MCDA techniques into two main groups. The first group comprises programming methods, and the second group contains Multi-Attribute Decision Analyses (MADA) methods with elementary, value-based and outranking approaches. Wang et al. (2009) divided MCDA methods into three categories: elementary methods, unique synthesizing criteria methods and outranking methods. Ibáñez-Forés et al. (2014) created a more detailed classification and divided the MCDM methodologies into eight categories (Table 1).

Regardless of different classifications, all of the authors classified the following in the category for outranking methods: Elimination and Choice Translating Reality (ELECTRE) method and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) method. Also, all authors classified Multi-Attribute Utility Theory (MAUT), Multi-Attribute Value Theory (MAVT), and Analytic Hierarchy Process (AHP) in the same category, but with different name (Value-based methods or Unique synthesizing criteria or Multi-Attribute Utility and Value). Both Wang et al. (2009) and Azapagic and Perdan (2005) made similar classifications with elementary, outranking and Value-based i.e. Unique synthesizing criteria methods. Also, these authors classified Technique for Order of Preference by Similarity to Ideal Solution method (TOPSIS) in the same group with MAUT, MAVT and AHP method. A more detailed classification is provided by Ibáñez-Forés et al. (2014) as shown in Table 1, but it can be concluded that they classified the

Table 1
Classification of MCDA methods.

Azapagic and Perdan (2005)			Wang et al. (2009)		Ibáñez-Forés et al. (2014)	
Categories		MCDA methods	Categories	MCDA methods	Categories	MCDA methods
Programming methods		Multi-Objective Optimization Goal Programming			Multi-Objective Mathematical Programming	Constrain Programming Goal Programming Linear Programming
Multi-attribute decision analysis	Elementary	Lexicographic Conjunctive Disjunctive Maximin/Maximax	Elementary	Lexicographic Dominance Conjunctive Disjunctive Maximin/Maximax Elimination by aspects Linear assignment Weighted additive	Elementary aggregation methods	Weighted product
	Value-based methods	Weighted sum TOPSIS	Unique synthesizing criteria	Weighted product TOPSIS Grey relational analysis Data envelopment analysis	Distance-to-target approach	Weighted sum TOPSIS Grey Relational Analysis Data Envelopment Analysis
		MAVT MAUT AHP SMART UTA		MAVT MAUT AHP SMART UTA	Multi-Attribute Utility and Value Theories	MAVT MAUT AHP/ANP
		EVAMIX		Fuzzy weighted sum Fuzzy maximum	Non-classical methods Complex aggregation methods	Fuzzy set methodologies ASPID Own mathematical formulae
	Outranking methods	ELECTE PROMETHEE ORESTE MELCHIOR REGIME	Outranking methods	ELECTRE PROMETHEE ORESTRE	Outranking methods	ELECTRE PROMETHEE
					Direct ranking	Stepwise expert judgment Delphi Scoring Method