MCDA help decision tool for the implementation of food waste valorisation alternatives: animal feed as case study

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Introduction

Up to one third of food is spoiled before it is consumed by people (Gustavsson, 2016). In spite of having a high potential to be reused in other productive processes, a low percentage of this food wastage is valorised. It involves negative social, economic and environmental impacts because of the natural resources used to produce food that no one consumes (FAO, 2016).

Food waste valorisation for the animal feed alternative depends on a high number of key factors. Thus, the great risk of underestimating any of these factors could make its full scale implementation technically unfeasible, economically unprofitable or environmentally unsustainable. Moreover, the geographical dispersion characteristic of food waste production requires optimizing the logistics routes for centralizing food wastes in the appropriate sitting for the treatment plant.

Life GISWASTE project (www.lifegiswaste.eu) has developed a Multi-Criteria Decision Analysis (MCDA) tool to help waste managers in the decision making at the time of implementing a full scale food waste valorisation strategy.

Material and methods

The multi-dimensionality and the complexity of a food waste management strategy implementation involve the necessity of using the MCDA methodology. **Analytical Hierarchy Process (AHP)** was selected as the most suitable MCDA method to simulate the feasibility of food waste valorisation strategies (Kim, 2013) (Luthra, 2016). It allows to assess simultaneously a number of possible choices and to partition the problem focusing on smaller decision sets one at the time (Vasiljević, 2011) (Saaty, 1980) (Bordas, 2006). In addition, **ArcGIS software** was selected for geographical assessment.

The decision-making process was divided into four categories: technical, geographical, economic and environmental, and decision matrices and rules were performed for each category. The relative weights of each decision-making criterion were integrated to assess the total ranks of the different scenarios. Then, each key factor at the given level was multiplied with its weight and the weighted performances were summed to get the score at a higher level. The procedure was repeated upward for each hierarchy, until the top of the hierarchy was reached and the overall weights with respect to goal for each decision alternative were then obtained. Finally, a decision matrix was made based on bibliography and the knowledge and experience of many experts.

The alternative with the highest score was considered the best alternative.

Results and discussion

The scenario selected to assess food waste valorisation for the animal feed alternative was the Basque Country region (north of Spain). The food wastes considered were vegetable wastes from processing industries and retail trade sector: fruit/vegetables, potatoes, apple pressing, grape pressing/grapes, bread and coffee husks.

After defining the raw scenario aim of study, the first step was the **Technical screening** of suitability of the food waste generators. For this screening, two exclusion criteria were taken into account: minimum required volumes for collection and maximum levels of undesirable substances. In this case, the food waste sources that generate less than 500 kg per month and/or exceed the maximum levels allowed by legislation were considered unsuitable for the animal feed alternative and they were directly ruled out. The performed net scenario includes a total amount of 25,820 tons of vegetable food waste.

Once the net scenario was performed, ruling out unsuitable generation points, the second step was the **Technical assessment** based on the scoring of each generation point (each technical key factor for each generation point was scaled from 1 to 10). The final score of each generation point was calculated by summing up the scoring of each technical key factor. Therefore, the technical feasibility of valorising vegetable food waste for the animal feed alternative in Basque Country region was scored as technical feasible.

After the technical assessment, the third step was the **Geographical assessment**. The siting of the animal feed production plant was performed based on the following criteria: i) Land for industrial use; ii) Distance to main roads; iii) Geographical dispersion; iv) Annual food waste generation; v) Seasonality linked to each type of food waste; and vi) total distance travelled by trucks. The most suitable sitting point for the animal feed plant was selected based on the location-allocation model in GIS (Zelenović, 2012). Once selected the sitting point for the treatment plant, the logistic routes between the food waste sources and animal feed plant location were calculated.

The fourth step was the **Economic assessment** which was performed assuming that identified animal feed plant would treat 25,820 tons of food waste. Therefore, vegetable food waste for the animal feed alternative in Basque Country scenario results as economically profitable based on the assessment of the annual Cost Income Ratio and some financial indicators performed with GISWASTE tool.

Finally, the fifths step was the **Environmental assessment** in order to determine the carbon footprint and water footprint of the vegetable food waste valorisation for the animal feed alternative. The drying process is the aspect with the greatest environmental impact. Thus, this stage is responsible for more than 80 % of the potential impact on climate change. The transportation and homogenisation processes have the second and third highest environmental impacts.

Conclusions

MCDA methodology, and specifically AHP method, is a powerful methodology for helping making decisions in waste management.

The use of this MCDA tool allows excluding in a preliminary screening food waste generators that do not achieve the minimum values stablished for the technical feasibility.

Moreover, public or private waste managers can simulate the technical feasibility, economic profitability and environmental sustainability of a defined scenario, as well as solve planning and logistics problems such as the location of a waste valorisation facility and the routes to centralizing food waste in this plant.

Finally, it will reduce the risk associated with the implementation of a food waste valorisation plant, minimising at the same time the environmental footprint and costs related to the traditional procedure.

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