ISSN 2250-3153

Group Decision Making For Safe Disposal of Commercial Fish Waste

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Abstract:
The present study primarily concentrates on the waste generated by the fisheries sector and its effect on the human health and environment. Fish wastages attract pathogens, create bad odor, general aesthetic degradation, contamination of water resources and other hazards. Therefore decision makers move for some alternative methods of disposing commercial fish wastages. Fuzzy mathematical modeling plays an important role in decision making techniques. In this paper we use fuzzy multi criteria group decision making method VIKOR to help the municipal authorities to choose the right alternative method for the safe disposal of commercial fish waste.

Key words: Fish Waste, alternative, criteria, VIKOR, Fuzzy MCDM, Nagapattinam

Introduction:

The word waste means that the substance of concern has no apparent value. The hazard or noxious of the waste determines how a waste should be managed The bio degradable waste includes all plants, animal, human products, the kitchen waste at every home, restaurants, agricultural farms, industries, vegetable markets etc., In coastal area fish waste is the main bio degradable waste which mainly contains organic matters. Traditional composting methods are essentially a biological recycling technology which is being revised and improved with new knowledge of environmental biotechnology. The disposal of these huge quantities of fish waste can create larger negative impact on environment. Therefore alternative methods, ecologically acceptable methods of disposal or reutilization of fish waste has to suggested and followed. The aspects of the problems are usually represented in the form of multiple criteria which often creates confusion among the decision makers. In order to raise awareness between the objectives and compare the difference among the alternatives in an optimizing framework, fish waste management decision making may depend on multiple criteria decision making (MCDM) models which promotes participation of all decision makers and synthesis of a wide variety of information. The components involve both quantitative and qualitative factors.

Review of literature:

MADM problem can be associated with a problem of choice or ranking of the existing alternatives (Zimmermann, 1987) (1). Bellman and Zadeh (1970) introduced the approach regarding decision making in a fuzzy environment (2). Baas and Kwakernaak (1977) applied the most classic work on the fuzzy MADM method and it was used as a benchmark for other similar fuzzy decision models (3). Fan et al. (2002) proposed a new approach to solve the MADM problem (4), where the decision makers were instructed to give his/her preference on alternatives in a fuzzy relation. A systematic and consistent decision making approach to dredging and disposal including contaminated sediment management have been developed in Ref. 5. A multi-objective integer programming approach to select hazardous waste treatment and disposal facilities, and transportation routes have been employed in Ref. 6 Radioactive waste attracts a special consideration in hazardous waste literature. In this research stream, Ref. 7 proposed a decision support system for the identification of optimal remedial strategies to restore water systems after accidental introduction of radioactive substances. Ref. 8 used this decision support system in their study searching for optimum remedial strategies for contaminated lakes. One can deduce from Ref. 9 the use of multicriteria decision analysis with an outranking methodology. A review of existing decision-making approaches at hazardous waste management regulatory agencies in the United States and Europe is presented in Ref.10. The hazards of contaminated dredged material disposal and the associated risks and costs which are highly uncertain have been incorporated in the decision analysis using fuzzy set theory in ref 11. A crisp and a fuzzy approach which are applied in dam safety and nuclear industries for risk-based decision analysis are investigated in Ref. 12. One can infer from Ref. 13 the use of the approaches investigated in their former paper for the management of contaminated ground water resources problem. VIKOR initiated by Ref.14, of which the compromise solution should have a maximum group utility (majority rule) and minimum individual regret of the opponent, is proposed to deal with multicriteria decision-making problems. A fuzzy approach has been applied to classical VIKOR to capture the imprecision in the evaluations of the decision makers. The use of fuzzy VIKOR is summarized (15, 16). Various defuzzification strategies have been suggested in the literature. Here we have chosen to use the graded mean integration approach (17).have proposed a fuzzy VIKOR multicriteria decision analysis for the selection of the most appropriate hazardous waste treatment methodology (18). Then, an application was presented to show the potential of the proposed methodology for the case of Istanbul. Chitrasen Samantra,andProf. Saurav Datta used fuzzy VIKOR in selecting the supplier (19).Decision-Making In Fuzzy Environment VIKOR stands for 'VlseKriterijumska Optimizacija I Kompromisno Resenje', means multi-criteria optimization and compromise solution was developed by Opricovic in late 1998 (Opricovic and Tzeng, 2004). (20) VIKOR method is popularly known as multi-criteria decision making method based on ideal point technique (Opricovic and Tzeng, 2007) (21). the positive-ideal solutions (best) value and negative-ideal solutions(worst) value for all criterion ratings (Wu and Liu, 2011; Kannan et al., 2009) (22).Select the best alternative in VIKOR by choosing Q(A(m)) as a best compromise solution with minimum value of Q and must have to satisfy with the conditions (Park et al., 2011) (23)

Objective and methodology:

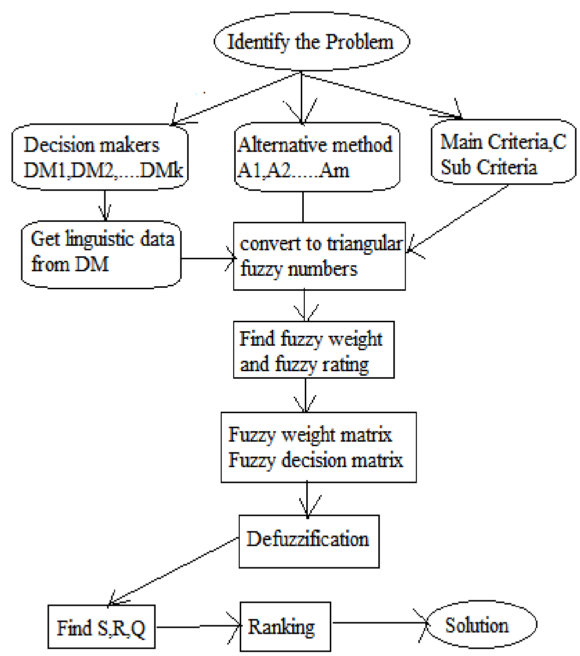
The objective is to help decision makers to choose the appropriate method for safe disposal of fish wastages using MCDM and fuzzy VIKOR method using linguistic data from the decision makers.

The alternative methods proposed to dispose/reutilize the commercial fish waste are as following:

1. Ocean disposal: 2. Landfill disposal: 3. Land application: 4. Processing for reutilization:

Justification:

Safe disposal of fish waste is an important task in managing the municipal solid waste. Managing this huge waste is a daunting task and disposing them at the dumping yards will have an adverse effect on the environment. Selection of best method enhances the environment and human health. Decision makers need mathematical modeling for making their decisions to optimize the offsetting of the waste and increase the benefits. Therefore the proposed model for group decision makers has been used to evaluate and select the most suitable method for this area for safe disposal of commercial fish waste.



Case study in Nagapattinam area:

The present work focuses on the fish waste generated in the Nagapattinam town, South India and its practical disposal or reutilization. The average fish waste generated during fish dressing in each stall is approximately 600 Kg per day and more than 600 Kg on Sundays (personal communication from stall owners). Thus the market generates 18 tons/month and 200 tons/year approximately. Therefore managing this huge waste is a daunting task. Hence the decision makers in the municipality office need to go for disposing methods

for safe disposal of fish waste. There are four alternative methods
A1: Ocean Disposal;
A2: Landfill Disposal;
A3: Land application;
A4: Processing for reutilization
Three main criteria were identified and they are as follows:
MC1: Minimize Economic cost
MC2: Minimize Risk factors
MC3: Maximize technical aspects
And sub criteria under MC1 are C1 to C3, sub criteria under MC2 are C4 to C6 and for MC3 sub criteria are C7 to C9
C1: Capital Cost C2: Maintenance Cost;
C3: Labor Cost C4: Human health risk;
C5: Transportation risk ; C6: Ecological risk;
C7: Offsetting Waste; C8: Economic Benefits;
C9: Endurance
Decision makers have used five linguistic variables for rating alternative methods and also for rating criterions. Table 1 below shows the weights of linguistic variables Table 2 shown below represents the linguistic variables for ratings

Linguistic variables for weights	
Very low	(0,0,0.25)
Low	(0,0.25,0.50)
Medium	(0.25,0.50,0.75)
High	(0.50,0.75,1)
Very high	(0.75,1,1)

Linguistic variables for ratings	
Very poor	(0,0,0.25)
Poor	(0,0.25,0.50)
Fair	(0.25,0.50,0.75)
Good	(0.50,0.75,1)
Very good	(0.75,1,1)

Next, the calculated fuzzy numbers of importance weight for each criterion by three decision makers is represented in the table 3.

	DM1	DM2	DM3
C1	**(0.75,1,1)**	**(0.75,1,1)**	**(0.75,1,1)**
C2	(0.5,0.75,1)	(0.25,0.5, 0.75)	(0.5,0.75,1)
C3	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)
C4	(0.25,0.5, 0.75)	(0.25,0.5, 0.75)	(0.5,0.75,1)
C5	(0.25,0.5, 0.75)	(0.5,0.75,1)	(0.5,0.75,1)
C6	(0.25,0.5, 0.75)	(0.75,1,1)	(0.5,0.75,1)
C7	(0.5,0.75,1)	(0.5,0.75,1)	(0.25,0.5, 0.75)
C8	(0.75,1,1)	(0.25,0.5, 0.75)	(0.5,0.75,1)
C9	(0.25,0.5, 0.75)	(0.5,0.75,1)	(0.25,0.5, 0.75)

Table 3: Importance weight of Criteria in terms of fuzzy numbers

Next, the rating of alternative method with respect to decision makers is shown

Fuzzy value for Alternative 1- Ocean Disposal:

DM	C1	C2	C3	C4	C5	C6	C7	C8	C9
DM1	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0,0,0.25)	(0,0.25,0.5)	(0.75,1,1)	(0,0.25,0.5)	(0.5,0.75,1)
DM2	(0.25,0.5,0.75)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0.25,0.5)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0.25,0.5)	(0.5,0.75,1)
DM3	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)	(0,0,0.25)	(0.25,0.5,0.75)	(0.75,1,1)	(0.25,0.5,0.75)	(0.5,0.75,1)

Fuzzy value for Alternative 2 – Landfil Disposal:

	C1	C2	C3	C4	C5	C6	C7	C8	C9
DM1	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0,0.25,0.5)	(0.25,0.5,0.75)	(0,0.25,0.5)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)
DM2	(0.5,0.75,1)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0.25,0.5)	(0.5,0.75,1)
DM3	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0.25,0.5,0.75)	(0.25,0.5,0.75)

Fuzzy value for Alternative 3- land application:

	C1	C2	C3	C4	C5	C6	C7	C8	C9
D	(0.7	(0.5,	(0.	(0.	(0.2	(0.	(0.	(0.	(0.

M 1	5,1,1)	0.75, 1)	5,0.75,1)	5,0.75,1)	5,0.5,0.75)	75, 1,1)	5,0.75,1)	5,0.75,1)	5,0.75,1)
DM 2	(0.5, 0.75, 1)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5, 0.75, 1)	(0.5,0.75,1)	(0.75, 1,1)	(0.75, 1,1)	(0.5,0.75,1)
DM 3	(0.5, 0.75, 1)	(0.25,0.5,0.75)	(0.75, 1,1)	(0.5,0.75,1)	(0.75,1,1)	(0.25, 0.5,0.75)	(0.5,0.75,1)	(0.75, 1,1)	(0.75, 1,1)

Fuzzy value for Alternative 4- Processing for reutilization:

	C1	C2	C3	C4	C5	C6	C7	C8	C9
DM 1	(0.75,1, 1)	(0.5,0.75,1)	(0.5, 0.75,1)	(0.75,1, 1)	(0.5, 0.75,1)	(0.75,1, 1)	(0.5, 0.75,1)	(0.75,1, 1)	(0.5, 0.75,1)
DM 2	(0.75,1, 1)	(0.25, 0.5,0.75)	(0.5, 0.75,1)	(0.5, 0.75,1)	(0.5, 0.75,1)	(0.75,1, 1)	(0.5, 0.75,1)	(0.75,1, 1)	(0.75,1, 1)
DM 3	(0.5, 0.75,1)	(0.5,0.75,1)	(0.75,1, 1)	(0.75,1, 1)	(0.5, 0.75,1)	(0.5, 0.75,1)	(0.75,1, 1)	(0.75,1, 1)	(0.75,1, 1)

Table 4: Rating of each alternative method under each criterion in terms of fuzzy numbers

Next, the cumulative fuzzy weight of each criterion and cumulative fuzzy ratings of each criterion with respect to the alternatives is calculated and fuzzy decision matrix and fuzzy weight matrix is formed.

The fuzzy decision matrix and fuzzy weight matrix is calculated and the corresponding crisp values are shown in table 5

Crisp values of Decision matrix and weight matrix of each criterion are presented in table 5.

		C1	C2	C3	C4	C5	C6	C7	C8	C9
$\widetilde{w}$		0.96	0.67	0.82	0.58	0.7	0.75	0.67	0.74	0.58
$\widetilde{D}$	A1	0.74	0.82	0.89	0.75	0.11	0.33	0.89	0.33	0.75
	A2	0.67	0.58	0.50	0.42	0.50	0.42	0.67	0.42	0.58
	A3	0.82	0.61	0.82	0.75	0.74	0.74	0.82	0.89	0.82
	A4	0.89	0.67	0.82	0.89	0.75	0.89	0.82	0.96	0.89

Table 5: Crisp Values of fuzzy decision matrix

Using the best and worst values find the value of S,R and Q

Compute the values of S_i and R_i (i=1,2…,m) by using the relation

$$S_i = \sum_{j=1}^{n} W_j \ (f_j^* - f_{ij})/(f_j^* - f_j^-)$$

Here i=1,2…,4 and j=1,2,…,9 since we suggest four alternative method and nine criterions.

$$Compute\ R_i\ using, R_i = \max[w_j\ (f_j^* - f_{ij})/(f_j^* - f_j^-)], j = 1,2,\dots,n$$

$R_1 = 0.75, R_2 = 0.96, R_3 = 0.59, R_4 = 0.42$

Compute the values of Q_i for i=1,2..,m using S_i and R_i

$$Q_i = \frac{v(S_i - S^*)}{S^- - S^*} + \frac{(1-v)(R_i - R^*)}{(R^- - R^*}$$

From the values of S and R, we get

$S^* = \min S_i = 1.01; S^- = \max S_i = 5.82; R^* = \min R_i = 0.42; R^- = \max R_i = 0.96$

$Q_1 = 0.55, Q_2 = 1, Q_3 = 0.26, Q_4 = 0$

The values of S, R and q are presented on the table 6.

	A1	A2	A3	A4
S	3.35	5.82	2.01	1.01
R	0.75	0.96	0.59	0.42
Q	0.55	1	0.26	0

Table 6: Values of S, R and Q

Ranking the alternative methods by sorting each S,R and Q in ascending order is shown in the table 7

RANK	1	2	3	4
By S	A4	A3	A1	A2
By R	A4	A3	A1	A2
By Q	A4	A2	A3	A1

Table 7: Rank of alternative methods

Conclusion:

Managing this huge waste is a daunting task and disposing them at the dumping yards will have an adverse effect on the environment. Hence the decision makers in the municipality office need to go for disposing methods for safe disposal of fish waste. Four alternative methods were considered for this study, Ocean Disposal, Landfill Disposal, Land application, Processing for reutilization. Three main criteria, Minimize Economic cost, Minimize Risk factors, Maximize technical aspects were identified and nine sub criterions were also considered. Linguistic variables are converted to fuzzy numbers and Multi Criteria Group Decision Making by VIKOR method is followed and it is concluded that the alternative method A4 is preferred by the decision makers as it is best ranked by Q. It is clear that A4 is best ranked by both S and R. A4 is said to be optimal compromise solution since it satisfied the necessary conditions.A4 is said to be a stable alternative since it is best ranked by both S and R. Therefore the fourth alternative method, Processing for Reutilization is preferred by all the three decision makers.

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