Utilization of analytic hierarchy process (AHP) to meet management objectives in fishery industry of the Sea of Oman

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Abstract

This article examines the use of analytic hierarchy process (AHP) to choose a priority for different purposes which have been used in fishery optimal management in the Sea of Oman. There are several stakeholder groups in the multi-objective planning methods. In this study, the AHP is used to determine the preferences (weight) of stakeholder groups for each of the objectives in the fisheries industry. This method is a multicriteria analysis system which is suitable for including the inconsistent opinion of different groups involved in the management. Based on the results, biological targets received higher weights compared to other targets with regard to stakeholder groups. Especially, the minimization of by catch was found to be the most important objective.

Keywords: Multi-objective, Management, Preferences, Analytic hierarchy process, Fishery stakeholders, Gulf of Oman

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Introduction

Multi-Objective decision analysis is a popular management tool which is used in various economic sectors Rodgers and Hunter (1991) around the world. Its aim is achieving various goals in different sectors such as fisheries management process including economic, biological, environmental, and political objectives (Pascoe *et al*., 2013).

Although fisheries management simply make up a portion of the management, numerous indexes have been suggested for its assessment. Several properties such as decline in the harvest of fish resources show that fisheries resources is not sustainable (Kjaersgaard, 2004).

Some general indicators such as virtual disappearance of certain important species and continuous reduction in the size of harvested fish show that the fishery is not being exploited on a sustainable basis (Koeshendrajana and Cacho, 2001). In order to achieve a sustainable and responsible exploitation, the design of management policies is required (Merrit and Criddle, 1993).

Optimum management policies have been designed using multi-objective techniques (Mathiesen, 1981). The goal programming (GP) model is planned to show how GP can be applied to help solve fishery management and the associated activities with various objectives. The method allows us to find the optimal result based on the weight of the goals in a decision-making process. The analytical hierarchy process (AHP) is used to assess stakeholder preferences towards the management options (Saaty, 1980).

There are important issues such as multi-objectivity of fishery management, lack of definitions for each objective and their weights for Iranian South Coasts that should be considered and tested which are important reasons for doing this research (Leung *et al*., 1978).

There are many groups of stakeholders in fishery management that have different views on rating and nature of objectives (Nielsen and Mathiesen, 2002).

Several multi-objective decision-making attempts have specifically defined objectives for fisheries management policy at the same time (Mardle *et al*, 2004).

One of these techniques that are designed to help the management is a multi-objective programming model. Each of the goals in this model has different weight (priority) based on the opinions of various stakeholders computed using AHP. In this planning model, each group is called stakeholder in the fishing industry (Hetherihgton, 1986). As described in the previous section, a part of the description of stakeholders is designed to review the role they have in the fisheries management process. This is an important first stage for evaluating the importance of each stakeholder within the process. This relates to a component of the modeling stage, where the preferences attained for each group may be aggregated into a set of overall objective preferences for a given case study. This analysis can provide a best compromise solution for comparative trade-off examination, but more importantly explicitly defines the role of stakeholders (Mardle and Pascoe, 1999). The objective of this study is to develop the methodologies and the associated

requirements for elicitation of interest group preferences. The method proposed to fulfil this is based principally on a thorough review considering methods and techniques that can be applied to develop interest group preferences for key criteria, i.e. degrees of importance (measured in terms of weights) of the criteria (Mardle and Pascoe, 1999).

In the fishing industry, the agreement of all interest groups on different objectives is essential to successfully program management **(**Mardle and Pascoe, 2002). In this study, an attempt has been made to evaluate the consequences of stakeholder actions in a special program on fisheries management where this range of stakeholders converge. The Analytic Hierarchy Process (Saaty, 1977) offers a model for stakeholder objectives preferences in such a system. However, there are several methods for analyzing different stakeholder preferences inside the management arrangement (Mardle and Pascoe, 2002).

It is obvious that stakeholder interests in the fisheries management process is varied. For example, fishermen and fisheries cooperatives, labor unions, environmental groups and government bodies, all have different interests (Mardle *et al*., 2004). Commonly in fisheries management process, objectives are classified under numerous major titles: biological, political, social (employment and personal safety) and economic objectives (Leung *et al*, 1998).

Mardle and Pascoe (2002) used a multi-objective planning model for fishery. In this research, objectives (economic, political, and biological) are classified and weights of objectives are computed and analyzed using AHP method from stakeholders views.

Kjærsgaard (2005) constituted hierarchical tree of objectives (economic - biological and policy) in the North Sea and after that, computed the weights of each of the objectives with AHP method according to different stakeholders views. Then, the collected data were used in multi-objective programming model to optimize the management of the fishing industry in Denmark. Gallic et al (2005) in France did the process of selection preferences in fisheries management through using the AHP method. In this study, stakeholders in the fishing industry have been identified and preferences of each stakeholder's goals computed. According to the results, profitability objectives and employment had greater weight from the point of view of fishermen group. Reynolds and Holsten (1994) considered value of risk factors and organising these risk factors into a hierarchical model. Results show that AHP is a successful technique for eliciting information and can be a valuable tool for expansion of expert systems in natural resource management. Qureshi and Harrison (2003) by means of Analytic Hierarchy technique offered preference weights of stakeholder groups. Results show that the Analytic Hierarchy Process is an appropriate method for prioritizing objectives and policies.

Materials and methods

Despite the fact that there are different types of studies on fisheries management, but in all these studies the steps have been as follows:

1) Identify the stakeholder groups of fisheries and fisheries management system,
2) Extract preferences (weights) for each group based on a multi-objective analysis,
3) Make an economic-biological optimization model using techniques such as multi-objective programming, and
4) Modulate the multi-objective function with computed weights (preference) for each group and compare the results.

It the process, the AHP method is used to compute the weights (Preferences) of stakeholders groups that are input as raw data into the programmed model. Also, it analyzes this data separately and compares the results with regards to the various stakeholders.

A benefit of the AHP is that it can be used to expand value arrangements between criteria as an inclusive decision-making construction for the analysis of management options. It allows managers to make use of their professional opinions and, in fisheries, can include interest group interface as well. The final solution represents the preference included in the system, giving decision-makers the chance to clearly state their preferences with respect to the identified objectives (Mardle and Pascoe,1999).

The prime use of the AHP is the resolution of choice problems in a multi-criteria environment. In that mode, its methodology includes comparisons of objectives and alternatives in a natural, pairwise manner. The AHP converts individual preferences into ratio-scale weights that are combined into linear additive weights for the associated item (Mirkin, 1979).

The AHP process follows below steps:

1 -Making Analytic Hierarchy

2 - Computing the weights

3 – Assessing the System Compatibility

The AHP, developed by Saaty (1980) has been applied in this study. Interviews and a questionnaire survey have been conducted among the most active stakeholders (Table 1).

Table 1: Example of objectives' comparison.

Economic objective	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Political Objective
Economic objective	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Biological objective
Biological objective	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Political Objective
Maximize Profit	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maximize Employment
Maximize Employment	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maximize safety and labor condition
Maximize safety and labor condition	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maximize Profit
Maintain industrial fishery at the present level	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maximize Profit
Minimize by catch	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maximize Profit
Minimize impact on birds	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maximize Profit
Maximize Employment	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Minimize impact on birds
Maximize Employment	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Minimize by catch
Maximize safety and labor condition	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maintain industrial fishery at the present level
Maximize safety and labor condition	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Minimize by catch
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Maintain industrial fishery at the present level	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Minimize by catch
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Maximize Employment	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Maintain industrial fishery at the present level
Minimize impact on birds	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Minimize by catch

The AHP provides an effective framework for the elicitation of preference in the fisheries of the Gulf of Oman (Mardle *et al.*, 2002) and is presented in Fig. 1.

The weights or preference can be absolute or relative. Weights encompass two parts -- the quantitative weight and the current evaluation of its importance.

Once the weighting scheme is determined [shown in matrix A], we solve the linear equation (or use approximation methods):

$Aw = \lambda_{max} w$ that is, $(A - \lambda_{max} I) w = 0$

If this equation has a nonzero solution for w, then λ_{max} [which is a scalar] is said to be an eigenvalue or characteristic value of A [which is a n x n matrix of pairwise comparisons] and w [which is a n x 1 matrix] is said to be an eigenvector belonging to λ. I is the identity matrix, which is a diagonal matrix with the main diagonal terms equal to 1 and zero otherwise. The solution provides the answer to the most likely outcome, given your judgmental rankings of all the individual criteria. The Problem Setup: Form Matrix of Ratio Comparisons and Multiply by w .

$$\begin{bmatrix} \frac{W_1}{W_1} & \frac{W_1}{W_2} & \frac{W_1}{W_3} & \cdots & \frac{W_1}{W_n} \\ \frac{W_2}{W_1} & \frac{W_2}{W_2} & \frac{W_2}{W_3} & \cdots & \frac{W_2}{W_n} \\ \frac{W_3}{W_1} & \frac{W_3}{W_2} & \frac{W_3}{W_3} & \frac{W_3}{W_4} \cdots & \frac{W_3}{W_n} \\ \frac{W_4}{W_1} & \frac{W_4}{W_2} & \frac{W_4}{W_3} & \frac{W_4}{W_4} \cdots & \frac{W_4}{W_n} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \frac{W_n}{W_1} & \frac{W_n}{W_2} & \frac{W_n}{W_3} & \cdots & \frac{W_n}{W_n} \end{bmatrix} \begin{pmatrix} W_1 \\ \cdot \\ \cdot \\ \cdot \\ W_n \end{pmatrix} = n \begin{pmatrix} W_1 \\ \cdot \\ \cdot \\ \cdot \\ W_n \end{pmatrix}$$

The main elements for developing the information required were literature review, ongoing model development, system observation, and representative survey.

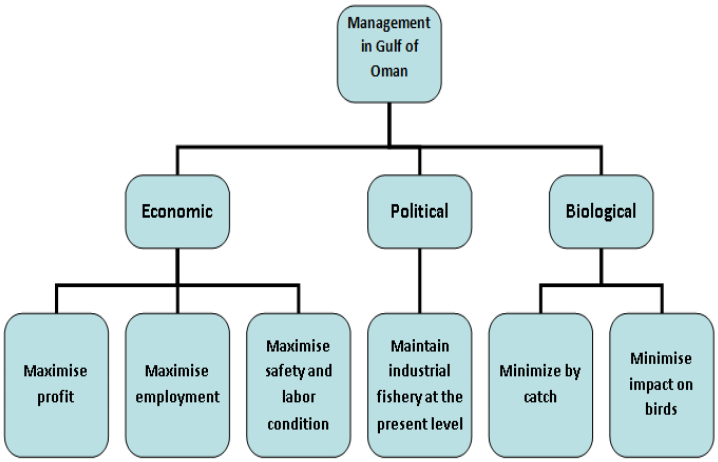

Figure 1: Analytical hierarchy process in the Sea of Oman.
Source: Nielsen and Mathiesen, 2002.

Results

In the first level of the objectives, fishery management in the Gulf of Oman is the key point. Levels in the second and third Objectives are generally consistent with expectations (Table 2). The environmental groups and governmental bodies have the highest priorities for the biological objectives. Groups related to the fishing industry (fishermen and fisheries cooperatives, labor unions, oil industry and processing) have the maximum preference for economic objectives. In terms of preferences for all groups, the biological objective has more weight, particularly the objective to minimize by catch (0/311).

Even the fishing industry stakeholders (fishermen - processing - labor unions) allocate a higher weight to this sub-objective.

As for the political objective, weights are slightly complex, and this sub-objective has the lowest priority for fishing industry groups, environmental and government, and also minimization of bycatch, another sub-objective, has the highest priority of importance.

Minimization of bycatch sub-objective has the highest priority for Iranian Fisheries Research Organization and Fisheries Organization (kjaersgaard, 2004). The fishery organizations and in particular the research centre of shrimp were chosen as they represent various viewpoints of scientists and experts in this field.

Table2: Results of weight allocation by stakeholders.

	All groups	Environmental groups	Labor Union	Processing Industry	Fishermen and fisheries cooperatives	Fishery organizations	Research center of shrimp and fishery
Economic Goals							
Optimizing profitability	0.13	0.069	0.259	0.205	0.186	0.091	0.152
Optimizing employment	0.111	0.07540	0.189	0.196	0.2.9	0.124	0.129
Optimizing personnel security	0.08	0.066	0.035	0.157	0.296	0.053	0.101
Policy Goals							
Maintanenace of fishery capacity level	0.195	0.101	0.291	0.263	0.13	0.092	0.113
Biological Goals							
Minimizing by catch	0.399	0.394	0.075	0.106	0.107	0.329	0.311
Minimizing the impact from fishing on birds	0.076	0.306	0.051	0.073	0.066	0.311	0.195

Discussion

Stakeholders of fishery industry such as production industry, fishermen and fishing companies, and other companies show a higher priority of importance for the sub-objective of profitability and continuation of the current activity and fishery capacity. The total allocation weight of stakeholders for bycatch sub-objective is more than other sub-objectives, and also this weight for optimizing staffs safety is the minimum.

Meanwhile notice that it can be used to compute weights as basic data in multi-objective programming model (GP) of fishery management.

Reference

Le Gallic, B., Mardle, S. and Boncoeur, J., 2005., Les objectifs d'une politique publique vus par les acteurs : une analyse multicritères de la politique commune de la pêche, *Économie Publique*, 16, 127-153.

Hetherihgton, A., 1986. Modeling a resource portfolio using AHP. *Resource Development*, 16(**1**), 32-7.

Kjaersgaard, J., 2004. Incorporating multiple objectives in fisheries management. Food and Resource Economics Institute (FOI). 43P.

Kjærsgaard, J., 2005. incorporating multiple objectives in fisheries management: experiences and conceptual implications' Department of Economics, University of Copenhagen, *København*, 6, 1-43.

Koeshendrajana, S. and Cacho. O., 2001, management options for the inland fisheries resource in south samatra, Indonesia: I Bioeconomic model, no.2001-2. Working paper series.

Leung, P.S., Muraoka, J., Nakamoto, S.T. and Pooley, S., 1978. Evaluating fisheries management options in Hawaii using analytic hierarchy process (AHP). *Fisheries Research*, 36(**3**), 171-183.

Mardle, S. and Pascoe, S., 1999. A review of applications of multi-criteria decision-making techniques to fisheries. *Marine Resource Economics*, 14, 41-63.

Mardle, S. and Pascoe, S., 2002. Modelling the effects of trade–offs between long and short– term objectives in fisheries management. *Journal of Environmental Management*, 65, 49-62.

Mardle, S., Pascoe, S. and Herrevo, I., 2004. Management objective importance in fisheries: An evaluation using the analytic hierarchy process. *Environmental Management*, 33(**1**), 2-1.

Mathiesen, L., 1981. A multi–criteria model for assessing industrial structure in the Norwegian fish meal industry, NATO.

Merrit, M.E. and Criddle, K.R., 1993. Evaluation of the analytic hierarchy process for aiding management decision in recreational fisheries: A case study of the chinook salmon fishery in the Kenai River, Alaska. Proceedings of International symposium on management strategies for exploited fish population, pp.683-703.

Mirkin, B.G., 1979. Group choice, John Wiley & Sons, NY. 252P.

Nielsen, J. and Mathiesen, C., 2002. Stakeholder preference for management of the Danish protein fisheries in the North Sea". Institute for fisheries management and coastal community Development, Paper presented at the 11th biannual Conference of the International Institute economic fishery. New Zealand

Pascoe, S., Dichmont, C.M., Brooks, K., Pears, R. and Jebreen, E., 2013. Management objectives of Queensland fisheries: Putting the horse before the cart. *Marine Policy*, 37(**2**), 115–122.

Qureshi, M. and Harrison Steve, R., (2003) Application of the Analytic Hierarchy Process to Riparian Revegetation Policy Options. *Small-Scale Forest Economics, Management and Policy*, 2(**3**), 441-458.

Reynolds, K. and Holsten, E.H., 1994. Relative importance of risk factors for spruce beetle outbreaks. *Canadian Journal of Forest Research*, 24(**10**), 2089-2095.

Rodgers, R. and Hunter, J.E., 1991. Impact of management by objectives on organizational productivity. *Journal of Applied Social Psychology*, 76, 322-336.

Saaty, T.L., 1977. A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, 15, 234–281.

Saaty, T.L., 1980. The analytic hierarchy process, New York: McGraw-Hill.