Marine Policy 61 (2015) 1–7

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Participative multi-criteria decision analysis in marine management and conservation: Research progress and the challenge of integrating value judgments and uncertainty

Rodrigo A. Estévez [a,*], Stefan Gelcich [a,b]

[a] Center of Applied Ecology and Sustainability (CAPES), Departamento de Ecología Pontificia Universidad Católica de Chile, O'Higgins 340, Santiago, Chile
[b] Centro de Conservación Marina & Laboratorio Internacional en Cambio Global, Pontificia Universidad Católica de Chile, O'Higgins 340, Santiago, Chile

ARTICLE INFO

Article history:
Received 1 May 2015
Received in revised form
20 June 2015
Accepted 20 June 2015

Keywords:
Decision making
Fisheries
Aquaculture
Participation
Consultation
Stakeholder engagement
Analytic Hierarchical Process
MCDA

ABSTRACT

Managers and practitioners have increasingly applied participative multi-criteria decision analysis (MCDA) in marine multi-objective management situations. Despite methodological advances and practical experiences, there is no systematic review that clarifies the current scope and challenges of participatory MCDA in fisheries management, aquaculture and marine conservation. Using the ISI Web of Science database, 95 peer-reviewed publications were found that report MCDA applications in marine management (fisheries or aquaculture) and marine conservation. Of these, 31 studies explicitly and systematically incorporate stakeholders' engagement at one or more stages of the MCDA process. Results show how participative MCDA has been applied in a wide range of marine multi-objective problems. Interestingly, 76% of studies included participation and 24% consultation processes. Most MCDA studies in marine environments were developed in Europe and Asia. Results highlight that despite successful experiences in participative MCDA, participation has been generally fragmented. Participatory processes have focused mainly at particular stages, such as the establishment of objectives and criteria, and elicitation of weights of importance. Conversely, other important stages of MCDA, such as identifying alternatives, estimating consequences or prioritizing management alternatives, exhibited low levels of participation and/or consultation. In addition, results suggest that uncertainties around multiple values judgments are seldom treated in marine MCDA studies. Greater rigor in promoting an active participation in the complete decision process and fully considering the uncertainties around people's value judgments are important research gaps, which if addressed, could substantially improve participative MCDA applications aimed at achieving sustainable management and conservation.

1. Introduction

As fisheries management and marine conservation evolve to include multiple services, values and stakeholder needs, calls to include participative decision making processes in marine planning are becoming increasingly common [1,2]. To promote stakeholder engagement throughout decision making processes, scholars have developed a series of conceptual frameworks and policy design instruments [3,4]. Participative multi-criteria decision analysis (MCDA) is a family of decision making protocols aimed at promoting effective stakeholder participation [4–6]. MCDA evaluates and prioritizes multi-objective management options when monetary values or cost-benefit analysis are inappropriate [7]. Practitioners would commonly integrate multi-dimensional data (e.g. economic, social and/or ecological), giving an analytic framework to consider value judgments in decision making. MCDA aids in clarifying stakeholders' values and objectives, promoting innovation, social learning and understanding [6,8].

In marine ecosystems, participative MCDA has begun to be used to aid participatory planning approaches [e.g. [9–11]]. Despite the potential and increasing interest in using MCDA, no review clarifies the scope, challenges and emerging issues behind the application of participatory MCDA. Such a review is important as it allows to identify: (a) the main decision objectives of participatory MCDA applications, (b) the extent to which different tools/approaches are applied to engage stakeholders in the MCDA process and, (c) the way uncertainties around the integration of different stakeholder value judgments are included in the process. In this sense, the main goal of this review is to contribute to a research agenda that can inform participative MCDA design through identifying critical research gaps, which if not addressed,

* Corresponding author.
E-mail addresses: roestevez@uc.cl (R.A. Estévez), sgelcich@bio.puc.cl (S. Gelcich).

http://dx.doi.org/10.1016/j.marpol.2015.06.022
0308-597X/

have the potential to undermine the performance of MCDA approaches for marine management and biodiversity conservation.

2. Background: the participative MCDA process

Fig. 1 presents the main steps of the participative MCDA. This process is not linear, and often practitioners develop only particular stages, depending of each decision context. The following stages have been highlighted as fundamental components in participative MCDA [4,12].

a. *Clarifying decision problem:* In an initial stage, practitioners and stakeholders explore a common understanding of the decision problem. Early stakeholder engagement allows managers to explore a wide range of values, attitudes and expectations, forecasting potential socio-environmental conflicts [13].
b. *Establishing objectives and criteria*: Meaningful participative processes are founded on clear statement of relevant stakeholders' objectives [14]. Objectives represent values, being operatiolanized by attributes or indicators. Hierarchy value trees are commonly used to articulate and organize objectives and attributes [14,15]. If based on transparent and inclusive approaches, identification of objectives may increase trust and compromise [16].
c. *Developing alternatives*: MCDA applications generally consider a limited set of alternatives. Recent studies in marine management suggest that active stakeholder participation in identifying management alternatives promotes creative solutions, implementation success and monitoring compliance [13].
d. *Estimating consequences:* Consequences are generally estimated by expert or directly by decision makers. However, in scenarios of poor-data and high levels of uncertainties, local knowledge and users experience have been critical for better estimation of ecological and social consequences [1,11,17].
e. *Evaluating trade-offs and weights*: Fundamental to any MCDA method is to establish the relative importance of the different objectives and criteria which stakeholders must decide upon. Relative importance of objectives can be represented in weights, which express a value judgment of the gain in the number of units of one attribute that compensates for loss on another [7,18]. Different methods have been used to establish weights of importance among objectives. The Analytic Hierarchy Process (AHP) is one of the most widely applied participative decision making protocols to prioritize objectives and alternatives. AHP analysis develops a set of pairwise comparison matrices, expressing the intensity of preference in a nine-point scale [19]. Alternatively, the swing weight method also allows the identification of key value trade-offs, focusing specifically in the range of consequences in the specified decision problem (worst and best outcomes for the whole set of alternatives) [7].
f. *Prioritizing alternatives*: Several MCDA methods have been applied to prioritize management alternatives. Most of them are based on additive value functions or dominance approaches (Outranking) [7,18].

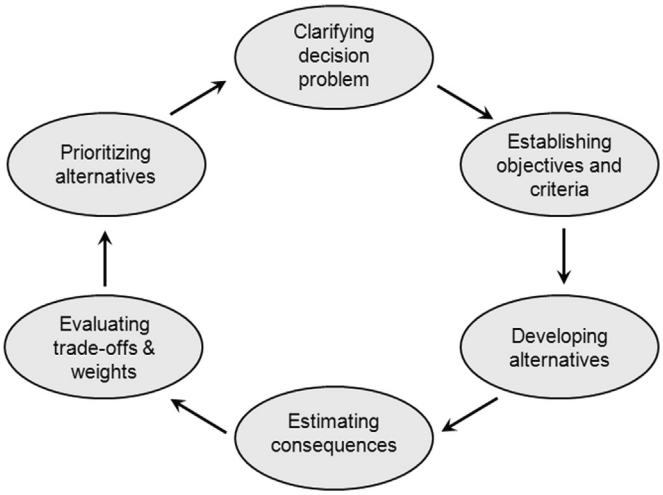

Fig. 1. Stages in a participative MCDA process [Modified from [4]].

This paper explores how researchers and practitioners have engaged stakeholders at different stages of participative MCDA in marine management and conservation. The paper also examines the diverse approaches used to consider uncertainties and multiple value judgments in the decision making process.

3. Materials and methods

A systematic search of the peer-reviewed literature in the Web of Science (ISI) database (SCI-EXPANDED, SSCI, A&HCI) was executed by using the following keywords: "*multi-criteria*", *multi-criteria*, "*multiple criteria*", *outranking*, "*analytic hierarchy process*", *AHP* and "*structured decision making*". All these terms were combined (AND) with *aquaculture, fisheries* and *marine*, avoiding duplication of papers. These queries resulted in 198 English-language papers published between January 1989 and August 2014.

The abstracts of these 198 papers were examined. A sub set of 91 papers that reported unequivocal applications of MCDA in fisheries management, aquaculture or marine conservation were selected. The 107 papers that did not meet this criterion were excluded. The excluded papers were typically literature reviews, software or operational models developments, marine transportation, ships engineering or ship marine design, technology diffusion, infrastructure projects, power generation, or morphological or physical analysis, which had no relation to participation processes in marine management or conservation. Because the set of keywords could leave out relevant papers that do not include the filter terms in the title, abstract, or keywords, the references of the 91 selected papers were examined. From this analysis a further four papers, also available in the Web of Science (ISI) database, were selected. Each of the final 95 papers was classified according to two broad areas: marine conservation and marine management (which included papers on aquaculture and fisheries). Then, the main decision objective was identified for each paper. The geographical distributions of case studies were also recorded.

From the list of 95 papers, 31 papers explicitly and systematically reported stakeholders' engagement at one or more stages of the MCDA process. The methods described to engage stakeholders in each of the 31 papers were recorded and classified, differentiating between participative or consultive process. A consultation process was broadly defined as *a two-way relationship in which citizens provide feedback to government* [20]. Participation was understood as *a relationship in which citizens actively engage in defining the process and content of policy-making* [20].

The analysis also explored how researchers and/or practitioners managed uncertainties around weights of importance in the decision making process. The different approaches and mechanisms to report uncertainty in the value models were classified in: (1) group coherence and cluster analysis, which refer to mechanisms to estimate the internal coherence of weights in a particular group [21]. (2) Sensitivity analysis, which refer to mechanism to estimate the sensitivity of alternatives' performance to variations in weights [22]. (3) Different value models, which refer to structure a specific set of weights for each stakeholder group,