Journal of Environmental Management 173 (2016) 141–150

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

Information preferences for the evaluation of coastal development impacts on ecosystem services: A multi-criteria assessment in the Australian context

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ARTICLE INFO

Article history:
Received 6 October 2015
Received in revised form
21 December 2015
Accepted 21 January 2016
Available online 6 February 2016

Keywords:
Analytic hierarchy process
Australia
Coastal development
Ecosystem services assessment
Information preferences
Multi-criteria analysis

ABSTRACT

Ecosystem based management requires the integration of various types of assessment indicators. Understanding stakeholders' information preferences is important, in selecting those indicators that best support management and policy. Both the preferences of decision-makers and the general public may matter, in democratic participatory management institutions. This paper presents a multi-criteria analysis aimed at quantifying the relative importance to these groups of economic, ecological and socio-economic indicators usually considered when managing ecosystem services in a coastal development context. The Analytic Hierarchy Process (AHP) is applied within two nationwide surveys in Australia, and preferences of both the general public and decision-makers for these indicators are elicited and compared. Results show that, on average across both groups, the priority in assessing a generic coastal development project is for the ecological assessment of its impacts on marine biodiversity. Ecological assessment indicators are globally preferred to both economic and socio-economic indicators regardless of the nature of the impacts studied. These results are observed for a significantly larger proportion of decision-maker than general public respondents, questioning the extent to which the general public's preferences are well reflected in decision-making processes.

1. Introduction

There is a call for methodologies and approaches to assess and integrate ecosystem services (ES) into interdisciplinary evaluation frameworks (Spash, 2008; Vatn, 2009; Lopes and Videira, 2013; Martín-López et al., 2014). ES values span multiple dimensions (O'Neill et al., 2008; Vatn, 2009; Chan et al., 2012; Martín-López et al., 2014) and it has increasingly been argued that the process of ES assessment should encompass economic assessment (measured, e.g., via dollar values), ecological assessment (measured, e.g., via biophysical indicators), and socio-cultural assessment (tracked, e.g., via qualitative analyses), alongside institutional analyses (Spash and Carter, 2001; De Groot et al., 2002; Vatn, 2005 and Vatn, 2009.

Participatory and deliberative approaches are deemed to play a valuable role in ES assessment (James and Blamey, 2005; Spash, 2008; Vatn, 2009; Antunes et al., 2009; Garmendia et al., 2010; Lopes and Videira, 2013) The importance of active stakeholder participation in ecosystem management and decision-making has increasingly been acknowledged, and this is now supported and integrated in various recent policies worldwide (Reed, 2008; Lopes and Videira, 2013; Rogers, 2013). In particular, public participation has been advocated as a possible way to improve ecosystem management decision-making processes (Reed, 2008). This is consistent with the view that it is the public's democratic right to participate in environmental policy and decision-making (Rogers, 2013).

Accounting for preferences and expectations of both decision-

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http://dx.doi.org/10.1016/j.jenvman.2016.01.025
0301-4797/

makers and the general public is therefore crucial in such participatory integrated management frameworks. For instance, concern about 'social license' could lead to decision-makers favouring the use of indicators that are familiar to and accepted by the general public. Populations which are increasingly concerned about and involved in management decisions (Reed, 2008; Rogers, 2013) will expect transparent and understandable decision-making processes. On the other hand, the need for indicators that best track the actual performance of management implies that decision-makers may favour indicators regardless of their public acceptability. In addition, both decision-makers and the general public may favour the use of particular indicators if they believe that they are likely to favour outcomes that are consistent with a particular 'agenda' or can be easily manipulated. In particular indicators that emphasize the distributional trade-offs between different social groups may be used to fuel conflict, or deliberately ignored to avoid it.

Both the need for a participatory framework in policy development and ecosystem assessment processes (Lopes and Videira, 2013), and the importance of articulating and integrating the different dimensions of ES (Martín-López et al., 2014), raise the issue of how economic, ecological and social criteria are weighted and balanced by both decision-makers and the general public when assessing the consequences of changes in ES.

Multi-criteria Analysis (MCA) can help address such questions. MCA encompasses a collection of theories, methodologies and techniques to explicitly integrate and balance a set of decision criteria (Figueira et al., 2005). MCA has been widely used in ES management (e.g. Vaidya and Kumar, 2006; Bryan et al., 2010; Prato and Herath, 2012; Fontana et al., 2013), because the complexity, the uncertainty, the conflicts as well as the diversity of stakeholders involved in ES management call for such procedures (Martinez-Alier et al., 1998; Munda, 2007; Gowdy and Erickson, 2005; Liu et al., 2010; Garmendia et al., 2010). There are many cases studies where MCA has allowed an in-depth analysis and quantification of the trade-offs between various economic, ecological and social management objectives or criteria. In particular, the Analytic Hierarchy Process (AHP), which allows evaluation of the relative priorities placed on competing criteria that can be organized hierarchically (Saaty, 1977), has been extensively used (e.g. Vaidya and Kumar, 2006).

However, the authors are not aware of any MCA study that has examined quantitatively the information preferences for competing economic, ecological or social ecosystem assessment indicators in a generalised management context i.e. that aimed at estimating the relative importance weight attached by stakeholders to various indicators tracking the multiple consequences of changes in ES, for management decision-making. The authors also know of no other studies that compared the weight placed by both the general public and decision-makers on such indicators.

The general objective of this work is to elicit and compare the weights attached by decision-makers and the general public to three main categories of indicators to assess changes in ES in a coastal development context. These indicators – namely (1) economic valuation indicators; (2) ecological indicators; and (3) socio-economic indicators – are the most commonly encountered 'in the field' in ES management, and mostly recommended by mainstream economists, ecologists, the social media and politicians. These weights are estimated in the context of a generic coastal development scenario where these indicators can be used to assess the impact of coastal development on three areas of consequences: on marine commercial activities, on marine recreational activities and on marine biodiversity. The analysis is undertaken in the context of Australian coastal management using AHP to elicit preferences from two nationwide surveys.

The paper is organized as follows. Section 2 presents the AHP technique, the development and design of the AHP-based model, its application to the Australian coastal management context and the data collection, as well as the different statistical methods used to analyse the AHP results. Section 3 shows the results of the AHP application for Australian decision-makers and general public, and their subsequent analysis: the elicitation of weights representing stakeholders' information preferences and the distribution of these preferences across the two populations. Section 4 discusses these results, and Section 5 concludes.

2. Material and method

2.1. The analytic hierarchy process

The authors selected the AHP technique in view of its numerous applications in the domain of ecosystem and land use management (Herath, 2004; Wattage and Mardle, 2005; Vaidya and Kumar, 2006; Ho, 2008; Diaz-Balteiro and Romero, 2008; Fontana et al., 2013), including coastal and marine ecosystems management (e.g. Himes, 2007; Pascoe et al., 2009a and 2009b; Innes and Pascoe, 2010; Tian et al., 2013). The AHP proposes a framework for the elicitation and analysis of preferences for criteria, objectives or various management alternatives in a hierarchical manner (Saaty and Vargas, 2001). The strengths and weaknesses of the AHP method in comparison to other methods have been discussed extensively (e.g. Saaty, 1994; Figueira et al., 2005; Linkov et al., 2006; Vaidya and Kumar, 2006; Ho, 2008; Sipahi and Timor, 2010). The reviews point to the fact that AHP has a robust theoretical base in terms of preference elicitation even though it has received criticisms, and that there are a substantial number of successful applications in many management or decision domains (Ishizaka and Labib, 2011).

Developing and conducting an AHP involves four main steps (Wattage and Mardle, 2005). The first step is the identification of the management problem and the selection of the competing criteria followed by their organization within a hierarchical tree.

The second step is the development of the pairwise comparisons that will be used to determine the individuals' priorities or preferences towards the criteria based on the hierarchical tree. These pairwise comparisons are usually based on a nine-point intensity of importance scale (Saaty, 1977). Once the data are obtained by surveying stakeholders, the third step is the analysis of the individual preferences obtained, based on the relative weights they attributed to each criteria.

The relative weights are derived from a pairwise comparison reciprocal matrix (A) of judgements and are found by solving (Saaty, 1977):

$$\sum_{j=1}^{n} a_{ij} w_j = \lambda_{max} w_i \quad \forall i \left(a_{ji} = {}^{1}/_{a_{ij}} \, and \, a_{ij} > 0 \right) \tag{1}$$

where indices i and j represent a pair of criteria, λ_{max} the principal eigenvalue, and the weights w_j are normalised appropriately. The solution is typically known as the principal right eigenvector.

The estimation of relative weights makes sense only if derived from consistent or near consistent matrices (Saaty, 1977). Consistency check must therefore be applied, i.e. it is necessary to check whether respondents were inconsistent in completing the set of pairwise comparisons. The matrix A is said to be consistent when $w_{ji} = a_{ij} w_{ij}$ and its principal eigenvalue, λ_{max}, is equal to n (i.e. the dimension of A). When A is inconsistent, then $\lambda_{max} > n$ and the variance of the error incurred in estimating a_{ij} can be shown to be $(\lambda_{max} - n)/(n-1)$ (Saaty and Vargas, 2001). Saaty (1977) defined