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Methodological and Ideological Options

Social Sensitivity Analyses Applied to Environmental Assessment Processes

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ABSTRACT

Social sensitivity analysis is aimed at exploring the robustness of complex governance processes through the involvement of stakeholders. This approach is based on the concepts of transparency and citizen participation. This paper presents a new methodology for the application of sensitivity analysis to environmental assessment projects. The general idea behind this method involves making the results of natural resource planning processes available to an "extended peer community". This community, also known as a stakeholder community, is allowed to evaluate the quality of planning processes and give their opinion on the results. A Decision Support System based on institutional analysis, multi-criteria analysis and focus group sessions is used to implement this approach in a case study involving sustainable land-based transport policies in Tenerife, Canary Islands. In this exercise, stakeholders are involved in framing transport governance issues appropriately and then in defining and assessing plausible policy alternatives. The results obtained highlight that social sensitivity analysis is a viable approach that guarantees robustness in environmental governance. In addition, methodological suggestions are made that might be of use to the sustainability assessment community.

1. Introduction

Environmental governance often concerns large areas, long time horizons and multiple stakeholders, which further complicate the governance process, increasing the uncertainties involved in it (Kangas and Kangas, 2004). Thus, environmental governance might be characterised as a process where, typically, facts are uncertain, values are in dispute, stakes are high and decisions urgent (Funtowicz and Ravetz, 1991). These values in dispute are further aggravated by the uncertainties related to the environmental systems, themselves (Corral Quintana, 2004; Corral-Quintana et al., 2016; Funtowicz and Ravetz, 1993; Funtowicz and De Marchi, 2000; Giampietro et al., 2006; Guimarães Pereira and Corral Quintana, 2009). All these elements complicate the traditional scientific approach, where a mixture of (partial) knowledge, assumptions, and ignorance are obstacles. In these cases, science should look for ways to overcome these obstacles by means of public participation (Ravetz, 2004).

As mentioned, there are significant uncertainties in the knowledge base of complex environmental problems that need to be addressed, such as technical (inexactness), methodological (unreliability), epistemological (ignorance) and societal (social robustness) uncertainties (Van Der Sluijs et al., 2008). Frequently, quantitative uncertainty and sensitivity assessment methods are applied, however, these are only capable of addressing technical uncertainties. Thus, mainstream uncertainty methods such as the Monte Carlo analysis, subjective probability, or Bayesian updating are not sufficient on their own for environmental and societal issues because the main feature of these problems is that unquantifiable uncertainties exceed quantifiable ones. Although quantitative techniques are essential in any uncertainty analysis, they provide only a partial insight into what usually is a very complex mass of uncertainties (Van Der Sluijs et al., 2008).

In situations where different interests prevail, dealing with technical uncertainties (like those related to data availability, input data, and the model itself) is not enough. In these cases, the legitimacy of planning processes is more affected by epistemological and social uncertainties, which complicate governance processes and hinder decision-making. Therefore, sensitivity analysis should be expanded to more inclusive approaches in which the decision processes become more relevant and transparent (Munda, 2005). Decisions need to be taken as to who takes part and takes decisions in the whole process, from the definition of the problem and its structuring (alternatives and criteria) to the evaluation of criterion scores, the selection of the multi-criteria method and the final decision. Certainly, these are all decisions that are beyond scientists and, therefore, should be collectively decided through a new social contract between the scientific community and society (Gibbons, 1999).

The aim of this paper is to propose a new approach for sensitivity analyses applied to environmental assessment processes. A method is

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implemented to enhance the robustness of the techniques and processes used in decision support analysis in the assessment of natural resources management policy options. The proposed social sensitivity analysis (SSA), based on the SSA concept developed by Corral Quintana (2004), tries to explore ways to improve the robustness of policy decision-making processes when high levels of uncertainties and conflicts between stakeholders are involved (e.g. inter-urban transport planning processes). Concretely, SSA focuses on the analysis of the assessment procedures applied during environmental decision-making processes, both the alternatives and criteria, as well as the method used during the assessment. In the case at hand, a participatory multi-criteria assessment is discussed. The next section presents the framework of analysis.

2. Methodological Approach

The proposed method is based on a combination of both technical and social methodologies (see Fig. 1).

On the one hand, a “classical” sensitivity analysis is applied in order to validate the technical results by changing the model's parameters. On the other hand, an “extended” sensitivity analysis is based on the feedback produced from different social discussions using focus groups, i.e. the community is involved in the decision-making process and gives opinions on the assessment results, including the sensitivity analysis outcome.

Sensitivity analysis (SA) has been thoroughly researched over recent decades. It is a technique that is intended to quantify how important input variables are $X = (X_1, \ldots, X_n)$ in defining the value of a given output variable $Y = f(X)$ and, therefore, evaluates the robustness of the results. Generally speaking, there are two main techniques to approach SA: (a) global SA and (b) local SA.

Global SA refers to techniques that pursue the quantification of output uncertainties resulting from simultaneous parameter changes (Turányi, 1990). This technique is able to test single and combined variable changes. A early example of global SA is the Fourier Amplitude Sensitivity Test (FAST) method developed by Cukier et al. (1973) to examine the sensitivity of the solutions when all rate coefficients are varied simultaneously. A Monte Carlo algorithm has also been proposed to analyse the sensitivity of a function with respect to a random set of variables (Sobol, 1990). A Monte Carlo SA involves numerous model calculations with probabilistically selected model input to determine uncertainty in model forecasts and in input variables that trigger uncertainty (Helton, 1993). Homma and Saltelli (1996) proposed a method based on Sobol's to calculate the total effect produced by a parameter on a model's prediction, including the synergic effects of that parameter and all the others. Other methods have also been proposed, such as “bootstrapping” used to produce confidence intervals (Archer et al., 1997) or the extended FAST that allows for the calculation of the total influence of each input factor on an output's variance (Saltelli et al., 1999).

On the other hand, local SA refers to the assessment of the effects of small changes of parameters on many responses (Turányi, 1990). Some of the first attempts to develop local SA have been the adjoint techniques intended to assess the sensitivity of responses to variations in a model's parameters (Cacuci, 1981a, 1981b). Oblow et al. (1986) have applied an automated technique to carry out large-scale SA on a geohydrological modelling problem. Another application of local SA to hydrogeology was performed by Smidts and Devooght (1997) to solve an inverse problem of hydraulic potential in widely distributed locations in a flow region. Local SA has also been applied to chemical-molecular based problems (Rabitz, 1989). For a review of local methods, see for example Turányi (1990).

As mentioned, there are high levels of uncertainty in environmental assessment processes due to the disputed values, high stakes and urgent decisions involved. These represent a range of scientific challenges that cannot be coped with by simple mathematical precision (Funtowicz and Ravetz, 1991). One proposal to deal with these levels of uncertainty has been the use of “extended peer communities” (Funtowicz and Ravetz, 1993). This refers to the extension of environmental governance to new participants in policy dialogues, involving “the participation of people other than technically qualified researchers; indeed, all the stakeholders in an issue form an ‘extended peer community’ for an effective problem-solving strategy for global environmental risks” (Funtowicz and Ravetz, 1993, p. 744). The extended peer community is, therefore, a necessary condition to achieve socially robust knowledge (Gibbons, 1999).

The second part of the methodology is SSA (see fig. 1), which is based on stakeholders' control of results (for a broader approach where the stakeholders are engaged in a quality check of the decision-making process, the reader may consult the work developed by Hernández-González and Corral, 2017). SSA aims to assess the quality of the assessment processes in governance issues. In order to succeed, SSA evaluates the following aspects:

- Criteria selected for the assessment. In conflicting situations, the acceptance of the assessment results (a.k.a. policy alternatives) might be jeopardized by a lack of consensus on the validity of the criteria used during the assessment.
- Method selected to carry out the assessment.
- Outcome that refers to the ranking of alternatives, including both those performing better and those in a worse position. This step is carried out through discussions among the different stakeholders involved in the process.

SSA strongly depends on social participation, the potential benefits of stakeholders' engagement in environmental governance are various (Giering, 2011): (a) ownership of policies, (b) better decisions in terms of sustainability and the inclusion of community values, (c) greater credibility of public agencies, and (d) faster planning

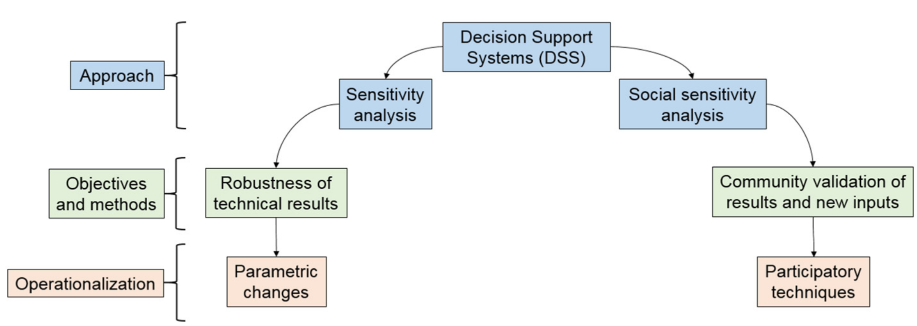

Fig. 1. Scheme of the proposed (social) sensitivity analysis approach.