



## Multi-criteria analysis for improving strategic environmental assessment of water programmes. A case study in semi-arid region of Brazil

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### ABSTRACT

Multi-criteria analysis (MCA) is a family of decision-making tools that can be used in strategic environmental assessment (SEA) procedures to ensure that environmental, social and economic aspects are integrated into the design of human development strategies and planning, in order to increase the contribution of the environment and natural resources to poverty reduction. The aim of this paper is to highlight the contribution of a particular multi-criteria technique, the analytic hierarchy process (AHP), in two stages of the SEA procedure applied to water programmes in developing countries: the comparison of alternatives and monitoring. This proposal was validated through its application to a case study in Brazilian semi-arid region. The objective was to select and subsequently monitor the most appropriate programme for safe water availability. On the basis of the SEA results, a project was identified and implemented with successful results. In terms of comparisons of alternatives, AHP meets the requirements of human development programme assessment, including the importance of simplicity, a multidisciplinary and flexible approach, and a focus on the beneficiaries' concerns. With respect to monitoring, the study shows that AHP contributes to SEA by identifying the most appropriate indicators, in order to control the impacts of a project.

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### 1. Introduction

The Paris Declaration on Aid Effectiveness (2005) committed donors and their partner countries to reforming the way in which aid is delivered. The aim was to improve effectiveness by harmonising efforts and aligning with the priorities of partner countries. Furthermore, to ensure that environmental considerations were taken into account in this new aid context, the declaration encouraged the use of strategic environmental assessment (SEA). SEA can be defined as “the formalized, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making” (Therivel, 1992). The adoption of SEA supports the decision-making process through the development and comparison of future scenarios. This helps to ensure that policies and programmes meet sustainable development objectives and that positive synergies

between economic and environmental development priorities are established and assessed.

In developing countries, where people depend more directly on natural resources than in any other society, SEA has become an essential tool for formulating future development strategies. The application of SEA to development cooperation has benefits for both decision-making procedures and development outcomes (OECD, 2006). It supports more informed decision-making by taking into account environmental aspects and by encouraging a systematic and thorough examination of development options. SEA helps to ensure the sustainability of economic growth, which, in turn, will support political stability and facilitate trans-boundary cooperation around shared environmental resources, thus helping to prevent conflict.

SEA is a complex procedure and various decision-making tools can be used within the process especially in the following steps: comparison of alternatives and monitoring. Examples include life cycle assessment (LCA) (Tukker, 2000), cost-benefit analysis (CBA) (Finnveden et al., 2009) and multi-criteria analysis (MCA) (Finnveden et al., 2003). MCA aims to rank a finite number of options on the basis of a set of evaluation criteria and it is a very flexible family of techniques. In fact a multi-criteria tool can be applied for all kinds of impacts, can be made site-time-specific or

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not, and quantitatively as well as qualitatively (Finnveden et al., 2003). These are key characteristics when SEA is applied in developing countries, where often data are not easily available. MCA in SEA procedure has been used to solve many environmental problems in energy, waste management or urban infrastructure sectors, among others (Bobylev, 2006; Finnveden et al., 2003; Fischer, 2003; Jay, 2010; Salhofer et al., 2007). However there are no examples of MCA application in SEA procedure for water programmes in developing countries.

The aim of this paper is to present the contribution of a particular multi-criteria tool, the analytic hierarchy process (AHP) (Saaty, 1980, 1990, 1994), to the SEA procedure, mainly with respect to comparisons of alternatives and monitoring. A case study in Jequitinhonha Valley, located at the semi-arid region of Brazil, is presented. Water resources are a major concern in this region, in relation to agricultural water management for dry-land and irrigated cultivation and to drinking water availability. Specifically, we use the SEA procedure and AHP to assess two water programme alternatives: the “One Million Cisterns Project” (P1MC) and the “Spring Assessment Programme”. When this study was carried out, both projects had already been implemented by NGOs as isolated pilot projects. According to the SEA and AHP results, P1MC is the most appropriate solution, so this project was promoted and implemented, and monitoring started in 2006. Today, more than 2000 cisterns supply safe water in Jequitinhonha Valley.

The paper is organized as follows: Section 2 analyses SEA challenges for developing countries; Section 3 introduces a detailed description of AHP and its contribution to SEA procedure; the case study is introduced in Section 4; Sections 5 and 6 present the results of the AHP contribution to the comparison of alternatives and monitoring, respectively; finally, Section 7 summarises the conclusions.

## 2. SEA for developing countries

The current trend of industrialization and urbanization in developing nations has a huge impact on anthropogenic and natural ecosystems (Alshuwaikhat, 2005). This is due, in particular, to the absence of decision-making capacity and the lack of effective and systematic environmental planning and management strategies. There is now greater concern than ever for future urban sustainable development, which is changing the way international development aid is provided (OECD, 2006). The aim, as expressed by the Millennium Development Goals, is to make aid more effective in supporting progress and in meeting the needs of the poor (OECD, 2006). Many decision analytic techniques and methods are offered to support environmental problem resolution. However, the appropriateness of the different methods in relation to the contexts in which they might be applied has not yet been explored (French and Geldermann, 2005).

SEA meets the challenge in this context, as it increases strategic development cooperation. It is an effective planning tool for developing countries, as it helps them to achieve sustainable development and environmental protection, to avoid project failure and social or economic impacts, and to fight poverty.

SEA is a process for analyzing and addressing the environmental and health effects of proposed policies, plans and programmes or other strategic initiatives (e.g. legislation or regulations). It can be applied at all stages and tiers of decision-making and at local, regional or national level (UNDP, 2005). SEA is an ex-ante approach that is applied early in the formulation of proposals, when major alternatives and options are still open, well before decisions are made.

The aims of SEA for developing countries are (UNDP, 2005):

- To provide a planning tool that supports the lack of an effective and systematic planning policy.

- To incorporate environmental and other sustainability objectives into the formulation of policies, plans and programmes (PPP).
- To mitigate the lack of transparency and accountability in policies and ineffective public participation in the development of PPP that is typical in developing countries.
- To include relevant stakeholders' opinions in order to focus on people's concerns, often secondary to political interests.
- To evaluate the significant environmental and health effects of strategic options and proposed actions.
- To improve the efficiency of the planning processes and governance.
- To provide a number of immediate and longer-term benefits for development agencies, planning authorities and governments.

Sometimes, SEA is criticised for its limited effectiveness in terms of affecting decisions (Therivel and Partidario, 1996). Recent literature has argued that in order to be effective in strategic decision-making, SEA must be more flexible and adaptive to the context (Nilsson et al., 2005; Nilsson and Dalkmann, 2001). In fact, SEA is considered a framework within which a range of different analytical tools and methods can be applied (Finnveden et al., 2003), especially in the comparison of alternatives. In recent years, increasing attention has been paid to combining analytical tools, although research into which tool is appropriate for which problem, or whether more than one tool should be applied in certain situations, is still in its infancy (Wrisberg et al., 2002). These aspects—adaptation of the SEA procedure to the specific context and the definition of a specific and appropriate tool for the comparison of alternatives in SEA—are crucial for developing countries, due to their particular condition. Such countries are characterized by particular social and economic circumstances, in which environmental strategies and plans should provide the best social benefits, to improve living conditions and to minimize environmental impacts.

The main stages and steps in SEA are (OECD, 2006):

1. Establishing the context for the SEA. This involves screening, setting objectives and identifying stakeholders.
2. Implementing the SEA. This step includes: collecting baseline data, identifying and comparing alternatives, identifying how to mitigate impacts, quality assurance and reporting.
3. Informing and influencing decision-making.
4. Monitoring.

The main contribution of AHP to SEA is in the comparison of alternatives and monitoring, as detailed in the following sections.

## 3. AHP contribution to SEA procedure

The following sections describe the AHP and its contribution to the comparison of alternatives and monitoring in SEA procedure.

### 3.1. AHP for comparison of alternatives

In comparisons of alternatives, different tools can be used to predict the environmental and socioeconomic effects of policies, plans and programmes. Like mentioned above, the most common tools are: LCA, CBA and MCA. The use of such tools leads to the identification of the best option to be implemented. In this paper, we assess MCA for decision-making and comparisons of alternatives (CIFOR, 1999; Keeney and Raiffa, 1976; Malczewski, 1997; Nijkamp et al., 1990; Wilson et al., 2004). MCA is a family of evaluation tools that rank or score the performance of options against multiple social, environmental and economic criteria (Hajkowicz, 2007) that

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