Dynamics of a decision support system in Strategic Environmental Assessment implementation

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Introduction

The implementation of the European Strategic Environmental Assessment (SEA) Directive 2001/42/EC (CEC, 2001) places new challenges in the environmental assessment arena. This research study aims to develop a systematic approach to SEA based on Geographic Information Systems (GIS) that helps to fulfil the requirements of the Directive in an integrated manner and informs the decision-making process.

The SEA Directive 2001/42/EC establishes a number of principal actions to be adopted in the environmental policy framework:

- Systematic environmental evaluation of certain plans and programmes;
- Preparation of an environmental report presenting the SEA results, according to that established in the Directive (including the assessment of the potential environmental implications of the plan or programme, the consideration of alternatives and sustainability goals);
- Ensure the transparency of the process by means of public participation (including cross-boundary consultation when necessary) and inclusion of public perceptions in the decision-making process;
- Enhance the effectiveness of the process through the monitoring of proposed mitigation measures and SEA results.

The effective adoption of these actions as part of current environmental legislation is facing difficulties in a variety of political and socio-economic contexts worldwide. The implementation of Directive 2001/42/EC presents several challenges at a practical level compared to the EIA Directive 97/11/EC (CEC, 1997) due to its strategic, socio-political and decision-making connotations. Since the introduction of the SEA Directive, practical methods and procedures are being developed; feasible methodologies are being explored and deficiencies in current practice are being identified. However, the debate in relation to the key aspects for an effective SEA methodology remains a 'hot topic'.

Public participation, informing and involving interested and affected public and government bodies throughout the decision-making process, and addressing their inputs and concerns in documentation and decision-making, has largely been viewed as a key to success and citizen support to environmental assessment processes. Although public participation methods have been largely explored, systems for influential inclusion of public concerns and interests in environmental assessment have seldom been defined. The SEA Directive, together with both the Aarhus Convention (1998) and the related Directive 2003/35/EC (CEC 2003 – to be implemented by June 2005), emphasise the clear need to provide for public participation in respect of the preparation of projects, plans and programmes relating to the environment.

Monitoring of plans and programmes is compulsory under the SEA Directive 2001/42/EC. Monitoring is a vital component helping to ensure that the process has gone full circle and that SEA has been valuable and successful. Current SEA procedures and elements often reflect existing EIA systems, and concerns exist that observed deficiencies in EIA monitoring and public participation methods are somehow replicated in SEA.

Methodological Context

The International Association for Impact Assessment (IAIA) published SEA performance criteria, with the aim of providing general guidance on effective SEA processes and helping to ensure good-quality SEA. The criteria establish that the SEA process shall be *integrated*, *sustainability-led*, *participative*, *iterative*, and *focused*, and in all cases the decision shall be *accountable*. In parallel, it has been argued (Marshall, 2005; Jones, 2005; Gazzola, 2004; Verheem & Tonk, 2000; Partidario, 2005) that an effective SEA method should be 'fit for purpose', i.e. adapted to the political and institutional arrangements of the country. A compromise should be sought to ensure the balance between the necessary flexibility to address the decision-making framework of each country and the coherency and responsiveness of the SEA process. Within the EU, SEA procedures should not only be pragmatic, reliable and comparable, but they should fulfil the Directive requirements.

Strategic Environmental Assessment Methods

Early SEA research and experience in areas such as transport and land use planning in Canada, UK, Ireland, Holland, Germany, Spain and Denmark (amongst others) have allowed preliminary development of strategic decision-making support tools. However there is substantial divergence amongst existing strategic environmental assessment methods. SEA types can be generally classified according to the plan/programme formulation phase, to the coverage of impact or to characteristics of the process (Fischer, 2002); all of which can be specific to the sector or to the local planning context. Some current SEA instruments include matrix and checklists methods – similar to those used in EIA (Scott & Marsden, 2003), computerised models that analyse spatial factors by applying multiple criteria (e.g. Moland - McCormick et al, 2001) and Analytical Strategic Environmental Assessment – ANSEA (Jiliberto & Alvarez-Arenas, 2000). Matrix based assessments generally evaluate the potential environmental effects resulting from implementing the objectives of the plan or programme against the sustainability goals set for the sector or region. ANSEA goes further, seeking to provide an analytical method that is focused on decision-making and complementary to standard SEA practice (Dalkmann et al, 2002). The European Environment Agency´s Moland Project, a computer-based spatial analysis system, has as a main objective to prepare computerised urban atlases. This will help evaluate environmental and socio-economic interactions and their effect on European landscapes; contributing, in parallel, to the preparation of land use and sectoral plans/programmes.

Although these developed SEA methods take consideration of the Directive requirements; a holistic approach for a comprehensive SEA process needs to be explored.

Geographic Information Systems

The application of technology and computer-based models is common practice in some phases of environmental assessment (Joao & Fonseca, 1996). Geographic Information Systems (GIS) constitute a useful tool to convey and present information by overlying geographically referenced data, thus facilitating the assessment of the spatial interaction of factors. The rapid development of GIS technology is providing new tools that go further than the bi-dimensional geographic assessment and representation of variables. The integration of modelling programmes and spatial analysis tools, and the added value of three-dimensional representations, contribute to the

development of a system that allows in-depth modelling of factor dynamics, as well as having the potential to create likely scenarios associated to the development of considered alternatives.

GIS approaches have been used in EIA since the early 1970s, when they were considered useful for the assessment of linear projects (e.g. roads, telecommunication and electricity lines). Nowadays, the applicability of GIS has extended to land use and resource planning. Currently it is being used in a wide variety of projects including: topographical modelling; industrial, landfill and wind farm site selection; computation of zones of visual influence; modelling the effects of urban expansion on the landscape; etc. However, the use of GIS is surprisingly limited considering the high analytical and modelling capability. Hacklay et al (1998) observed that restricted use of GIS can be related to limited knowledge and comprehension of the system by EIA experts.

GIS can be used throughout the various phases of the SEA process: from acquiring, digitising, storing, editing and representing information related to the vulnerability of resources, through assessing the magnitude and extent of environmental impacts associated with the plan/programme, integrating multiple analysis criteria and weighting factors, to modelling of considered alternatives and presenting final results. Furthermore, GIS approaches allow rapid update of information and consequently could facilitate the monitoring and auditing phases of the SEA. Besides, they allow re-utilisation of data, providing readily available background information for evaluating future plans and programmes or for similar strategies and projects in the wider area.

The quantity and quality of the information in digital format has grown in recent years, creating an important digital georeferenced database infrastructure. The EU is playing an important role in the creation, standardisation, usage and sharing of geographic information, supporting initiatives such as INSPIRE (Infrastructure for Spatial Information in Europe) that proposes to put pertinent, harmonised and quality geographical information to the service of the formulation, application, monitoring and evaluation of policies.

Strategic Environmental Assessment and New Technologies

Although a lot has been done advancing theory and methods in SEA, it is an area that is rapidly evolving. Further research and development can contribute to an enhanced SEA method ensuring a viable, effective, transparent and flexible process that is applicable throughout the variety of European socio-political systems. Without overlooking the flexibility needed to ensure appropriate SEA performance, a number of authors agree that there is a need to define a standardised method to normalize procedures as this will allow comparative monitoring of the effectiveness in the implementation of the SEA Directive (Clark & Partidario, 2000; Verheem, 2000; Jiliberto, 2002ab; Therivel & Partidario, 1996). However, it is debatable whether current SEA effectiveness criteria and principles are similarly applicable through the range of European planning contexts (Gazzola, 2004). Therefore, there is a need to address the concept of ‘standard-but-flexible’ (i.e. consistent but adaptable) when defining SEA methodology.

Considering the fast development of new technologies, the current use of computer-based systems and the analytical capability of GIS, together with the need to define an effective strategic environmental assessment method, this research aims to design a computerised GIS model. ***Geographic Information Systems for Strategic Environmental Assessment (GISEA)*** is born as a result of the limitations identified in the theoretical and practical methods developed to date. The objective is to define a systematic and holistic approach that will bring together all key actions of Directive 2001/42/EC, namely environmental analysis of factors, public participation and monitoring; a user-oriented integral and systematic solution that will aim to

solve some of the difficulties encountered in current SEA practice. Most importantly, GISEA is conceived as an environmental decision-support tool.

The GISEA research project does not intend to reinvent concepts or methods for environmental evaluation. The objective is to define and develop a technique based on existing SEA methods of best practice and in GIS data processing technology - adapting the software to strategic evaluation in a way that integrates and analyses economic, social, and environmental factors in a georeferenced manner. The system will evaluate the importance of key factors using specific weighting criteria that take account of public perception. It will graphically present the results of the evaluation, allowing rapid identification of areas of concern and most sustainable alternatives. Similarly, the software will be programmed to identify spatial indicators that will facilitate monitoring of mitigation measures and SEA results. The indicators will also contribute to creating a database of baseline information that can be used in future decision-making processes. In any case, the method should have adequate flexibility to allow adjusting values, assessment factors and weighting criteria and thus have the ability to be adapted to the variety of socio-political contexts within the EU.

Dynamics of the System

The principles on which GISEA is based are:

1.- Adapting ArcGIS software to suit the analysis of actions and criteria associated with SEA. A preliminary study will identify feasible SEA models, which will be combined and adequately modified to define and design a quantitative and transparent approach that will form the basis of the computerized GISEA model.

2.- Evaluation of the relevant variables will be carried out by appropriately defining scoring ratios and applying multi-criteria analysis. These will combine values associated with: the vulnerability of the environmental resources, perceptions derived from public participation, and the socio-economic significance of developing the plan/programme.

3.- Weighting criteria associated with public perception will be based on the results of the consultations carried out with the competent authorities, interested and/or affected parties, and the general public. The results of public participation will be derived from a thematic and graphic questionnaire designed for this purpose.

4.- A hierarchy of values will be defined according to the vulnerability of social and environmental factors and the relative importance of economic factors. Factors and their values will be digitised and integrated in the data-layering exercise. These will be mapped within the GISEA system for their interactive evaluation, which will respect the previously defined hierarchy.

5.- Information associated with environmental resources will be primarily analysed in terms of vulnerability, according to their present status that will be reflected in existing indicators. The software will be programmed to detect the degree of overlap in combination with the vulnerability of the different layers of environmental information. Results will be colour-coded according to sensitivity of the areas to a potential impact (Figure 1).

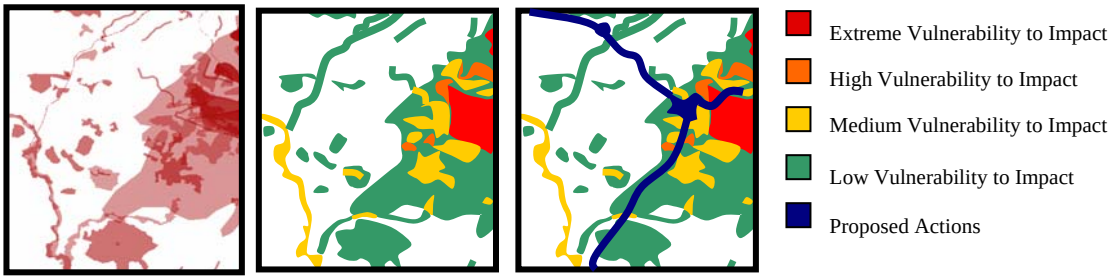

Figure 1.- Sample of the computerised GISEA model

6.- Once the environmental vulnerability and the social and economic values have been evaluated, the total environmental impact associated with the different areas will be calculated by means of incorporating the public perception factor or 'tolerability factor'. This can be represented by a formula with the following structure:

Total Impact = Vulnerability to Impact (Overlying of factors) x Tolerability Factor (Public perception)

7.- Similarly, the software will be programmed to analyse the results of the SEA process in terms of quantities, indicating the area or the length affected by the actions contemplated in the plan or programme. The computation of such information will be presented in percentages, similar to the example reflected in Figure 2 below.

Action	Extreme Impact	High Impact	Medium Impact	Low Impact	No Impact
New Road	0%	30%	20%	20%	30%
Urban Expansion	0%	0%	40%	60%	0%

Figure 2.- Example of representation by percentages of the results derived from the analysis of the effects of the plan or programs.

8.- Breakdown of the results in percentages (in relation to possible environmental impacts resulting from the implementation of the plan/programme) allows effective comparison of alternatives as well as definition of spatial indicators that will facilitate the monitoring and auditing phases of SEA. They will also allow identifying objectives for better resource planning (such as the reduction of roads that cross wildlife corridors, etc.)

9.- Results will be presented in a quantitative, comprehensive and graphic format, and will be accompanied by tabulated data and informative text. Thus, the maps derived from the SEA process will present the inter-relation among factors, the advantages, disadvantages and limitations of the plan or programme, as well as the relation among cause and effect - reporting it all in a graphic, fast and concrete way. The representation of the codified results (by colours and with spatially definite variables) will allow fast identification of potential conflicts and viable alternatives, informing the decision-making process and facilitating a general consensus. Likewise the information will be easily scrutinisable by the decision-makers.

Conclusion

It is considered that a computerized, transparent and standardized methodology will:

- Facilitate and accelerate the SEA process;
- Help to secure credibility in decisions;
- Result in a more effective process with regards to time, resource and budget requirements;
- Facilitate EIA processes and regulate individual projects; and
- Contribute to monitoring the implementation of Directive 2001/42/EC at European level.

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