A decision support system for sustainable tourism: the SFIDA project

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Abstract

SFIDA is a project funded by the European Commission within the LIFE – Environment Programme and co-financed by DG Environmental Quality of Regione Lombardia (Italy). The main objective of the project is to develop a Decision Support System (DSS) suited to integrate environmental concerns into the definition of a plan for sustainable tourism for three municipalities located close to Lake Garda. The DSS can be used to generate information and stimulate participation, making the decision transparent, repeatable and participated. The components of the DSS support several phases of the planning process, including the environmental and socio-economic analysis, the definition of the plan procedure, the impact representation, the evaluation and comparison of the alternatives, and the management of the conflict among decision-makers.

Keywords: group decision, decision support systems, participation, negotiation, multi-criteria analysis, WebGIS.

1 Introduction

Decision-making processes for land planning and development are complex, because they usually involve both administrators and a number of stakeholders with different opinions and interests. In this kind of processes economy and society have always been key factors of discussion but, in the last decades, environmental concerns and sustainability issues as well have come to the fore, making administrators and planners aware of the importance of these factors in decision-making. As a consequence, it is necessary to redefine the decision-
making process structure, integrating environmental concerns into the process, and ensuring three essential requirements:

- **Transparency**: a shared information on technical analyses and political decisions is necessary to make the interested subjects aware of what is going on.
- **Repeatability**: the documentation and the software implementation of every step of the process allow to change any element (according for example to newly available information), and go through the process again.
- **Participation**: it is necessary to identify and involve the interested subjects (decision-makers, stakeholders, etc.), supporting the communication with analyses and tools easy to access, understand, and use.

**SFIDA - Sistema Finalizzato all’Integrazione della Dimensione Ambientale** is a project that focuses on the development and application of a system for the integration of environmental concerns into land planning. The project is co-financed by the LIFE – Environment Programme of the European Commission and the General Division for Environmental Quality of Regione Lombardia for the period November 2002 – May 2005, is coordinated by the research centre Centro Ambiente – Poliedra, Politecnico di Milano, and involves three Italian municipalities (Padenghe sul Garda, Pozzolengo, and Sirmione). The main objective of the project is to develop a Decision Support System (DSS) suited to assist the definition of an *inter-municipal plan for sustainable tourism* for the three municipalities involved in the project, which, all very closely located to Lake Garda, suffer various problems related to tourist flows.

For a comprehensive dissertation about the role of DSSs in environmental applications, the reader is referred to Guariso and Werthner [1]. A DSS may be used to support several phases of the land planning process, including the procedure definition, the socio-economic and environmental analysis, the impact analysis, the alternatives evaluation and comparison, and the management of the consequent conflict. Using the DSS can be especially helpful to:

- arrange activities in a logical frame, assigning an active role to every subject involved, and clearly structuring the steps of the process;
- manage communication among decision-makers, planners, and stakeholders;
- organise and stimulate the participation.

This approach has been studied and applied also in the field of environmental impact assessment (see for example Laniado and Muratori [2]).

## 2 The SFIDA DSS components

The SFIDA DSS is designed as a system with a user-friendly interface, easy to understand by a broad range of subjects, and accessible by everyone on the Internet.

The main components of the DSS are:

- a *procedure communication software*, which enables to clearly represent, understand, and communicate the procedure to be undertaken for the plan development; this can be very useful, since plans are often characterised by very complex procedures;
– a data catalogue, which collects information on both socio-economic and environmental data available for the area under analysis;
– an online geographic information system (WebGIS), which enables to generate thematic maps for the socio-economic and environmental analysis, through the collection, logical organisation, elaboration and representation of the relevant data;
– a software for impact representation, which supports the identification of the environmental and socio-economic impacts of the alternatives, basically relating them to the result of cause-condition-effect chains;
– a software for alternatives comparison and conflict management, which enables to compare the alternatives on the basis of their impacts, in the framework of a multi-criteria analysis method, and to manage the conflict due to the presence of a variety of criteria, decision-makers and stakeholders, supporting the consequent negotiation.

The following sections give more information about each component.

3 The SFIDA software for procedure communication

A plan procedure takes into account and organises the steps to be undertaken and the relationships among them, the responsibilities of the different subjects involved, and so on. A useful tool to represent the procedure and support its communication can be a graph, which is a structure made of a finite number of nodes and a finite number of arcs, where every node represents a step of the procedure, differently shaped and coloured depending on the kind of activity and the responsible subjects, while arcs represent logical and temporal relationships. More details (such as activities to be performed, laws, constraints, responsible agencies, and time schedules) may be made accessible through hypertextual browsing of sub-graphs and/or explanatory documents.

The software developed in the project offers tools to design this kind of hypertextual graphs and automatically builds web pages to browse it. The planners can then publish the procedure on a website, making it clear and visible to all the interested subjects, that can check it at any time, being constantly informed about what is going on and who is involved.

The software is being used to support the definition of the procedure of the SFIDA plan for sustainable tourism, which is in progress and will be one of the products of the project. In addition, the same software is also used to represent the methodological scheme of the plan, where each box represents a task and can be clicked to see the sub-scheme that specifies how to perform that task. The scheme can be browsed on the project website.

4 The SFIDA data catalogue

Fundamental requirement of the socio-economic and environmental analysis is the availability of data. Most of the times, it is difficult to obtain information on what data exist, their characteristics, and their availability, because data are
spread among many different institutions, agencies, and other subjects. The main reason for this is the absence of a knowledge-sharing culture. Too often the subjects that produce the data, even if publicly funded, act as owners of the data and impede their diffusion. Such a problem can be addressed giving impulse to a network of databases accessible via the Internet. In addition, it may be very useful to develop online electronic catalogues (meta-databases) which describe the available data and are linked, if possible, to the data download websites.

The SFIDA project has developed a data catalogue directly accessible through the project website. For each data identified, a form consisting of five sections (general information, temporal and spatial coverage, production, accessibility, and comments) was filled. The user can browse the catalogue using a free text search or a guided search. The data catalogued refer not only to the three municipalities involved in the project, but also to some bordering municipalities with regard to relevant aspects, such as traffic and tourist flows. The catalogue forms were filled under close collaboration with the officers responsible for data monitoring and collection; officers were contacted not only in local institutions, but also in regional and national institutions and research centres, as long as the data they collected were referred to, or at least covered, the SFIDA project area (e.g. the data of the Regione Lombardia Geographic Information System).

5 The SFIDA WebGIS

The geographic information system (GIS) for the environmental and socio-economic analysis has to be functional and simple, in order to be used effectively in the participation process. For this reason, in SFIDA the GIS is designed as a light geographic information system, i.e. a tool suited for the specific decision-making problem, accessible on the Internet (WebGIS), and running on regular laptops. Therefore, only the data that are significant for the area and the issues under analysis are included in the GIS database.

In the WebGIS, data are used to calculate indicators that can be visualised in thematic maps. The user may choose between two different paths: the first path offers a list of pre-defined indicators, while the second path, for expert users, allows to estimate the value of customised indicators, which the user may define applying mathematical or logical operators to the data available in the database. Every pre-defined indicator is associated with a form providing information about the data, hypotheses and simple models used to estimate its values, and suggestions for the interpretation.

All indicators are computed, if possible, at the same pre-defined spatial detail, which is based on a zoning of the area under analysis that identifies specific and relatively homogeneous portions of the territory, easily recognisable by everyone. The zoning was carried out for the area under jurisdiction of the three municipalities involved in the project, under close collaboration with their technical offices: for each municipality, about 15 homogeneous areas were defined (fig. 1 shows an example).
The user may choose to calculate the indicators also for any aggregation of the zones, for the municipalities, and for any aggregation of the municipalities. When time series are available, it is also possible to display a chart showing the trend of the indicator.

The WebGIS developed is available on the Internet through the project website, and is linked with the data catalogue, so that the user can easily switch from one tool to the other.

6 The SFIDA software for impact analysis using networks and matrices

The DSS may provide helpful software tools to organise and communicate the logical path relating the plan alternatives to their impacts. For instance, a highway project causes effects on traffic, land use, employment, landscape, etc., but, generally, each effect can in turn be considered a cause of further effects: traffic causes noise and emissions of air pollutants, and emissions cause a change in air quality, which affects, among other things, human health. The logic structure of the cause-effect chains can be represented using networks, in which nodes represent causes and effects and arcs represent cause-effect relationship. When networks get complicated, the same information can be represented in a tree structure that is easier to read. As an example, fig. 2 shows a partial and simplified tree related to a road construction.

To elaborate the information of a cause-effect chain, it is useful to represent each passage between a level of the tree and the following level with a matrix. The cells of the matrix may contain indicators of the entity of the cause-effect relationships, which can be estimated using qualitative or quantitative methods,
based on the level of detail of the alternatives definition, of the significance of the impact, and on the available data.

When the conditions of the cause-effect relationships are specified, the rows and the columns of each matrix have to be further disaggregated. For example, the single cause-effect relationship between air pollutant emissions and concentrations actually is a cause-condition-effect relationship, since it is necessary to consider external conditions (such as the meteorological factors) and the spatial and temporal distributions for both the cause and the effect nodes.

![Figure 2: A simplified tree representing a cause-effect chain related to a road construction.](image)

The software developed in the project offers tools to design this kind of trees. Both nodes and arcs may be differently characterized (by shape, colour, thickness, etc.) depending on their properties, which obviously should be documented. Using a user-friendly interface, it is possible to add, remove or modify nodes and arcs. It also allows to switch to matrix representation, in which causes are shown on columns, effects on rows and their relationships (i.e. indicators) in the cells. Matrices showing subsequent levels are linked and it is possible to switch from one to another.

The matrices can then be processed through successive aggregation steps to generate an impact vector for each alternative, as described in Laniado and Muratori [2]. Placing the column vectors related to every alternative side by side, an evaluation matrix is obtained, which is the input required by the next phase of alternatives comparison.
7 The SFIDA software for alternatives comparison and conflict management

Methods used to compare different alternatives on the basis of multiple criteria usually attempt to determine directly the final choice, ranking the alternatives on the basis of a specific logic (an overview of methods for multi-criteria decision-making can be found in Gal et al. [3]). It might prove more useful to invert such an approach: the joint analysis of all the rankings generated with the different logics, together with the sensitivity analysis, highlights the conflicts between the alternatives. Instead of directly looking for the best alternative, more sensible would be to use such information to gradually eliminate the worst, or at least the less satisfactory alternatives.

It is often important to take into account the conflicts among the social groups involved, who usually voice different interests, opinions, and reference value systems. Of course conflicts cannot be solved analytically, but an analytical support to negotiation, consisting mainly in giving clear information, can be very helpful and constitute the basis for negotiation (see for example Kersten [4]).

The easiest way to give information on the social conflict is to compute a series of indexes, for instance related to the more disagreeing subjects, the conflicting elements and the degree of consent of a choice, and the negotiability margins (see for example Colorni et al. [5]).

Pointing out the most critical and conflicting elements of the alternatives can also help to generate new alternatives, which can be similar to previous ones (maybe with some changes and/or mitigation measures), or totally different. Therefore, the process of choice among alternatives taking into account multiple criteria and involving multiple stakeholders and decision-makers becomes an interactive procedure, possibly converging to a consensus solution.

The DSS developed for the SFIDA project includes a software tool (whose previous basic version is described in Colorni et al. [6]) that allows to perform a comparison among alternatives using the Multi Attribute Value Theory (Keeney and Raiffa [7]), and moreover supports sensitivity analysis and conflict management.

The following short notes summarise its main functions:

- **definition of alternatives and evaluation criteria:** it structures the evaluation criteria in a tree and the alternatives in a list;
- **management of the evaluation matrix:** it manages the matrices representing the impacts of the alternatives, allowing the user to change both contents and representation (tables/graphs);
- **definition of value functions,** which express the level of satisfaction of the decision-makers and/or the subjects involved; the software manages the functions allowing to change their parameters;
- **attribution of weights:** through a graphical interface it allows to assign coefficients of relative importance (weights) directly on the criteria tree; this vector of weights can be defined by each subject involved, in order to calculate the ranking for the different points of view;
– *ranking of the alternatives*: it calculates and displays the ranking of the alternatives, obtained through a weighted sum;
– *sensitivity analysis*: it shows how the ranking varies depending on the chosen weights, giving indications on the robustness of the ranking; in particular, this tool allows to identify a critical weight interval, outside of which the ranking, and consequently the top ranked alternative, would change, as a function of the weight vector. Fig. 3 shows one of the graphical interfaces to perform sensitivity analysis and communicate its results.
– *conflict analysis*: it calculates indexes of conflict among the decision-makers and/or the subjects involved, based on the distances among the weight vectors they assigned to the criteria, and allows them to change the parameters they expressed, in a iterative way, until they reach a consensus.

The software has not been used in the SFIDA project yet, since, as of the writing of this paper, its implementation is in progress.

Figure 3:  Graphical interface to perform and represent the sensitivity analysis.

8 Conclusions

The focus of the SFIDA project is not only to design and develop the software described in this paper, but also to test it in a real planning process. The use of these tools intends to make more transparent, repeatable and participated the decision-making process. For this purpose, the tools are designed to be easy to understand and use and are accessible via the Internet. The project website itself (www.sfida-life.it) is a tool to stimulate the participation and manage the communication, making available not only the software but also an online forum
and relevant project documents, including meeting minutes and presentations, technical reports, and activity plans.

The application of the system within a participated process for the plan for sustainable tourism will test its potentiality and will identify its limitations. Towards the end of the project, the DSS will be presented in a workshop where its transferability to other cases (e.g. Local Agenda 21 processes) will be discussed.

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