



The main objective of the **SFIDA Project** (November 2002-July 2005) was to design, implement and test a set of software tools for communication, information and decision support, that facilitate the integration of **environmental concerns** and **participation** in public decision-making processes.

The project was funded by the LIFE-Environment financial instrument of the European Community and by the General Directorate for Environmental Quality of Regione Lombardia. The project partners are the Consortium **Poliedra-Politecnico di Milano**, the Sustainable Development Unit of **Regione Lombardia**, and the **Sirmione, Padenghe sul Garda and Pozzolengo** Italian Municipalities in the Brescia province.



The **Decision Support System (DSS)** was created and tested within the development of strategic options for sustainable tourism in the three partner Municipalities. The methodology used supports participation, transparency and traceability in the entire decision-making process.



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# progetto sfida



**ENVIRONMENTAL SUSTAINABILITY  
AND PARTICIPATION**  
METHODS AND TOOLS TO SUPPORT  
DECISION-MAKING PROCESSES

## The methodology

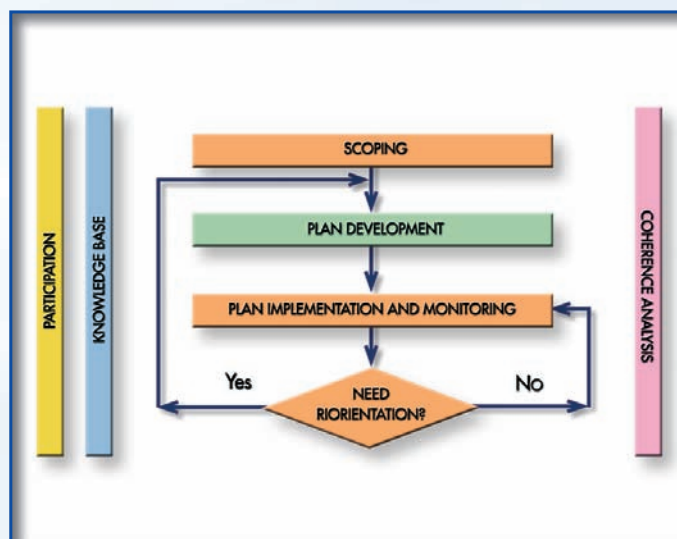
Public decision-making processes involve interconnected policies, plans, programs and projects, each with its own procedural autonomy. All must provide for the integration of environmental concerns and for the active participation of interested parties. The complexity and variability of the context require flexibility and the capability to periodically reorient the process.

In response to these needs, a Decision Support System (DSS) was designed and created in the SFIDA Project. The DSS was tested for the development of strategic options for a sustainable tourism plan. A methodology that considers the entire life cycle of the plan was proposed. The phases of the methodology are the following.

**Scoping:** plan influence area is identified, preliminary analyses are performed and general principles to set up the plan activities are defined.

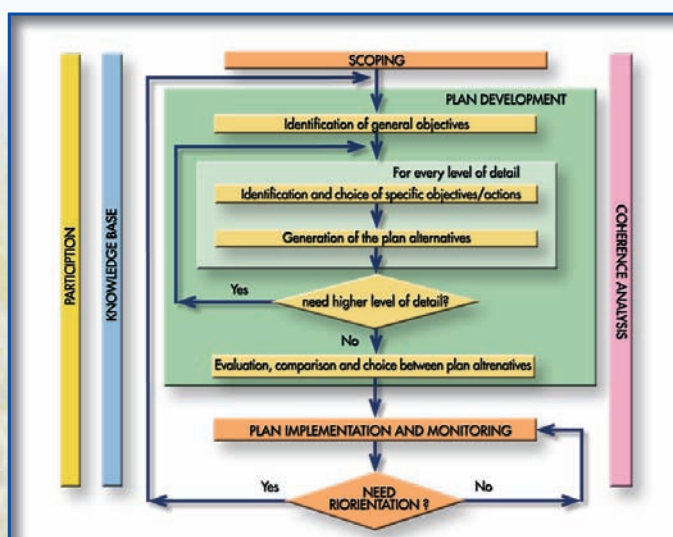
**Plan development:** general objectives are identified, specific objectives and actions are defined and selected, plan alternatives are generated, their effects are determined and estimated, and the alternatives are compared to make a choice.

These steps can be repeated to attain the required level of detail and operational accuracy.



*The methodological scheme*

It is also necessary to design a system to monitor the plan implementation and its effects. The **monitoring** activities will allow to reorient the decisions if the effects or the context are not as predicted.



*The methodological scheme: details*

Furthermore, some elements characterise the entire decision-making process and are present in every phase. These include: **participation**, aimed at guaranteeing all interested parties the possibility to express their opinions and proposals; **knowledge base**, which contains all the information useful for the decision-making process; **coherence analysis**, which points out contradictions between policies, plans and programs, and clarifies each phase of the process.

# The Decision Support System

The software tools developed in SFIDA constitute a **Decision Support System (DSS)** for the generation and management of information needed in the decision-making process.

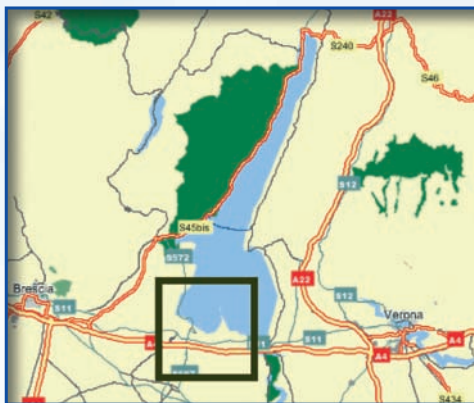
This set of tools allows for the implementation of a shared knowledge base, the introduction of rationality elements in the decision-making process through organisation of the activities, and the establishment of conditions for active participation in the process. The public is given the opportunity and ability to examine the analyses and choices made in the process and can express points of view, ideas and preferences.

The DSS makes the entire decision-making process **transparent and repeatable** with regards to both the procedure and the contents of studies and analyses. The DSS cannot eliminate the subjective factors of the process, but it rationally organises the logical path and the information necessary for an informed and responsible decision.

Several activities related to the decision-making process can be supported by the DSS: organisation, transparency and communication; access to information and data analyses; generation of plan alternatives; estimation of the effects; evaluation and comparison of plan alternatives and negotiation between interested parties.

<b>Organisation, transparency and communication of the process</b>	<ul style="list-style-type: none"><li>● Logbook</li><li>○ Transparency of the procedures</li><li>○ Actors map</li></ul>
<b>Access to information and data analysis</b>	<ul style="list-style-type: none"><li>● Data catalogue</li><li>● Light information system</li></ul>
<b>Building of the alternatives</b>	<ul style="list-style-type: none"><li>● Generation of actions and alternatives</li></ul>
<b>Estimation of the effects</b>	<ul style="list-style-type: none"><li>● Representation of cause-effect chains</li><li>● Representation of the procedures and of the results of the effects estimation</li></ul>
<b>Choice among alternatives and support to negotiation</b>	<ul style="list-style-type: none"><li>● Evaluation and comparison among alternatives and conflict analysis and management</li></ul>

## The Case Study



The DSS has been tested to support a **participated planning process** in Sirmione, Padenghe sul Garda and Pozzolengo, the three Italian partner Municipalities close to Lake Garda. The focus of the case study is the development of sustainable **tourism** strategies. This subject is particularly interesting because of its many related topics: when tackling tourism issues it is possible to coordinate decisions about land use, mobility, environmental quality, and so forth.

Based on preliminary analyses and public participation, a particular aspect of each municipality has been studied in greater depth: in **Sirmione**, the definition and assessment of alternative options for the mobility system; in **Padenghe sul Garda**, the conservation and promotion of inland and coastal areas; in **Pozzolengo**, the definition of a shared vision of future tourism strategies.



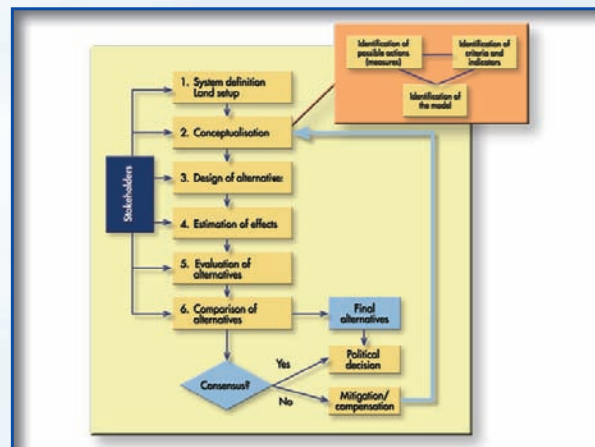
## Process transparency and communication

### Why a logbook?

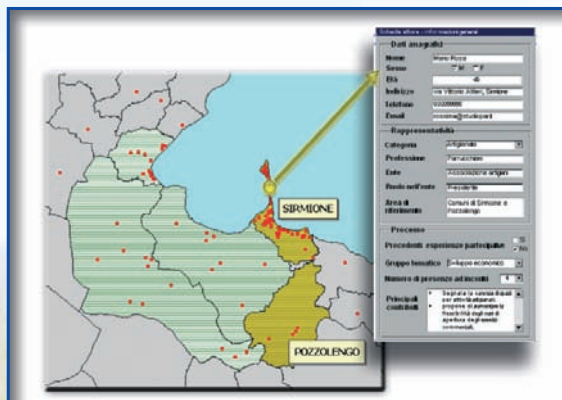
To track the decision-making process and to ensure its transparency, the activities and achievements of the process must be shared as they happen. This gives several benefits. First, those involved or affected can follow the process step by step and they can verify if their comments and suggestions have been considered. Second, as a result of the first benefit, they will be motivated to propose new ideas and express opinions on the matters in discussion. These benefits can be provided by an Internet “logbook” that contains a schematic representation of the decision-making process, a description of who is involved, and the documents created during the process.

### How to build the logbook?

**Flowcharts** that are easy to read and browse can represent decision-making procedures effectively. Nodes represent the individual activities and are connected by arcs that indicate the time sequence and logical path that the activities follow. Each node can be linked to documents with more detail on the activity (e.g. task manager, people involved, duration, and other references).



Flowchart representation of main activities.  
Each activity has a link to sub-charts  
for minor activities



Example of actors map

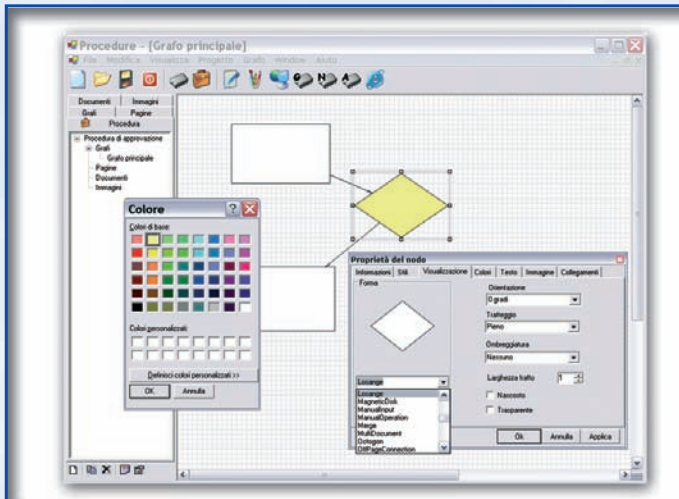
During the decision-making process, documents (e.g. reports, meeting minutes, pictures) describing how the activities are performed can be attached to the flowcharts. Also the actors map can be associated with information on which events a person has attended and reports containing that person's contributions.

The critical task is to regularly update the logbook. An up-to-date logbook keeps people well informed, facilitates active participation in the decision-making process and allows to receive opinions and suggestions for the following phases of the process.

# The STRARIPA software

The SFIDA logbook was developed using STRARIPA (the Italian acronym for "software tool for transparency, repeatability and participation").

Through its user-friendly interface, STRARIPA can build the procedure flowcharts and create and update web pages that contain the flowcharts and all the documentation associated with the activity nodes.



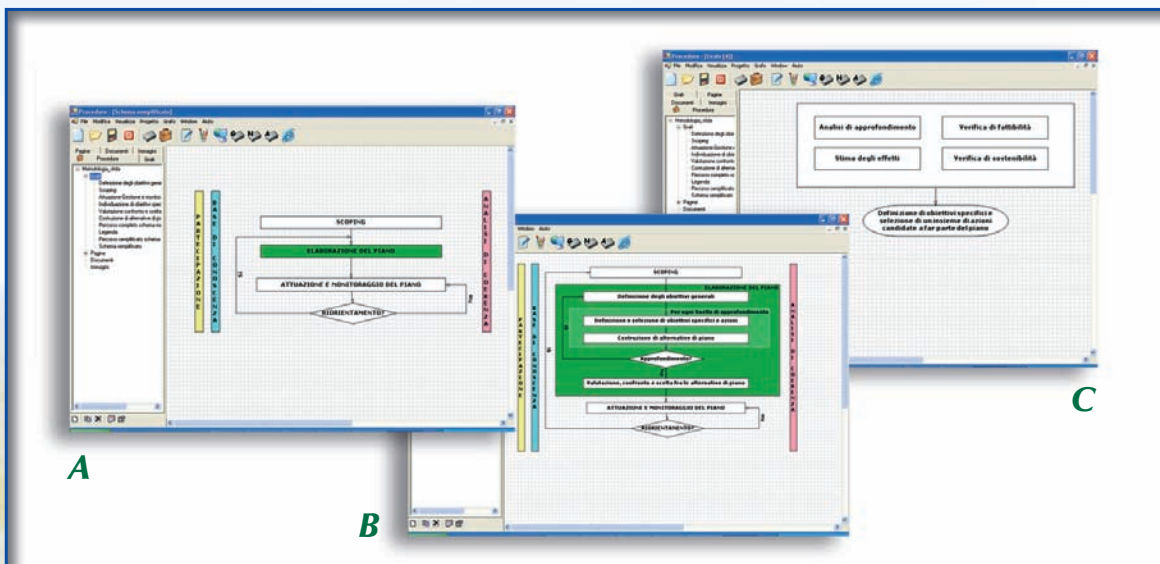
*Building a flowchart: setting node properties*

STRARIPA can create nodes with customised properties. This enables representation of the activities properties in a visual way. The user can choose the shape, orientation, colour and text format of the node. For example: the colour could represent the stakeholders responsible for the activity (e.g. public administrations, agencies, citizens), while the shape could indicate the type of activity (e.g. technical studies, consultations, decisions).

This software was used to design the **flowchart of the methodology** proposed in the SFIDA project. Every node in the flowchart was assigned the documentation produced during the project.

The foreground figure shows the SFIDA methodology phases.

Clicking on the "plan development" node reveals the sub-charts of the corresponding activities. Clicking on any node of the sub-charts reveals information on related sub-activities.



*A. Graph of the SFIDA methodology*

*B. Expansion of the activities of the "plan development" phase*

*C. Sub-chart of the activity "definition of specific objectives and actions"*

STRARIPA was developed using Visual Basic .NET.

## Access to information

### Why share information?

Relevant and quality information must be easily available to promote a participated decision-making process. However, there are obstacles to overcome, such as dispersion and heterogeneity of the data, and lack of a knowledge-sharing culture, even in public administrations.

These obstacles make it difficult to collect existing baseline information on territorial, environmental, economic and social matters. The **“data catalogue”** helps to collect and analyse such information and enables the users to browse it on the Internet.

### How to catalogue the data?

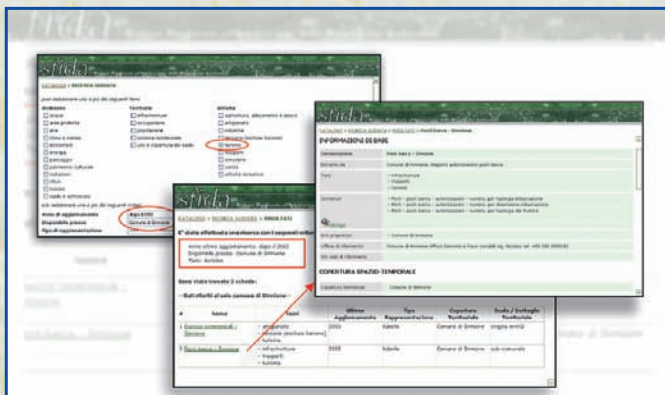
The data sources can be classified into a **“meta-database”** which describes the available data and possibly permits direct access to it. The information on the data is structured into sections (such as “temporal and spatial characteristics”, “production”, “access”). Each section contains fields which provide specific information on every aspect.

### How to use the catalogue?

The data catalogue can be browsed by using an online search engine, which has an easy to use interface and offers several search options. Once a user has specified an area of interest, (s)he can make a **free text search** or a **keyword search**.



The keyword search can be carried out in two ways: the **guided search** is the simplest method since it only requires specifying main keywords; the **advanced search** uses more complex and flexible queries on any fields of the catalogue. It is possible to narrow the search result by applying cascade criteria or even applying a different type of search.



The search result is shown in a preview page containing a list of the matching data. Each element of the list is briefly described with the essential characteristics (e.g. keywords, last update year, coverage) and is linked to the web page containing the entire information on the data.

*Interface of the catalogue:  
search form, result preview page,  
data information*

# The SFIDA data catalogue

The SFIDA **data catalogue**, which is browsable online through the project website, allows access to information on the national through local level data that are available for the Sirmione, Padenghe sul Garda and Pozzolengo municipalities. The **keywords** used as search criteria are **themes** classified in "environment", "territory" and "activities", as showed in the figure below.

Environment	Territory	Activities
<input type="checkbox"/> water	<input type="checkbox"/> infrastructures	<input type="checkbox"/> agriculture, breeding and fishery
<input type="checkbox"/> conservation areas	<input type="checkbox"/> occupation	<input type="checkbox"/> crafts
<input type="checkbox"/> air	<input type="checkbox"/> population	<input type="checkbox"/> industry
<input type="checkbox"/> climate and meteorology	<input type="checkbox"/> residential system	<input type="checkbox"/> tertiary (without tourism)
<input type="checkbox"/> ecosystems	<input type="checkbox"/> land use	<input type="checkbox"/> tourism
<input type="checkbox"/> energy		<input type="checkbox"/> transport
<input type="checkbox"/> landscape		<input type="checkbox"/> education
<input type="checkbox"/> cultural heritage		<input type="checkbox"/> health system
<input type="checkbox"/> radiation		<input type="checkbox"/> recreation
<input type="checkbox"/> waste		
<input type="checkbox"/> noise		
<input type="checkbox"/> soil		

It is also possible to search the data by specifying such **criteria** as: "update year", "available at", "data type", "area".

Running a search generates a results preview page with the links to the individual data pages, arranged in descending order of relevancy to the query as determined by the search engine. The data information pages are organised in the following sections: general information, temporal and spatial coverage, production, access, and notes.

#	Nome	Temi	Ultimo Aggiornamento	Tipo Rappresentazione	Copertura Territoriale	Scala / Dettaglio Territoriale
1	Ingressi alla Villa Romana - Sirmione (Elaborazioni SIG)	- patrimonio culturale - turismo	2003	tabella e grafico	Comune di Sirmione	singola entità
2	Busli auto disponibili (Elaborazioni SIG)	- trasporti	2003	GIS e tabelle	Comune di Sirmione	singola entità
3	Isola di Padenghe - Sirmione (Elaborazioni SIG)	- trasporti - turismo	2003	tabella e grafico	Comune di Sirmione	comunale
4	Area verde (Elaborazioni SIG)	- ecosistemi	2003	GIS e tabelle	Comuni di Padenghe sul Garda e Sirmione	singola entità
5	Salmidaglia Inglese (Elaborazioni SIG)	- acque	2003	GIS e tabelle	Comuni di Padenghe sul Garda e Sirmione	singola entità

Example of a result preview page

GENERAL INFORMATION	PRODUCTION
NAME	PRODUCED BY
DATA SOURCE	DATA TYPE
THEMES	GEOLOCATION
CONTENTS	ELABORATION
OWNED BY	PROGRESS
REFERENCE OFFICE	SUPPORT TYPE
REFERENCE WEB SITES	FILE TYPE
SPACE COVERAGE	
MAXIMUM LEVEL OF SPACE DETAIL	
OTHER LEVELS OF SPACE DETAIL	
MAXIMUM SCALE	
OTHER SCALES	
LATEST UPDATE	
TIME SERIES: FIRST YEAR	ACCESS TYPE
TIME SERIES: LAST YEAR	ACCESS WEBSITE
TIME SERIES: DURATION	FILE TYPE
INTERVAL	AVAILABLE AT
TEMPORAL AGGREGATIONS	COST
	LATEST PUBLICATION

List of catalogue fields in each section

Each section contains some **codified** fields that use short text to record basic information and **descriptive** free text fields for additional explanatory remarks. When the page is initially opened, only the codified fields content appears, then the user can also access the descriptive fields through hypertext links.

When possible, the catalogue provides also direct links to the data so that it can be viewed and downloaded.

The prototype uses a relational database implemented in Microsoft Access. The search engine was developed using ASP and Visual Basic languages.

# Understanding the territory

## Why a "light" information system ?

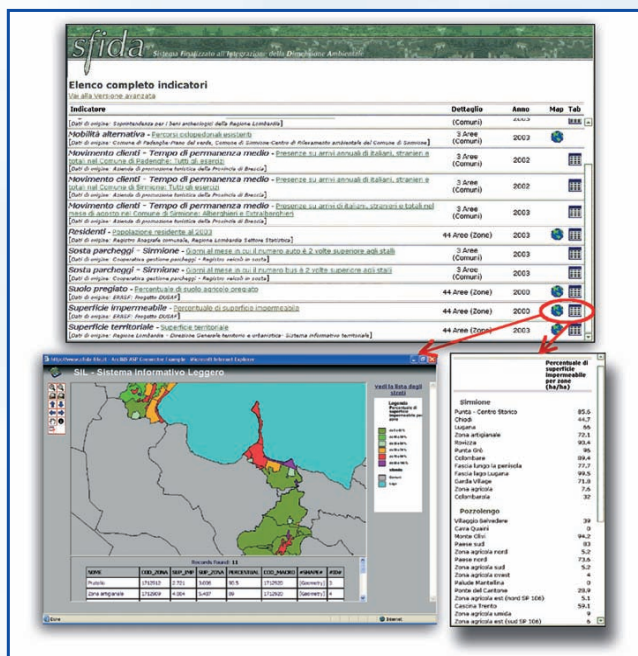
In order to understand the characteristics of a land area (e.g. region, municipality or town) and predict its evolution, it is necessary to analyse the existing data and calculate indicators related to the activities, the pressures and the state of the environment. This analysis can be facilitated by using a **light information system** created with WebGIS technology. The light information system allows indicators to be defined, calculated and published on the Internet. Using the georeferenced data contained in the system, it is possible to perform typical GIS spatial analyses and functionalities, such as area identification, queries or map overlaying.

The term "light" means that the system contains only the data significant to the given decision-making problem or plan, is accessible on the Internet, can run on a regular laptop, is user-friendly and does not require specific knowledge of the software. This simplifies data access and is important for the participation process.

## How to use it?

The light information system provides **default indicators** and shows their spatial distribution on thematic maps. Related time series, if available, are presented using tables or graphs that show temporal trends. The system administrator uses the software to calculate the default indicators from the data. Users can then view the calculated results by selecting a theme, area of interest and spatial aggregation level.

The WebGIS technology can also be used to calculate and represent **user-defined indicators**. The user can select from the system the data needed to calculate the indicator, and then specify how to combine the data with logical operators and mathematical expressions.



An indicator is shown in a thematic map and in a table

## How to manage it?

Developing and maintaining a light information system on the Internet requires specific skills in database and WebGIS technologies. Building the system is a complex task involving data collection, creation and personalization of the user interface, definition of the thematic maps features, definition and calculation of default indicators for different spatial details, and selection of background layers used for map comprehension.

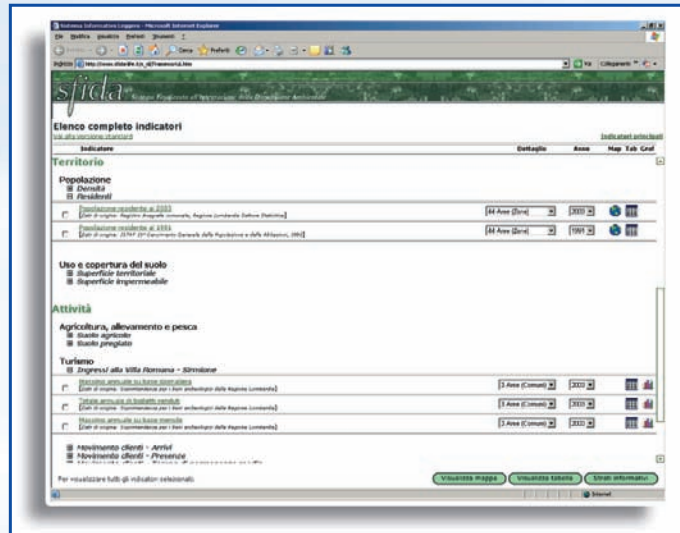
Creation of a user-friendly interface that automates most of the tasks needed to build the system and update the data can greatly simplify operations for functionaries and technicians.



# The SFIDA light information system

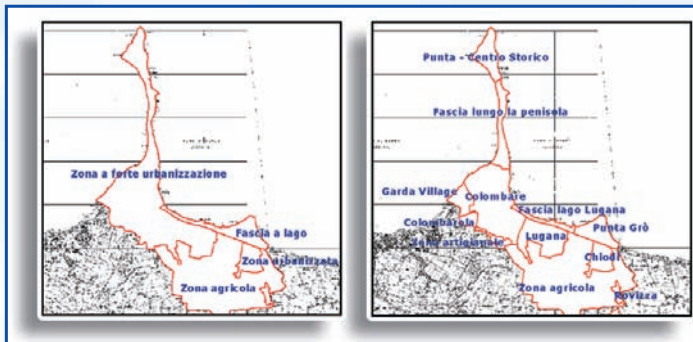
The SFIDA **light information system** contains indicators related to the area of Sirmione, Padenghe sul Garda and Pozzolengo. Indicators may be viewed in thematic **maps**, **tables** or **graphs**. The system presents a hierarchical list of default indicators, divided first into the three data catalogue categories (environment, territory and activities), then into subcategories that can be easily browsed by clicking the plus sign to their left.

Each indicator is documented in the data catalogue with information describing how the indicator is calculated from the data and links to the original data information pages.



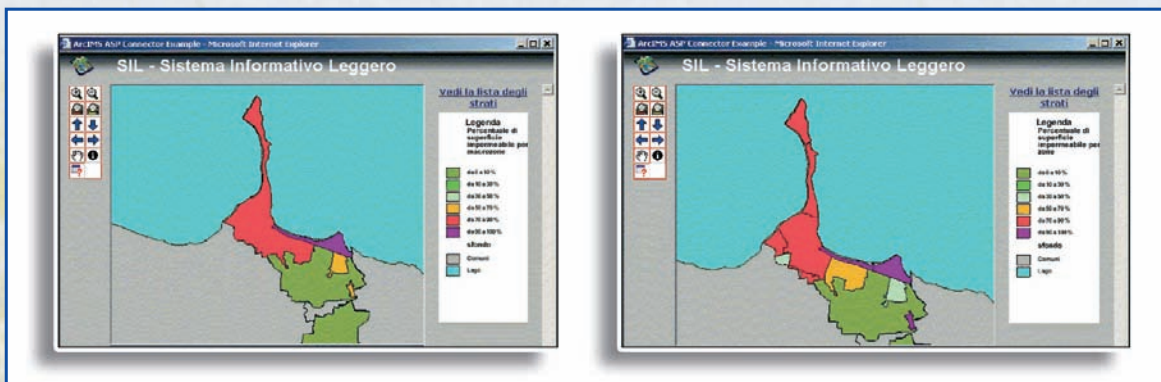
On the right, a light information system page allowing to select the indicators

Indicators can be displayed at different **spatial aggregation levels**: municipalities, macrozones, and zones. The zoning of the municipal territory was determined based on land use and data availability.



For example, the Sirmione municipality territory has 4 macrozones, which are then subdivided into 12 zones as shown on the left.

The maps below represent the "percentage of impermeable surface" indicator for the macrozones and zones.



The prototype was developed using ESRI ArcIMS software, which allows georeferenced data to be displayed on the Internet. The end user can view the maps with a web browser.

## Building the alternatives

The generation of plan alternatives involves identifying and combining action proposals in order to meet plan objectives. An active involvement in the process by the stakeholders and the public is essential in the development of viable alternatives. Participation can be facilitated using a software tool that simulates building alternatives from a catalogue of proposed actions and modifying existing ones.

### How to document the actions?

In order to generate the plan alternatives, it is necessary to understand and document the characteristics of the proposed **actions**, which can usually be classified by type (for example, land use regulations, incentives, infrastructures, and so forth).

The characteristics of the actions may be described in an **online catalogue**. It is particularly important to document the feasibility of an action, in terms of available technology, financial resources and other criteria. The sustainability of the action's effects must also be documented, considering its strengths and weaknesses and the presence of incompatible, synergic or complementary actions.

The catalogue must also be searchable by, for example, objective, sector and location.

GENERAL INFORMATION	NAME	EFFECTS ANALYSIS	POTENTIAL EFFECTS
	ACTION TYPE		MITIGATION ACTIONS
	SECTOR		DOCUMENTATION ON EFFECTS ESTIMATES
	LOCATION	RELATION WITH OTHER ACTIONS	COMPLEMENTARY ACTIONS
	DESCRIPTION		SUGGESTED ACTIONS
	VISIONS		UNSUITABLE ACTIONS
	GENERAL OBJECTIVES		INCOMPATIBLE ACTIONS
	SPECIFIC OBJECTIVES		
	PROGRESS		
	COST AND FINANCING SOURCES		
NOTES			

*List of possible catalogue sections and fields*

### How to build the viable alternatives?

Starting from the online action proposals catalogue, the software supports the generation of plan **alternatives**, providing several ways to read the available information.

Depending on the relations among the actions, the software can indicate which actions to consider or exclude based on the actions previously selected by the user.

In the software each action can be associated with one or more strategic visions. By combining action proposals related to the same vision, it is possible to build alternatives that accomplish that vision. These alternatives can then be suggested as a starting point for discussion. During the participation process, stakeholders and the public may build alternatives combining actions not necessarily associated with the same vision. The software can then determine the compatibility of these alternatives to each vision.

It is possible to determine the sustainability of the alternatives by studying the combined estimated positive and negative effects caused by their actions. Sustainability can also be analysed from the effects side. For example, it is possible to identify a set of actions that cause a particular negative effect and from there define the appropriate corrections or mitigations.

# The SCOVA software

SCOVA (the Italian acronym for “software for alternatives and visions building”) was developed for the Pozzolengo case study to define action proposals and to build alternatives related to future visions of tourism development.

Each action is catalogued using a form with information on potential positive and negative effects on tourism, environment, local economics, financial aspects, society, transport and other services.

The actions in the catalogue can be classified by their related strategic visions and sorted by sector (tourist accommodations, land use, activities and services, and mobility) or by general objectives (improving tourist attractiveness, protecting the territory’s environment, guaranteeing a good local economy, improving quality of life, and managing the mobility system).



SCOVA homepage



Example of an action’s general information

List of an action’s potential effects

**ACTIONS**

- Order by sector
- Order by general objective

- Accommodation capacity
- Land planning
- Activities & services
  - Sport activities in natural areas
  - Itineraries and guided tours
  - Typical local products
- Cultural activities
- Mobility system
  - Parking location and dimensioning
  - Traffic control
  - No access to historical centre
  - No access to peninsula

With SCOVA, existing alternatives can be browsed and new alternatives can be built by selecting action proposals from a hierarchical list. Each alternative is defined by a name, a brief description and its set of actions. The software can automatically create a report of the effects of each alternative.

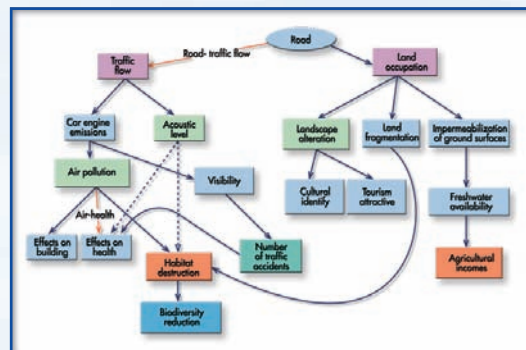
On the left, an actions list ordered by sector

The SCOVA prototype uses a relational database implemented in Microsoft Access. The interface was developed using ASP .NET language.

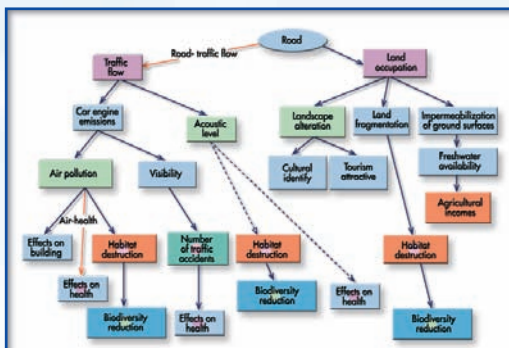
## Representation of the cause-effect relations

In order to evaluate territorial, environmental, economical and social effects of the plan actions it is necessary to understand their causes, possibly with a detailed reconstruction of the “**cause-effect chains**”, where each effect can be a cause for further effects. Cause-effect chain analysis is a complex task and it requires a high level of transparency. With this aim, three different representations of the same information can be used: **graphs**, **trees** or **matrices**. The choice of the representation depends on the application. Communication of the analysis can be done by publishing the representation on the Internet together with all the related available information.

**Graphs** are hierarchical structures made of a set of nodes (rectangles in the figure) and arcs (arrows). Nodes represent causes and/or effects and the arcs are relations between two nodes. For example, the first level of a graph structure may be composed by nodes that represent determinants, the second may be referred to pressures and the third to the state of the environment. Nodes and arcs can be associated with appropriate documentation (e.g. manuals and guidelines, information on data, availability of evaluation models, links to websites).



Example of a graph



Example of a tree

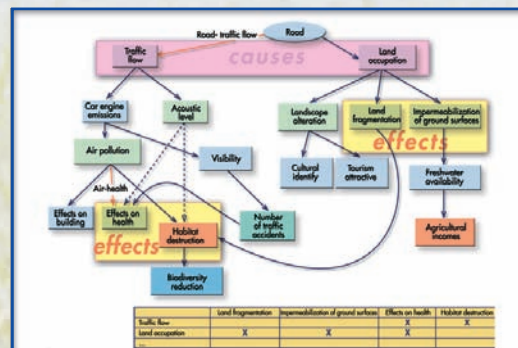
Graph interpretation may become more difficult when different causes impact on the same effect: if there are multiple intersections among the arcs, a **tree** structure can be used. In the tree, the nodes where more arcs converge are duplicated; each node can have multiple effects, but no more than one cause. Compared to the graph structure, the tree structure is less compact, but permits an easier interpretation of the logical paths that connect a cause and an effect, whatever their distance in the chain is.

Cause-effect relations can be represented also using **matrices**, each one having a set of causes on one dimension and a set of effects on the other. The cells indicate the existence of a relation between the row and the column element.

The entire information contained in a graph or tree can be represented with a sequence of matrices, one for each pair of successive levels.

Furthermore it is possible to define matrices through a customized selection of nodes to be considered the causes and the effects.

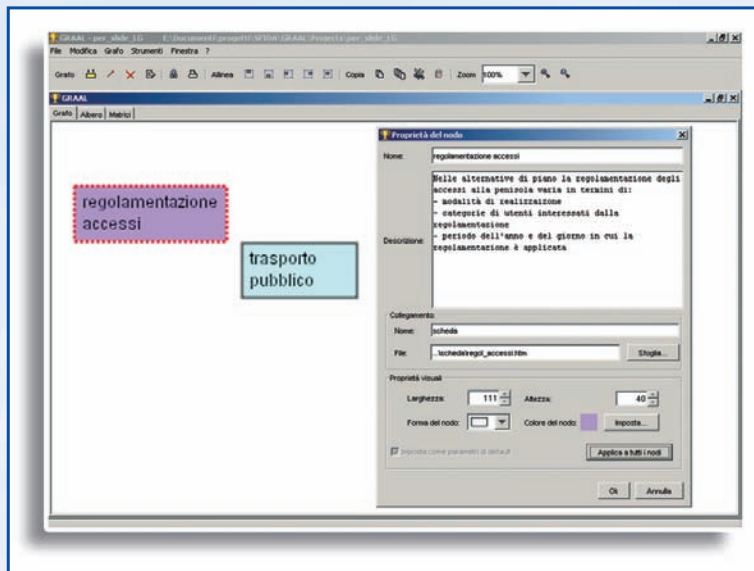
Matrices are the most adequate support in order to represent the results of the effects evaluation phase and to provide a basis for further elaborations.



Graph with a customised selection of causes and effects and correspondent matrix

# The GRAAL software

**GRAAL** (the Italian acronym for “graphs and trees”) was developed in the SFIDA project to aid functionaries and technicians to create graphs, trees and matrices, produce documentation and export such objects to browsable web pages. With GRAAL the user can easily switch from a representation to another with no loss of information.



*Building a graph: setting node properties*

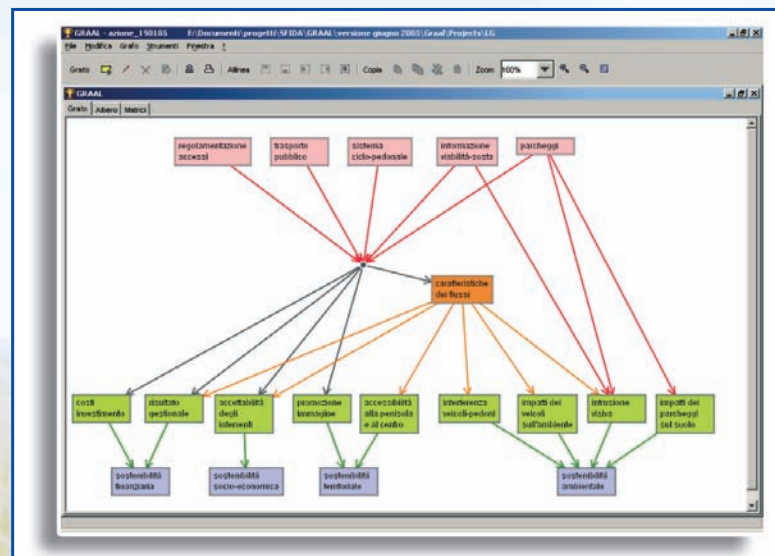
For an effective communication, it is possible to customise properties and characteristics of each element of a graph (e.g. text, dimension, colour, border, shape). Doing so, the user can highlight, for example, the level of relevance of causes/effects choosing different colours for the nodes, or the presence of estimates obtained from mathematical models, setting the thickness of the related arc.

GRAAL was used to draw the graph on the right, which concerns **the alternative options for the mobility system** in Sirmione.

Red nodes represent actions, while green nodes represent the effects of such actions. The effects are then grouped by financial, socio-economical, territorial and environmental sustainability (purple nodes).

Some of the effects depend on the alternative as a whole, represented by the grey dot.

Note that, in order to estimate some of the effects, it is necessary to model first the vehicular and pedestrian flows (orange node).



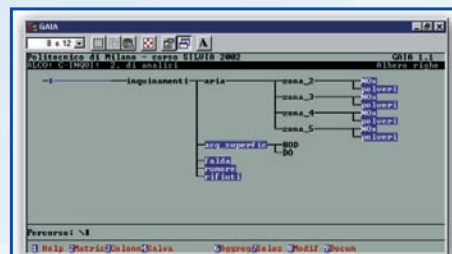
*An example of graph: cause-effect chains related to the alternative options for the mobility system in Sirmione*

GRAAL was developed using Java language.

## Representation of the procedure and of the results of the effects estimation

Often, in order to measure a phenomenon, the estimates of the phenomenon impacts must be expressed at an highly disaggregated level (in time, in space, by sectors or particular situations, and so forth). To do this, **cause-condition-effect** relationships are used. The disaggregated data can be organised into trees for ease of understanding and can also be put into a cause-condition-effect matrix. In order to keep track of the operations performed, the matrix cells may be associated with documentation relating the hypotheses made, the models used and the results obtained.

The matrix can contain quantitative estimates (deriving from mathematical models) and qualitative estimates. The qualitative information can be transformed into numbers through conversion tables (**vocabularies**), which assign a numerical value to each qualitative expression.



Above, an example of a tree for causes disaggregation; below, an example of a cause-condition-effect matrix

## How to produce a synthetic representation of the effects?

Matrices resulting from data disaggregation are often large. Such size makes interpretation of the data difficult. As a result, **re-aggregations** are used. When the effects on a certain indicator are estimated independently for each cause, the cumulated effect may be computed through simple operations, such as sum, mean or maximum. In some cases, effects simultaneously produced by a set of causes need to be estimated through complex models which use temporal dynamics and non-linear theory.

To reduce the number of indicators representing the effects, aggregate indices can be made by combining a set of indicators by logical or mathematical operators.

An example of a vector of the effects of an alternative

The ultimate goal for aggregation is representing the measurements of the effects of each alternative in a vector, that is a single column composed of as many cells as the number of the indicators or indexes resulting by the aggregation activity.

The evaluation matrix, which reproduces the alternatives on one dimension and the indicators on the other one, is obtained laying such vectors side by side.

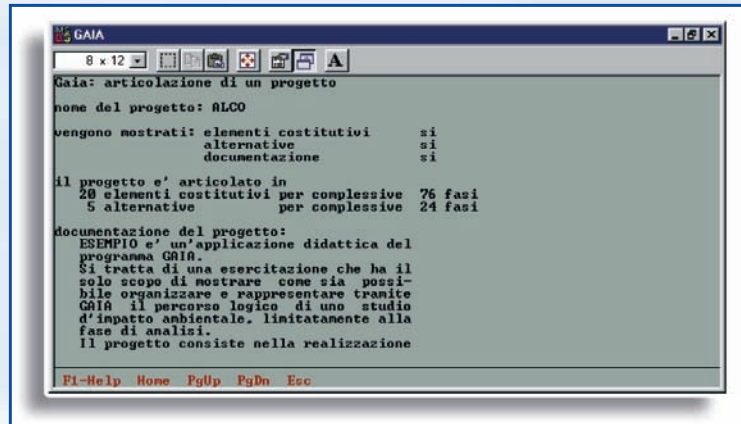
The matrix is the basis for evaluating and comparing the alternatives.

The base scenario, also known as **do nothing alternative**, which represents the development of indicators in absence of plan actions, can be included in the set of alternatives.

An example of an evaluation matrix

## The GAIA software

GAIA (the Italian acronym for “guide for environmental impact analysis”) was originally developed with the aim of supporting the estimation of the impacts and the creation of the evaluation matrix in Environmental Impact Assessment processes. However, it may be used within every decision-making process requiring the representation of the procedures and of the estimation of the effects.



*GAIA screenshot for a project description*

GAIA is an electronic spreadsheet which represents cause-condition-effect chains by matrices, whose rows and columns represent the components of disaggregation trees at the desired level of detail. Each matrix's cell may contain both quantitative and qualitative estimates, either obtained from databases and simulation models or provided by experts. It is also possible to add documentation that tracks data sources and procedures followed.

	sbancamenti	cantiere	pavimentazio	traffico	pavimentazio
acque.superf suolo	.5		.1	.4	.1
inq.atm entita .mod	.3	4	0	.9	.1
armonia.paes				400	
traf.pesante	10	3			
congestione	500	50	30		150
costi	100	40			
occupazione					

*GAIA screenshot reporting relationships among causes (the different activities for the realisation of a road) and effects (on environment, landscape, traffic and economy)*

The main functions GAIA offers on trees and matrices are:

- building and modifying trees and adding documentation;
- defining rows and columns of the matrices;
- inserting and modifying estimates of the effects and adding documentation;
- aggregating rows and columns of the matrices.

For each alternative, these operations allow to produce a column vector representing the impact estimates. GAIA automatically builds the evaluation matrix, where the columns are the alternatives and each rows is a complete set of indicators.

GAIA dates back to 1991 and requires the MS-DOS operating system. A GAIA version compatible with modern operating systems is now being designed.

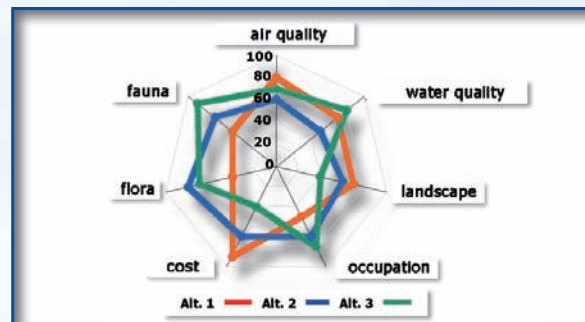
# Evaluation of the alternatives and conflict management

## How to compare the alternatives?

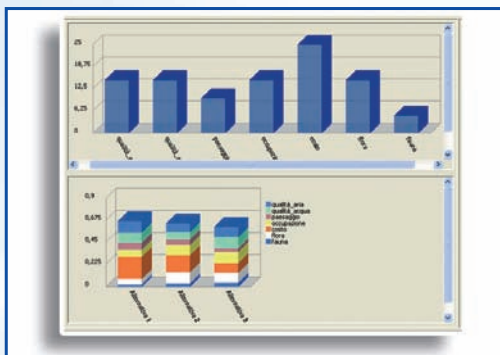
The goals considered in a decision-making process often conflict with each other – thus there is no one optimal solution, nor a solution where everyone's desires are met.

The comparison among alternatives can be a flexible and dynamic process, during which the maximum amount of information is generated through repeated investigations. Some alternatives might turn out to be unrealistic and thus rejected, therefore efforts can be concentrated on creating new alternatives or developing mitigation to the existing ones.

The first way to produce information consists in putting on a **radar diagram** the level of satisfaction produced by each alternative on each indicator. The diagram is made of as many oriented semi-axes as the indicators considered. The farther the position of the alternative from the origin of the semi-axes, the higher the satisfaction it produces.



An example of a radar diagram



Graphical representation of the weights (above) and the corresponding rankings (below)

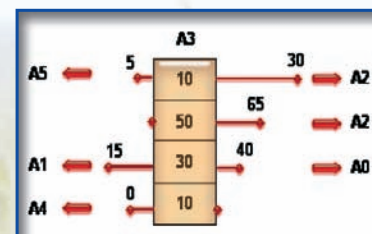
**Synthetic indexes** can be created to supply comprehensive indication of each alternative behaviour. Different logics may be used, the most common of which are sensitive either to the average performance or to risk and imbalance.

Frequently the weighted sum index is chosen: every objective is assigned a weight reflecting its relative importance with respect to the others. Computing the weighted sum index for the whole set of alternatives allows their rankings to be determined.

## How to face uncertainty and subjectivity?

Uncertainty and subjectivity are always present in the decision-making process: they characterise the estimation of the impacts of the alternatives, the definition of the level of satisfaction for the values of the indicators and the weights assignment.

In face of uncertainty, a **sensitivity analysis** can be used to identify the intervals of variation of single parameters (for example, the weights) within which the ranking of the alternatives keeps stable, at least in its first position. The wider these intervals, the more solid the ranking and the more reliable the choice among the alternatives. Suppose, as in the example in figure, that, given a weights vector, the alternative A3 gets the first position in the ranking. Increasing or reducing the value of every single weight for an interval larger than the value indicated in figure may cause a different alternative to reach the first position.



A graphical representation of the results of the sensitivity analysis

As a means to face subjectivity, **conflict indexes** which reflect distances among the positions expressed by the actors, for example upon weights, may be computed. They may be the basis for conflict management, which requires discussions on systems of interests and values aimed at reducing such distances. Highlighting the issues of convergence and of greater contrast, as well as the entity and typology of acceptance of the others' positions required to converge to a common position, constitute a valid support for negotiation activities.

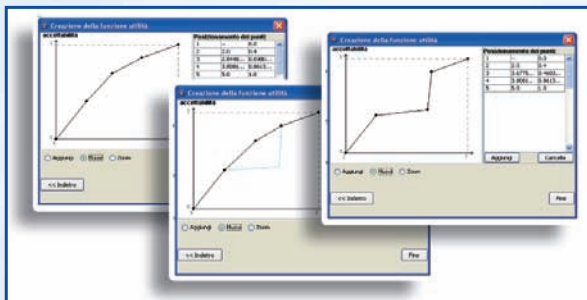
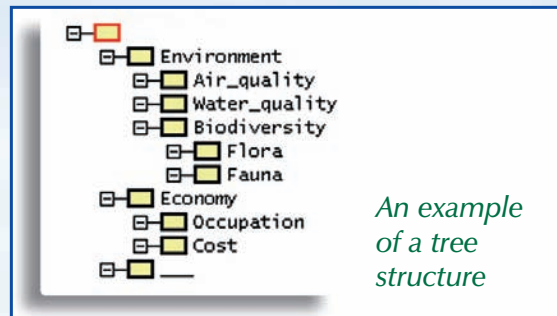


# The AMACI software

**AMACI** (the Italian acronym for “multi attribute analysis, conflict and uncertainty”) was developed in the SFIDA project. The software supports conflict management and analysis and evaluation and comparison among the alternatives. It can be used alone by a single involved actor or can be used interactively and cooperatively by many of them, in case they accept discussion and sharing of ideas throughout the process. In both situations, AMACI supports the comparison among their positions providing them with the key information to understand their differences and suggesting them the direction towards a potential compromise.

A hierarchical tree **structure** represents the set of objectives.

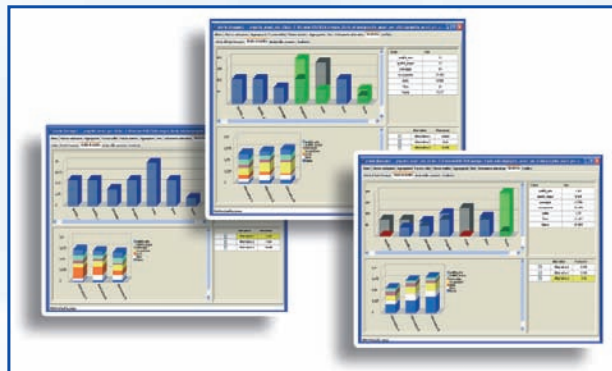
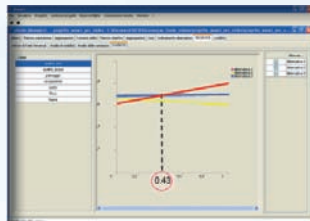
The definition of the level of satisfaction for the performance of each indicator and the assigning of weights are based on **interactive functionalities** - keyboard input and graphical definition are available.



Screenshots for the definition of the level of satisfaction for the values of each indicator

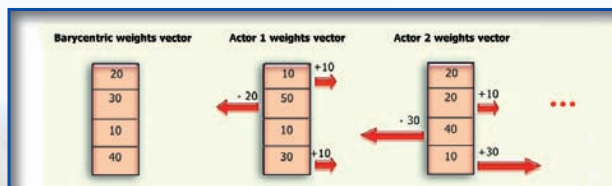
**Sensitivity analysis** on the weights values may be performed either through manual procedures, shifting the bars of an histogram representing the weights, or through automatic functionalities which show the intervals of stability of the solution.

Value of the weight causing a rank reversal in the first position



Computation of the rankings after shifts on the weights

AMACI supports negotiation among the actors involved through the computation of a **barycentric vector of weights** among those expressed by the actors. Moreover, it computes the distance between such a vector and each actor's weights, suggesting how to change his/her weights towards a shared position.



Computation of the barycentric vector of weights and suggestions for negotiation

		Alternatives				
		A0	A1	A2	A3	
Actors	Actor 1	25	X	X	40	
	Actor 2	10	65	X	70	
	Actor 3	X	X	20	15	
	Actor 4	55	X	60	45	

25,40,... Percent frequency the column alternative is first for the row actor  
 X The column alternative is never first for the row actor

Graphical representation resulting from the rankings among objectives

AMACI allows avoiding expressing numerical weights. Actors may express a **ranking among the objectives**, on the basis of which the software computes the probability for every alternative to be first in the ranking.

In the example on the left, only alternative A3 may result first in all the actors' rankings.

AMACI was developed using the Java language.