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Integrated Spatial Assessment (ISA): A Multi-Methodological Approach for Planning Choices

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1. Introduction

In decision-making processes for urban planning and design, evaluation can be considered a relevant *tool* to build choices, to recognize values, interests and needs, and to explore the different aspects that can influence decisions. Evaluation can be considered a *process* to integrate approaches, methods and models, able to support the different needs of the decision-making process itself. According to Trochim and Donnelly (2006), it is possible to define a *planning-evaluation cycle* with various phases requested by both planners and evaluators. The first phase of such a cycle, the so-called *planning phase*, is designed in order to elaborate a set of potential actions, programs, or technologies, and select the best ones for implementation. The main stages are related to (1) the formulation of the problem, issue, or concern; (2) the broad conceptualization of the main alternatives to be considered; (3) the detailing of these alternatives and their potential implications; (4) the evaluation of the alternatives and the selection of the preferable one; and (5) the implementation of the selected alternative. These stages are considered inherent to planning, but they need a relevant evaluation work, useful in conceptualization and detailing, and in assessing alternatives and making a choice of the preferable one. The evaluation phase also involves a sequence of stages that includes: (1) the formulation of the major goals and objectives; (2) the conceptualization and operationalization of the major components of the evaluation (program, participants, setting, criteria, measures, etc.); (3) the design of the evaluation, detailing how these components will be coordinated; the analysis of the information, both qualitative and quantitative; and (4) the utilization of the evaluation results. Indeed, evaluation is intrinsic to all types of decision-making and can take different meanings and roles within decision-making processes, especially if it is related to spatial planning (Alexander, 2006). "Evaluation in planning" or "evaluation within planning" seems to better interpret the concept of *planning-evaluation* proposed by Lichfield (1996) where the binomial name makes explicit the close interaction and reciprocal framing of evaluation and planning: evaluation is conceived as deeply embedded in planning, affecting planning, and evolving with it (Cerreta, 2010). Indeed, the evolution of evaluation methods reflects their evolving relationship with the planning process and the way in which they interact with the diversity and multiplicity of domains and values. To identify an analytic and evaluative structure able to integrate different purposes and multidimensional values within the decision-making processes means to

develop evaluation frameworks not focusing only on the environmental, social and economic effects of different options, but also considering the nature of the stakes, selecting priorities and values in a multidimensional perspective. It is crucial to structure *complex decision-making processes* oriented to an integrated planning, that can support the selection, the monitoring and the management of different resources, and the interaction among decision-makers, decision-takers, stakeholders and local community.

In the above perspective, it is essential to adopt normative and instrumental approaches, but also "explorative" ones, open to plurality and dialogue among the different expertises involved (Fusco Girard et al., 2007). Facing the complexity of interacting perspectives, interests, and preferences (Wiek & Walter, 2009) means to identify a dynamic decision-making process, where *integration* represents the crucial point. An integrated approach to planning-evaluation involves many institutional and non-institutional stakeholders with divergent and conflicting values and mandates, with a high complexity of issues and interdependencies. According to Waddell (2011), the main challenges for an integrated approach are related to conflicting institutions, conflicting values, conflicting epistemologies, and conflicting policies. Different institutions have responsibility for different aspects of the domain, having narrow and often competing mandates; values differ among both institutional and non-institutional stakeholders, including the citizens, and they can be related to tangible and intangible dimensions; divergent epistemologies surely also are part of the assessment of the problems of integrating planning, using both quantitative and qualitative methods and models in order to overcome the gap between *implicit knowledge* and *explicit knowledge* (Te Brömmelstroet & Bertolini, 2010); conflicting policies at different levels and scales have to face legislation requirements and restrictions and need to find ways to open up the planning process on the project evaluation level to be consistent with broader normative guidance on integrating planning efforts.

In order to face the different levels of conflicts related to a spatial planning process, three main types of integration (Lee, 2006) can be considered:

- *vertical integration of assessment*, which means to link together separate impacts, that are undertaken at different stages in the policy, planning and project cycles;
- *horizontal integration of assessments*, which means to bring together different types of impacts (economic, environmental, social, etc.) into a single, overall assessment at one or more stages in the planning cycle. It means also an horizontal co-ordination between contemporaneous assessments for separate, and also interrelated, planning and project cycles;
- *integration of assessments into decision-making*, that means to integrate assessment findings into different decision-making stages in the planning and project cycles.

The above types of integration can be helpful in facing the complexity of the planning environment, overcoming the limits of sectoral approaches and taking into account the multi-sectoral character and broadly defined content of many of the projects/plans to be assessed, the relative importance of complex impacts (indirect, induced and cumulative), the spatial and temporal complexity of their distribution, their multiple links, horizontal and vertical, and impacts from other projects or plans (Cerreta & De Toro, 2010; Lee, 2006) (fig. 1).

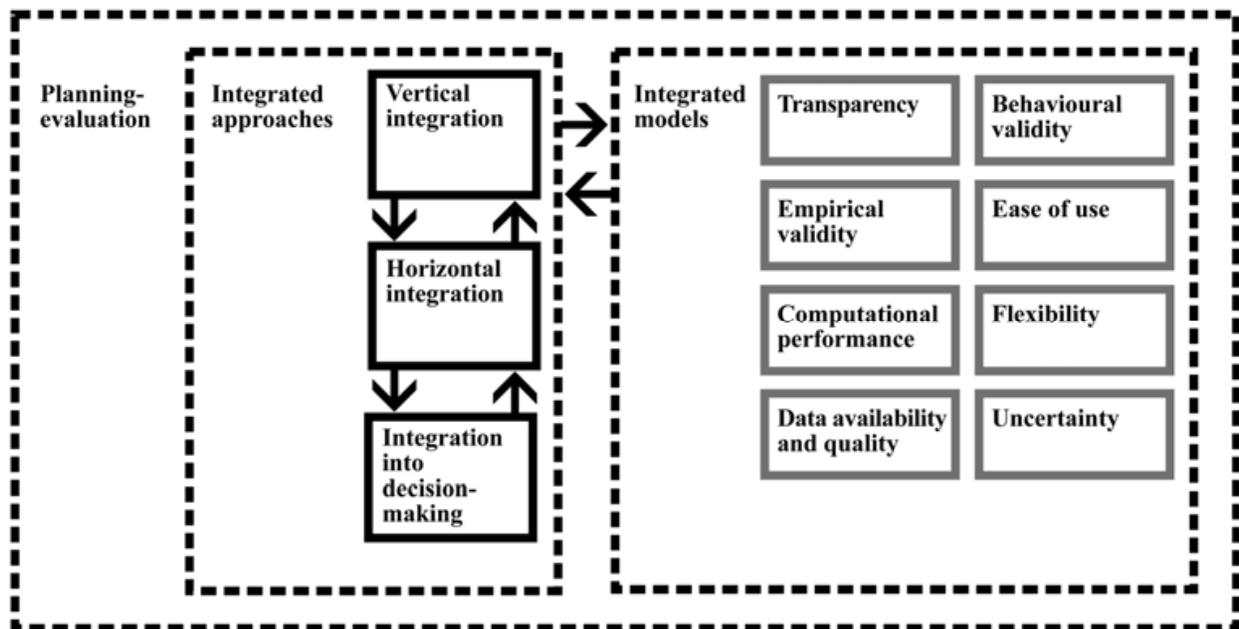


Fig. 1. Planning-evaluation: integrated approaches and integrated models

At the same time, some key challenges still facing integrated modelling and their application in practice include the following main characteristics (Waddell, 2011):

- *Transparency*: models will not be credible as tools for decision support in complex, conflict-laden domains such as land use, transportation and environmental planning, unless they can be explained with a sufficient degree of transparency;
- *Behavioural validity*: for a model to be credible in a contested domain, it must have sufficient behavioural validity to be believable as an independent artefact, within some clearly defined scope of applicability. Behavioural validity includes more common sense or intuitive understandings of how the world works;
- *Empirical validity*: models must be tested against observed data in order to assess their empirical validity. A model has to respond to input assumptions and make predictions that will reasonably correspond to observed reality. A model can be used to predict outcomes into the future, and it should be able to capture the essential trends in outcomes over some period of time;
- *Ease of use*: if a model is too complex to explain and implement, it also will ultimately not succeed in practice. A model system must strive to achieve a threshold of usability that makes it possible for staff within planning agencies to be able to use it, taking into account that complexity can lead to more mistakes;
- *Computational performance*: a model has to be characterised by a good computational performance able to define a valid simulation of reality modifications;
- *Flexibility*: a model has to be able to satisfy users in all cases and for all applications. Indeed, models and software platforms that are too rigid become a serious constraint, and limit applicability; models need to be adaptable to different users and different data and needs;
- *Data availability and quality*: in implementing a model a crucial point is developing the input data for it. In general, the science and tools to develop data usable in modelling are far from addressing the needs of users. Then data can be incomplete and error

prone. Further, it is difficult to integrate them into a coherent database that is internally consistent. The difficulty of developing the data for a model system can be a very important obstacle to consider;

- *Uncertainty*: only recently uncertainty has come into the lexicon of integrated modelling, but is becoming increasingly important in decision-making process related to spatial planning, especially in choosing among different alternatives.

The construction of suitable models is oriented to face complex problems that arise in socio-technical, socio-economic and socio-ecological contexts in order to transform an existing problem situation into a form that is more acceptable, understandable and manageable (Amin & Roberts, 2008). Often decision-makers and planners failure to fully understand such problems results in failures to formulate effective intervention strategies. In this research, Soft Operations Research (Soft OR) combined with System Dynamics (SD) modelling, Multi-Criteria Analysis (MCA), Multi-Group Analysis (MGA) and Geographical Information System (GIS) can help to improve stakeholders' understanding of a complex problem situation and to facilitate learning about it in a perspective of defining shared strategic actions.

2. Multi-methodological framework in decision support systems

According to Te Brömmelstroet & Bertolini (2010), the concept of *knowledge generation* is essential for building integrated strategies, where *socialization* (tacit with tacit: sharing experiences to create new tacit knowledge, observing other participants, brainstorming without criticism), *externalization* (tacit with explicit: articulating tacit knowledge explicitly, writing it down, creating metaphors, indicators and models), *combination* (explicit with explicit: manipulating explicit knowledge by sorting, adding, combining, looking to best practices) and *internalization* (explicit with tacit: learning by doing, developing shared mental models, goal based training) (Nonaka & Takeuchi, 1995; Nonaka et al., 2006) represent the main phases and the four key modes of knowledge conversion.

Through a process of knowledge generation iteratively acting in all four modes of knowledge conversion, interplaying between tacit knowledge and explicit knowledge, and by experiencing the four knowledge conversion modes, planners can develop a shared explicit language and use it to develop integrated strategies (Healey, 2007; Te Brömmelstroet & Bertolini, 2010). This approach to knowledge management to support strategy-making is also consistent with the epistemological structure of "post-normal science" developed by Funtowicz and Ravetz (1993), considering two crucial aspects: *uncertainty* and *value conflict*.

According to post-normal science, to recognize the importance of difference implies a different way to address complex systems and to face complexity means to take into account the self-organization chances, non-linear dynamics, non-continuous behaviours of complex systems and participated decision-making processes. This means to broaden the field of decision-makers and to involve new social actors in order to create an "extended community", able to elaborate new solutions (Funtowicz & Ravetz, 1994).

The approach of post-normal science forces decision-makers and planners to find solutions not only coming from the "expert knowledge", but also legitimated by "common

knowledge”, including uncertainty as part of the decision problem, and considering solutions based not only on exact scientific data (*hard data*), but also on public decisions, shared by the community (*soft data*). Indeed, facing and/or solving complex problems depends on the capability to consider them under different points of view, and to manage uncertainty, filling the gap between experts and community.

According to the above perspective, it stands out that “integrated evaluations” can be a key tool to support the decision-making process, especially when uncertainty, complexity and values of different social groups are many, different and conflicting (van der Sluijs, 2002). Integrated evaluations not only consider the inputs of data expressing the impacts of different solutions, but are also “open” to a wide public participation, so that they can offer more information for the evaluation itself and, in addition, can make the decision-making processes and the results more acceptable (Golub, 1997; Munda, 2008). Participation becomes essential not only to examine and evaluate choices on social, ethic, political, economic, environmental levels, but also to legitimate choices and make them acceptable for the community itself. Integrated evaluations constitute an ongoing process both, iterative and interactive, multi-disciplinary (respecting the issues addressed) and participative (respecting communities), able to recognize the relevance of *technical indeterminacy* and *value multiplicity*.

In this view, it is important to combine different approaches in the same framework, integrating different evaluation tools, such as environmental, social and ethical balance sheets, and also Economic Valuation, Input-Output Analysis, Life Cycle Assessment, Risk Assessment, Ecological Impacts, Ecological Footprint, Mass/Energy Valuation, Multi-Criteria Decision-Aid Methods, Future Studies (Finnveden et al., 2003).

Other relevant tools that could be useful to consider are those covering the possibility of combining Multi-Criteria Analysis and Multi-Groups Analysis with Geographical Information Systems (GIS), Internet Technology, Spatial Decision Support Systems, Cellular Automata Models. Integration of differing evaluation models with GIS (Malczewski, 1999) becomes decidedly important in the construction of a Spatial Decision Support System: a variety of territorial information (social, economic and environmental) may be easily combined and related to the characteristics of the different options of territorial use, facilitating the construction of appropriate indicators and improving impacts forecasting, leading up to a preference priority list of the various options. Integration among Multi-Criteria Analysis, Multi-Group Analysis and GIS may be exceptionally useful when there are strong conflicts, in which the role of local actors, their relations and objectives may be considered as a structuring element in the process of information construction in a spatial and dynamic evaluative model (Al-Shalabi et al., 2006; Joerin & Musy, 2000, Nekhay et al., 2009; Şener et al., 2010; Thirumalaivasan et al., 2003; Vizzari, 2011). In the recent years, theoretical research and new technologies have improved the identification and implementation of integrated approaches for building planning strategies and actions.

2.1 A selection of multi-methodological decision support systems

Some interesting examples of integration among different and complementary methods and techniques in spatial planning field have been proposed, where the application of GIS is

combined with evaluation tools and Planning Support Systems (PSS). A multi-methodological decision support system can be considered as the integration of a *dynamic system* (able to consider the time evolution), a *deliberative system* (able to include all the stakeholders), a *comprehensive system* (able to take account of quantitative and qualitative aspects related to different components) and a *spatial system* (able to identify the territorial effects also through their visualization) (fig. 2). According to this approach, a multi-methodological decision support system should be characterized by the interaction of Knowledge Base (KB), Relational Database Management System (RDBMS), Graphical User Interface (GUI), Geographic Information System (GIS), Multi-Criteria Analysis (MCA), and Multi-Group Analysis (MGA).

Indeed, PSS include: visualization tools that make it possible to get a 3-D, visual sense of what one alternative future might look like; sketch-planning tools that allow users to enter rules and then to visualize the outcome of those assumptions; simulation systems trying to model the behaviour of urban agents and the potential effects of alternative policy actions. Some selected models were developed in the transport sector, considering the relevance of infrastructures and mobility in land use transformations.

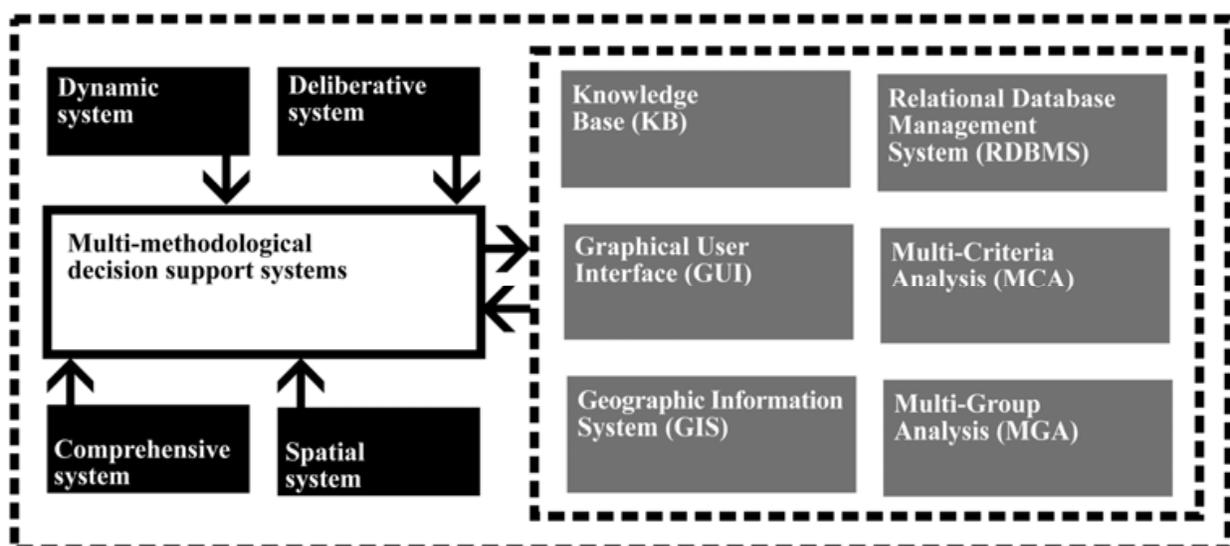


Fig. 2. Main characteristics of multi-methodological decision support systems

2.1.1 UrbanSim

UrbanSim, designed by Paul Waddell in the mid-1990s, falls in the third category of PSS, but also provide accessible visualization and stakeholder interaction (Waddell, 2002, 2011; Waddell et al., 2003) (fig. 3).

UrbanSim was developed as Land Use and Transport Interaction (LUTI) model in order to respond to a variety of needs to assessing the possible consequences of alternative transportation, land use, and environmental policies, trying to better inform deliberation on public choices with long-term, significant effects. The main reason was that the urban environment is so complex that it is not possible to anticipate the effects of alternative

actions without some kind of analysis reflecting the cause and effect interactions that could have both intended and possibly unintended consequences. It is a software-based simulation system for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment. Since its initial release, UrbanSim has been increasingly adopted for operational planning use in the USA, Europe, Asia, and Africa, in planning agencies and in university research. The user community and research collaborators directly and indirectly support the application and refinement of UrbanSim. It is defined by an interactive web site that provides a virtual meeting ground for users and developers of the system, approximately half of them from the USA, and half from a rapidly growing list of countries. It can be used by cities, counties, non-governmental organizations, researchers and students interested in exploring the effects of infrastructure and policy choices on community outcomes.

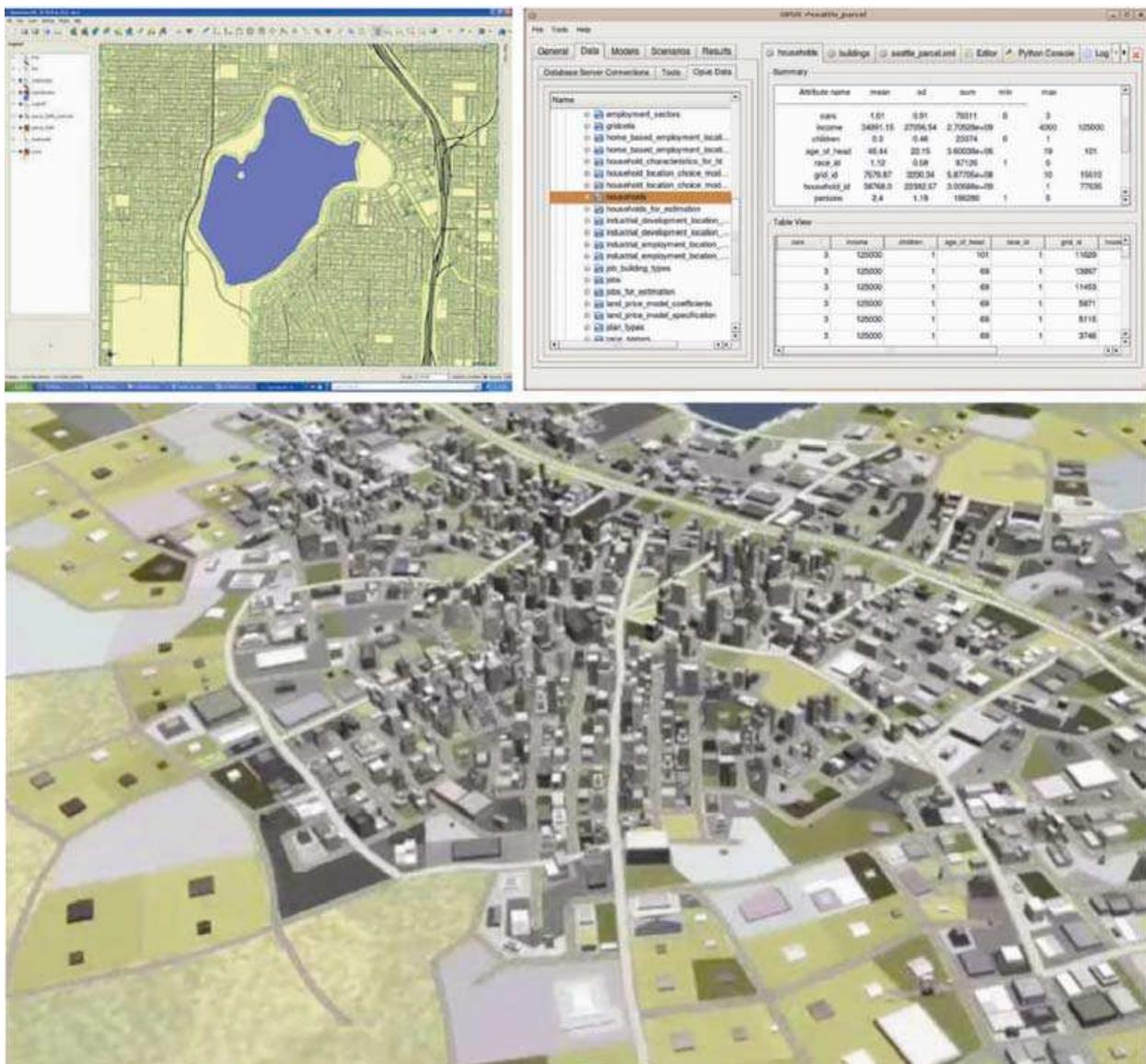


Fig. 3. Example of UrbanSim application (source: <http://www.uanalytics.com/urbansim>)

2.1.2 Metropolitan Activity Relocation Simulator (MARS)

Metropolitan Activity Relocation Simulator (MARS) is another interesting model designed to improve decision-making process with specific attention to transport system (Emberger et al., 2006) (fig. 4). It is a dynamic Land Use and Transport Interaction (LUTI) model designed to support the decision-makers all through decision-making process (objective definitions, policy instrument identification, assessment of short and long-term impacts and appraisal), helping understanding of the concepts underlying the model and providing a transparent process. MARS is based on the principles of systems dynamics (Sterman, 2000) and synergetics (Haken, 1983), and is considered an ideal tool to model dynamic processes.

The MARS model environment allows to calculate a wide range of relevant indicators, and users can choose the set of indicators that fit the needs of their specific decision-making context. Then, MARS calculates the policy-dependent values for the key-indicators and allows the assessment and appraisal of the strategy, including also Cost-Benefit Analyses (CBA) and Multi-Criteria Analyses (MCA).

UrbanSim and MARS are only an example of the most advanced European LUTI models, that also include IRPUD (Wegener, 1998, 2004), DELTA (Simmonds, 1999, 2001), MEPLAN (Echenique et al., 1990), MUSSA (Martínez, 1996; Martínez and Donoso, 2001).

2.1.3 Land Allocation Decision Support System (LADSS)

Land Allocation Decision Support System (LADSS) (Matthews et al., 1999) is a tool developed at The Macaulay Land Use Research Institute (UK) for agricultural land use planning. More recently the term LADSS refers to the research of the team behind the original planning tool (fig. 5). Indeed, the focus of the research of the LADSS team has evolved over time from land use decision support towards policy support, climate change and the concepts of resilience and adaptive capacity. LADSS is the collective term for a farm-scale integrated modelling framework (IMF) that is being developed in order to simulate whole-farm systems. The acronym describes the projects original purpose as a land use planning tool back in the early 1990s. More recently, the project has expanded beyond its original remit to focus much more on deliberative processes involving decision-makers and other stakeholders. The LADSS framework core is biophysical simulation models overlaid by financial, social and environmental accounting modules. This framework provides a basis for the case-study assessment of how policy and environmental changes can impact upon land-use systems. Recently, these studies have centred around three main themes: Climate Change, CAP Reform and Agricultural Sustainability.

The focus of LADSS has changed in recent years from a tool designed to assist in the decision-making processes of land managers to a much wider framework that involves stakeholder groups as part of an integrated assessment approach, using a Decision Support System (DSS) as component of the process to explore options provides the decision-maker with a better understanding of the consequences of changes in land use and management. An integrated assessment approach is preferred, able to combine the DSS with deliberative processes involving stakeholders. The LADSS software runs on a Sun/Solaris platform and is made up of a Knowledge Base (KB), Graphical User Interface (GUI), Geographic Information System (GIS) and Relational Database Management System (RDBMS).

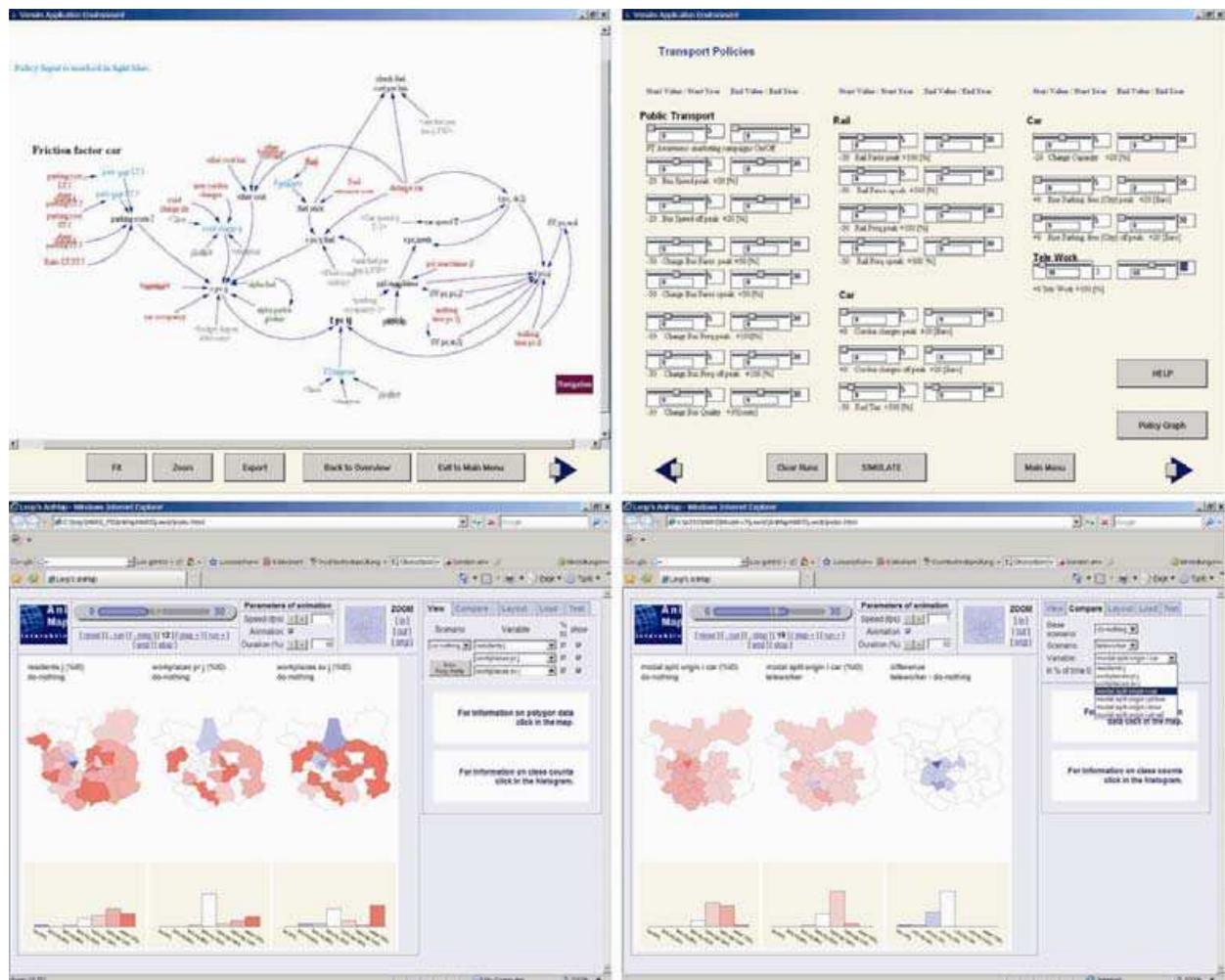


Fig. 4. Example of MARS application (source: <http://www.ivv.tuwien.ac.at>)



Fig. 5. Example of LADSS application (source: <http://www.macaulay.ac.uk/LADSS>)

2.1.4 LUCIS model

Another interesting approach is illustrated by the **LUCIS Model** (Carr & Zwick, 2007) that provides the information to understand and implement the Land-Use Conflict Identification Strategy (LUCIS) (fig. 6). LUCIS was developed over a period of ten years in a graduate design studio at the University of Florida for students from the Departments of Landscape Architecture and Urban and Regional Planning. Its conceptual basis was derived from Odum’s Compartment Model (1969) that proposes four general land-use types for land classification. It evolved to use traditional land-use suitability analysis as a basis for projecting future land-use alternatives. Indeed, the LUCIS model uses the ArcGIS geo-processing framework to analyze suitability and preference for major land-use categories, determine potential future conflicts among the categories, and build future land-use

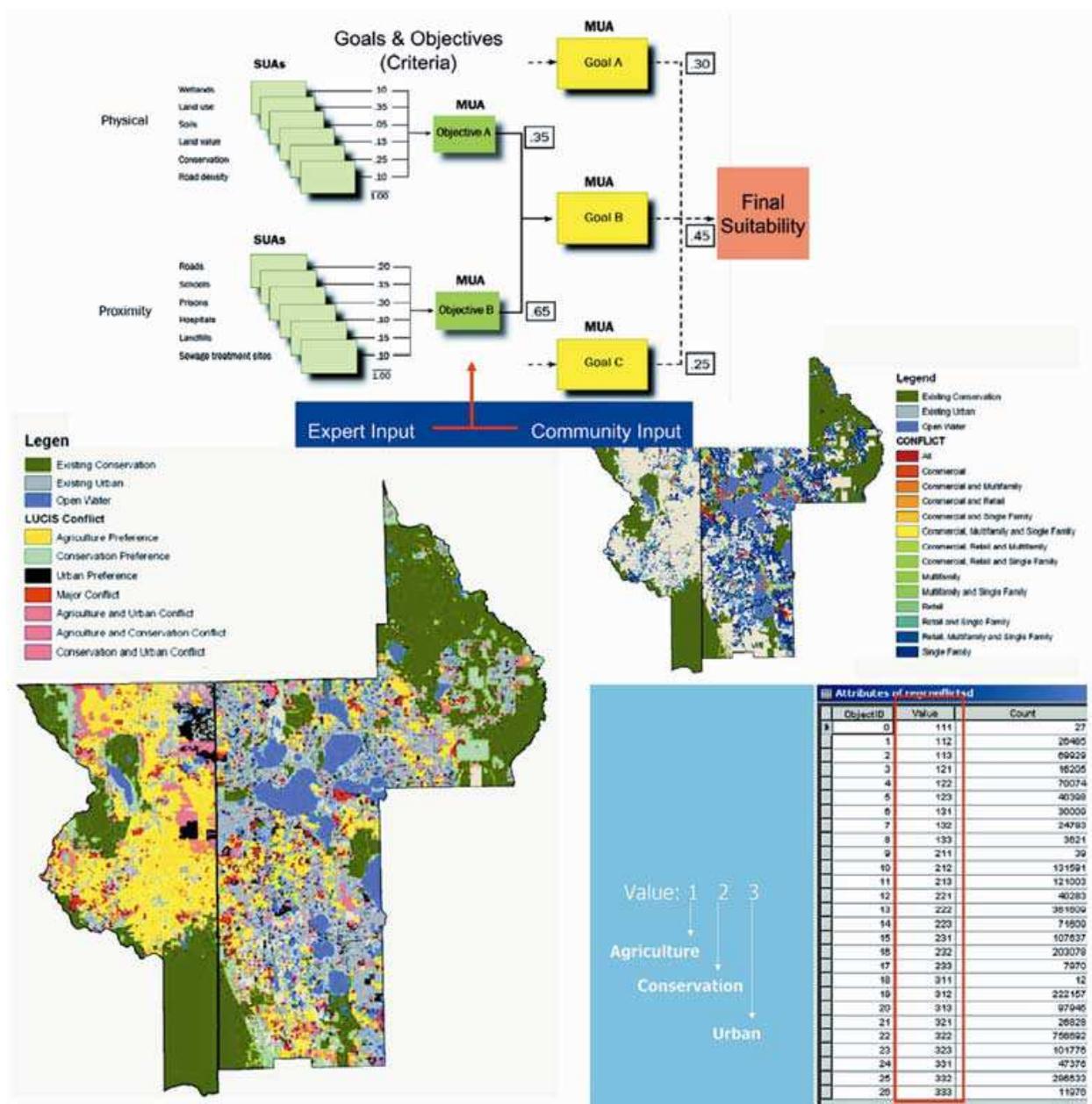


Fig. 6. Example of LUCIS Model application (source: GeoPlan Center, University of Florida)

scenarios. The basic concept is developing alternative future land use scenarios considered as a proactive approach to land management, resource management, and political and economic responsibility. With the help of technical tools such as Geographic Information Systems (GIS), regions across the United States are using scenario modelling to paint a picture of future development patterns. The selected methodology illustrates the impact of population increase and paves the way for developing more sustainable patterns of land use, producing a spatial representation of probable patterns of future land use for the following categories: existing conservation lands, existing urban lands, existing agricultural lands, areas for future conservation land use, areas for future urban land use, areas of probable future conflict between agricultural and conservation land uses, areas of probable future conflict between agricultural and urban land uses, areas of probably future conflict between conservation and urban land uses, areas of probable future conflict among agricultural, conservation and urban land.

2.1.5 What if?

In order to explore possible futures for a community **What if?** is an easy-to-use GIS-based Planning Support System (PSS) (Klosterman, 2001), that can be implemented to prepare long-term land use, population, housing and employment projections, political jurisdictions, and user-defined areas such as school districts, and traffic analysis zones (fig. 7). The

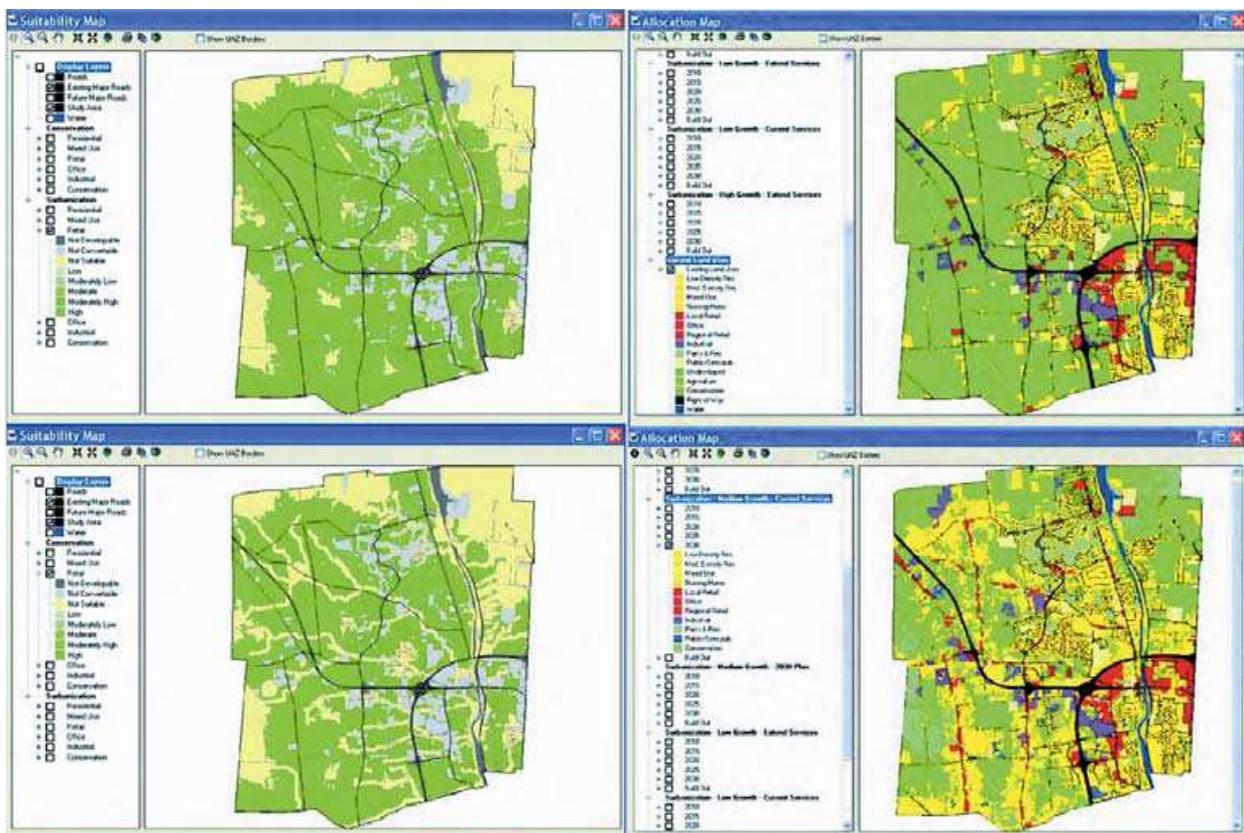


Fig. 7. Example of What if? application (source: Brail, 2008)

package is easy to use, customized to the user's GIS data and policy issues, and provides outputs in easy-to-understand maps and tables. Indeed, What if? can be used to prepare long-term land use, population, and employment projections for census tracts and user-defined areas such as political jurisdictions and traffic analysis zones. It allows users to determine quickly and easily the impacts of alternative policies to control urban growth, preserving agricultural land, or expanding public infrastructure in easy-to-understand maps and tables. What if? has been designed to be used in public settings by professionals, elected officials and private citizens. Local governments, regional planning organizations, and non-profit organizations across the United States and around the world have used it. As its name suggests, What if? allows planners, public officials, stakeholders, and private citizens to determine what would happen if public policy choices are made and assumptions about the future would prove to be true. Policy choices that can be considered in the model include the expansion of public infrastructure, the implementation of farmland or open space protection policies, and the adoption of land use plans, zoning ordinances, and other growth controls. What if? allows users to generate easily and quickly suitability maps and tables reporting the relative suitability of different locations for accommodating future land use demands.

2.1.6 Ecosystem Management Decision Support and Multi-scale Integrated Models of Ecosystem Services (MIMES)

An application framework for decision support of ecological assessments at any geographic scale is **Ecosystem Management Decision Support (EMDS)** (Reynolds et al., 1996) that integrates GIS, logic, and decision modelling to provide decision support for a substantial portion of the adaptive management process of ecosystem management (fig. 8). The NetWeaver logic engine evaluates data as respect to a knowledge base that provides a formal specification for the interpretation of data. The decision engine sets strategic priorities of landscape units, based on landscape condition derived from the logic model as well as any other management considerations pertinent to decision-makers. EMDS integrates state-of-the-art (GIS) as well as logic programming and decision modelling technologies in the Windows environment to provide decision support for a substantial portion of the adaptive management process of ecosystem management. EMDS uses **Criterion DecisionPlus (CDP)** from InfoHarvest, Inc. and **NetWeaver** from Rules of Thumb, Inc. as core components. The NetWeaver component performs logic-based evaluation of environmental data, and logically synthesizes evaluations to infer the state of landscape features. The Criterion DecisionPlus component prioritizes landscape features as respect to user-defined management objectives, using summarized outputs from NetWeaver as well as additional logistical information considered important to the decision-makers (InfoHarvest, 2001). In particular, Criterion DecisionPlus (CDP) decision management system helps structuring and communicating complex decisions among alternatives. It is a graphical Windows Desktop application that includes multi-criteria decision analysis (AHP and SMART) and uncertainty management. CDP manages both qualitative and numerical inputs, and helps eliciting preferences from decision-makers, and then provides contributions, sensitivity and tradeoffs analysis in order to validate those preferences.

According to the necessity to implement an integrated approach in planning, the **Multi-scale Integrated Models of Ecosystem Services (MIMES)** (Gund Institute for Ecological

Economics, 2007) is a suite of models for land use change and marine spatial planning decision-making (fig. 9). The models quantify the effects of land and sea use change on ecosystem services and can be run at global, regional, and local levels. The MIMES use input data from GIS sources, time series, etc., to simulate ecosystem components for different scenarios defined by stakeholder input. These simulations can help stakeholders evaluating how development, management and land/sea use decisions will affect natural, human and built capital. Building interactive databases for regional, integrated decision-making is an important aspect of implementing MIMES.

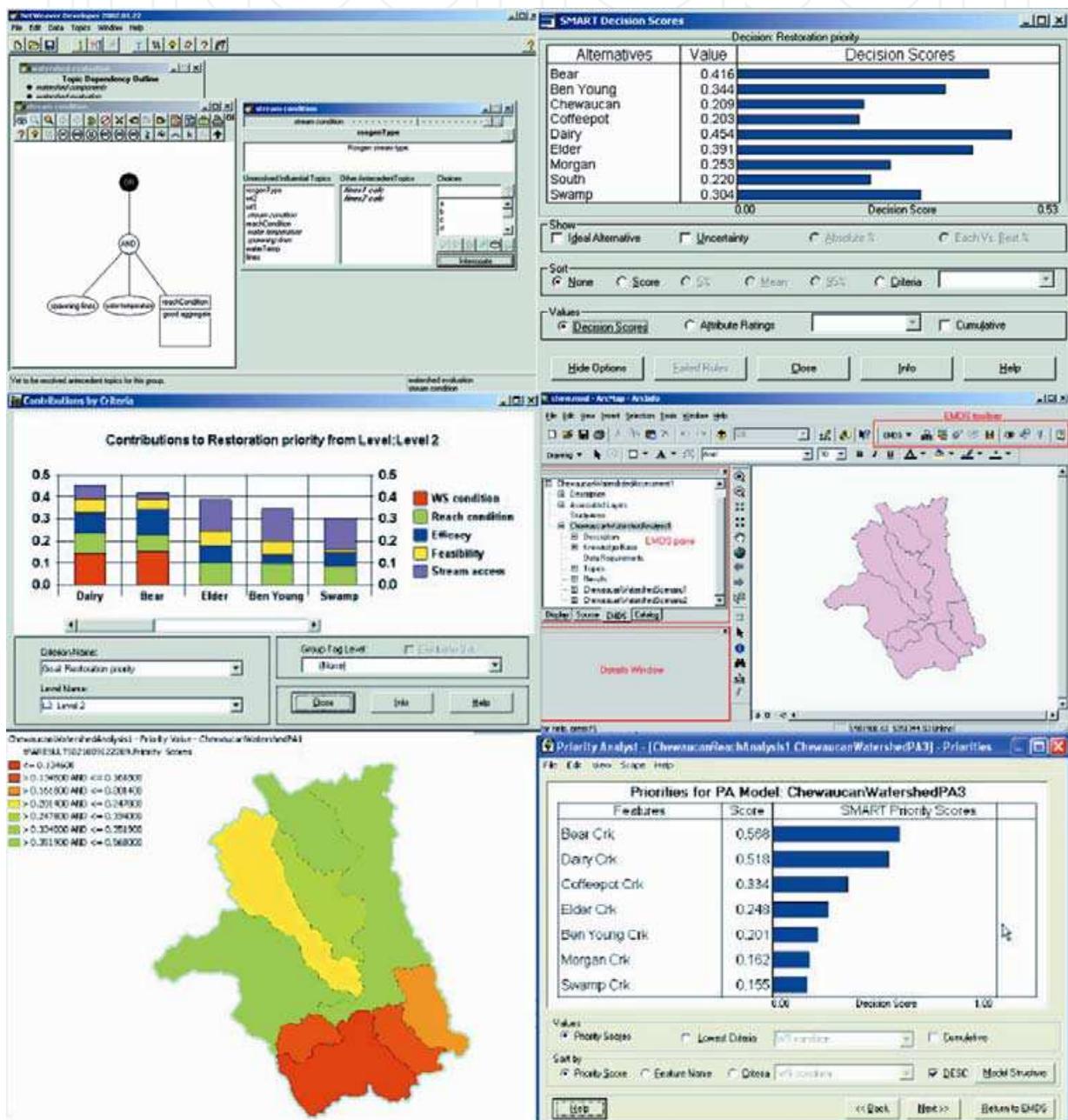


Fig. 8. Example of EMDS application (source: Reynolds et al., 1996)

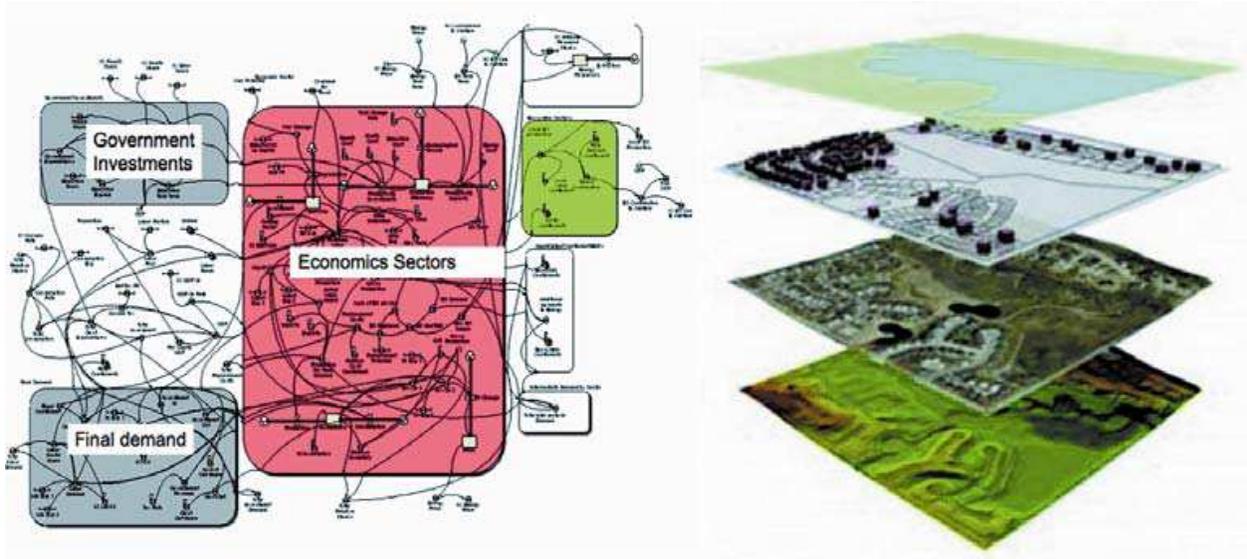


Fig. 9. Example of MIMES application (source: <http://www.afordablefutures.com/services/mimes>)

2.1.7 INDEX planning support software, the Land Change Modeler (LCM) for ecological sustainability, and MAPTALK

The implementation of an interactive GIS planning support tool is represented by an integrated suite named **INDEX Planning Support Software** useful for assessing community conditions, designing future scenarios in real time, measuring scenarios with performance indicators, ranking scenarios by goal achievement, monitoring implementation of adopted plans (Allen, 2001) (fig. 10). Introduced in 1994, it is now supporting a wide variety of planning processes across the United States, with over 150 organizations in 35 states equipped with the software. INDEX is designed to support the entire process of community planning and development, and applications often begin with benchmark measurements of existing conditions to identify problems and opportunities reserving attention in plans. INDEX is used to design and visualize alternative planning scenarios, analyze and score their performance, and compare and rank alternatives. Once plans are adopted, INDEX supports implementation by evaluating the consistency of development proposals against plan goals. Over time, achievements can be periodically measured with progress reports.

The Land Change Modeller (LCM) for Ecological Sustainability is an integrated software to analyze land use change, projecting its trend into the future, and assessing its implications for habitat and biodiversity change (Clark Labs, 2007) (fig. 11). Commissioned by the Andes Conservation Biology Center of Conservation International, LCM is a vertical application developed by Clark Labs and integrated within the IDRISI GIS and Image Processing software package. The Land Change Modeler for Ecological Sustainability is oriented to the pressing problem of accelerated land conversion and the very specific analytical needs of biodiversity conservation. LCM is organized into five main areas: analyzing past land use change, modelling the process of change, predicting the changes into the future, assessing implications for biodiversity, and their evaluating planning interventions for maintaining ecological sustainability.

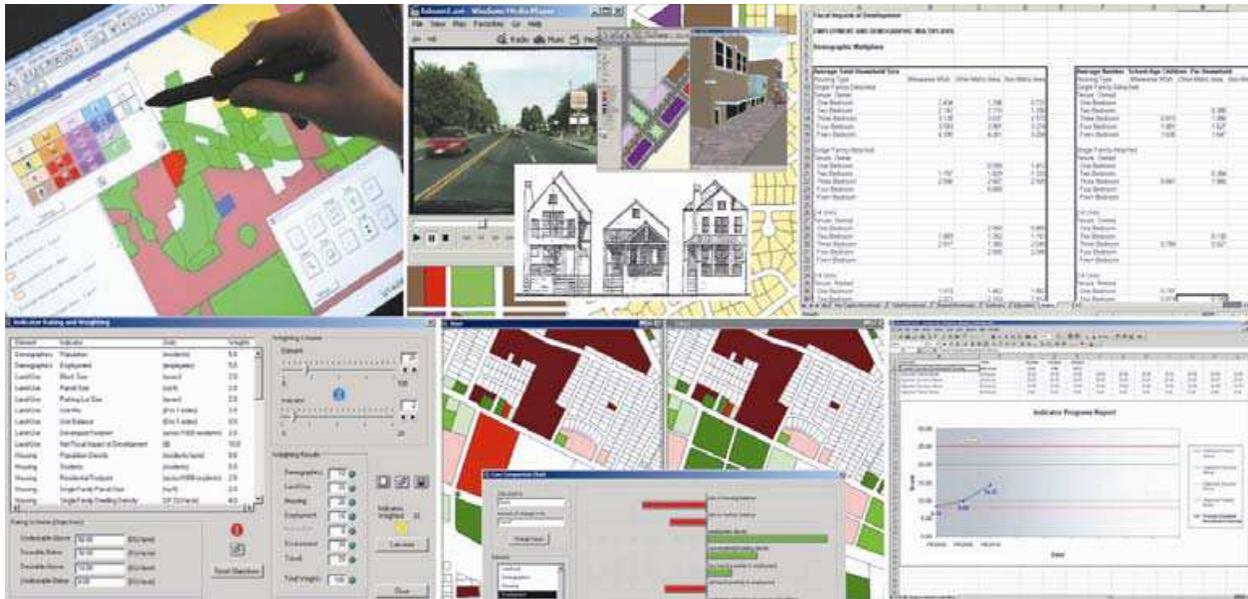


Fig. 10. Example of INDEX Planning Support Software application (source: www.crit.com)

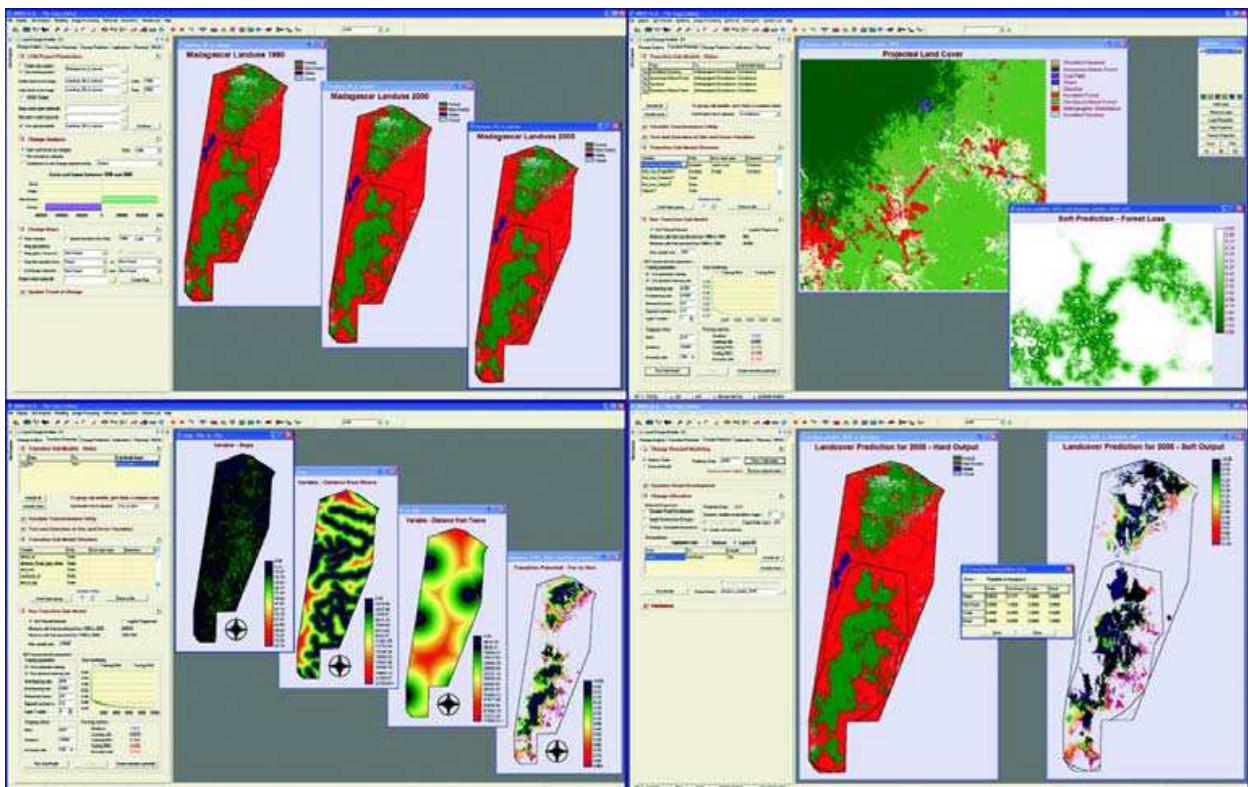


Fig. 11. Example of LCM application (source: Clark Labs, Clark University, www.clarklabs.org)

Another approach related to dynamic and spatial decision-making is developed by **MAPTALK** (WISL, 2003), that offers a mutual GIS able to make an efficient use of this geographic information in spatial decision-making processes were stakeholders feel no qualms using it (fig. 12). Stakeholder participation and group decision-making is effectively supported by digital support of spatial brainstorm, discussions and (geographic) information sharing.

MAPTALK thereby facilitates dialogue, decision-making and constructive engagement, and can be considered as an accelerator for spatial planning processes. The use of MAPTALK results in a directly available coherent plan, with a well-documented process. Together with the Landscape center of Alterra and Wageningen Interactive Network Group (WING) a service is provided to facilitate interactive spatial planning processes.



Fig. 12. Example of MAPTALK application (source: <http://www.maptalk.nl>)

2.1.8 Integrated planning for resilient communities: A technical guide to integrating hazard, ecosystem and land use planning

A toolkit is designed to support integrated planning that addresses hazard mitigation and ecosystem-based planning within a land use planning context: **Integrated Planning for Resilient Communities: A Technical Guide to Integrating Hazard, Ecosystem and Land Use Planning** (Hittle, 2011) (fig. 13).

The toolkit crosses disciplines and jurisdictional boundaries and can highlight the benefits of ecosystem conservation. It is characterized by the integration of three decision-support tools and methods, and the implementation of an integrated analysis of hazards, ecosystem conservation goals, and land use measures. A skilled expert team for community resiliency toolkit implementation is necessary, even if the required expertise will vary according to project size, complexity, and timeline.

Indeed, successful integration and implementation of ecosystem-based management, hazard analysis, and land use planning requires public and stakeholder involvement. It is relevant that each tool has a particular role in the toolkit, even if some roles are shared or overlap, giving the user flexibility in how the tools are applied:

- **CommunityViz** is the primary tool used to depict land use scenarios and summarize indicators across all tools. It is used to model future growth, to change suitability to create different future use patterns, and to associate hazard and ecosystem data with specific polygons or parcels. It also produces outcomes in terms of many socio-economic indicators.
- **NatureServe Vista** takes the land use scenarios from CommunityViz and depicts additional scenario details important for ecological analyses, such as hazards or land management activities. Vista then assesses different land use scenarios to determine

how well they meet conservation goals for a set of conservation elements. The results are a set of performance measures as respect to goals, and maps of areas where the scenarios are compatible with or conflict with conservation goals. Vista also supports generation of alternative scenarios for assessment in CommunityViz.

- The **Roadmap** calculates the exposure of various populations and facilities to hazards. The outputs of the calculations are percentages of various populations or facilities impacted by various hazards. It is also possible to create a spatial representation of where hazard risk and vulnerability overlap. These spatial representations can guide the creation of alternative future scenarios, which can then be assessed as respect to vulnerability, if some assumptions are made about where future populations or facilities are likely to be.
- **Iterative Assessment and Planning:** the tools are linked using a series of scenarios, such as (1) current land use and other conditions; (2) expected "business-as-usual" land use at a future time, and (3) preferred or alternative future land use(s). The alternatives identified are entered into CommunityViz, either by specifically changing land use characteristics for polygons, or by changing the rules for build-out, suitability scores for parcels, or the way growth is allocated. Several iterations may be required to develop a preferred scenario that meets as many objectives as possible. This process is also educational for stakeholders as the tools can demonstrate tradeoffs among objectives, or actions that satisfy multiple objectives at once.

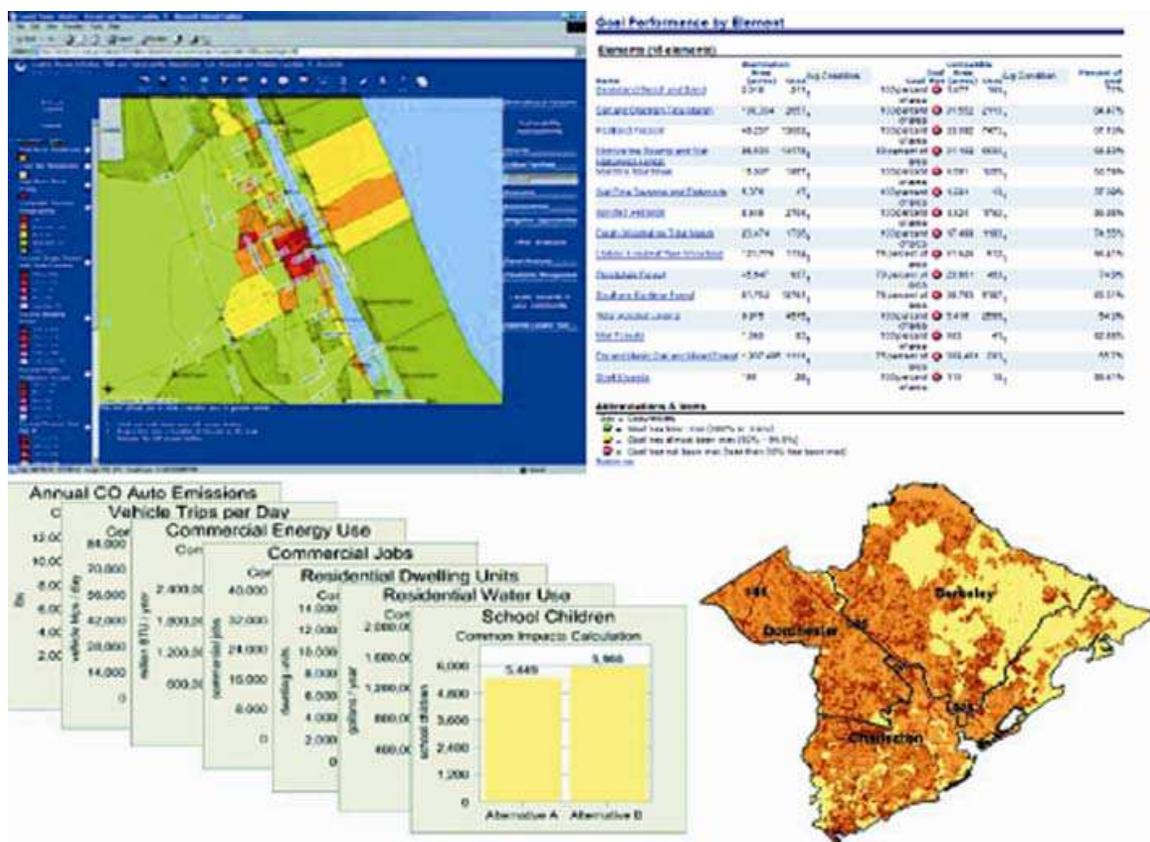


Fig. 13. Example of Integrated Planning for Resilient Communities: application (source: <http://resilient-communities.org>)

The result of these steps will be the “proposed scenario” that can be presented to decision-makers and stakeholders for review. Undoubtedly, further requests for changes will be made and the toolkit can be used to assess the ramifications of any of these proposed changes. The result of that process will be the “accepted scenario” or plan that will become the basis of a revised “future land use scenario” in the toolkit.

The relevance of the selected models is related to their potential to implement in a synergic way different planning and evaluation tools, in order to support decision-making process oriented to the elaboration of strategic planning choice and situated actions.

3. The Integrated Spatial Assessment (ISA) approach

Taking into account of the above potentials and critical aspects of multi-methodological decision support systems, it is relevant to identify an integrated approach for planning-evaluation where the process and its phases are able to understand the local needs and guide situated decision-making process.

The proposal of a multi-methodological evaluative framework, that includes the cognitive skills and habits of the stakeholders and experts involved in mutual, joint and dynamic learning processes, can help generating more efficient and effective results than sectoral approaches, where interdisciplinarity and transdisciplinarity are essential. In the above perspective the Integrated Spatial Assessment (ISA) approach has been proposed, in which the recognition of tangible and intangible values is the basis for a collective decision-making that includes: the development of goals, the sharing of knowledge, negotiation and compromise, problem-posing and problem-solving, the evaluation of needs, and the definition of goals, but also the attention to questions of justice and equity (Sinclair et al., 2009).

The proposed approach may help communities clarify values, be more adaptive and proactive, respond to change, set personal and communal goals, and participate in the planning decision-making process. At the same time, the application of spatial tools, as Geographical Information Systems, is a useful support to identify territorial references and link values and planning choices. The integration of Multi-Criteria Analysis (MCA) and Multi-Group Analysis (MGA) and Geographical Information Systems (GIS) is remarkably fruitful in land management where the role of local agents, their relations and objectives may be considered as a structuring element for the process of information construction in a spatial and dynamic evaluative model (Joerin et al., 2001). Compared to traditional forms of GIS utilization, it should be possible to evaluate data covering not only the current situation but also:

1. the spatial characteristics of options proposed;
2. the temporal modification of data following the options implementation;
3. the expressed preferences of local agents;
4. the conflict analysis among the various stakeholders;
5. the evaluation of various options in order to obtain a preference priority list.

Taking into account the previous steps, we defined a methodological process that combines the contribution of different methods and tools. In particular, the first methodological step that we propose is the application of Problem Structuring Methods (PSMs) combined with Public Participation Geographic Information Systems (PPGIS) for the construction of a

shared knowledge framework. The PSMs are methods that provide a useful support to information structuring within Decision Support Systems, and are able to deal with a variety of non-structured problems and situations, prevailing over traditional approaches and following communicative conceptions of planning (Rosenhead & Mingers, 2001). In particular, non-structured problems are characterised by a multiplicity of agents; a multiplicity of points of view; incommensurable interests, important intangible values, and uncertainty. In these situations, through PSMs it is possible to visualize a problem so that participants can clear up their positions and converge in one or more potential issues aimed at building consensus. Through PSMs it is possible to represent graphically the complexity of the issues examined, explore the space-solutions, compare discrete alternatives, face uncertainty in terms of "possibilities" and "scenarios" rather than in terms of probability and prediction. PSMs are based on an explicit modelling of cause-effect relations, and their technical simplicity allows them to be used in "facilitated groups" and workshops.

At the same time, the PPGIS is defined by Sieber (2006) as the use of GIS to broaden public involvement in policy-making as well as the value of GIS to promote the goals of nongovernmental organizations, grassroots groups and community based organizations. PPGIS is meant to bring the academic practices of GIS and mapping to a local level in order to promote knowledge production. The idea behind PPGIS is empowerment and inclusion of marginalized populations, who have little space in the public arena, through geographical technology education and participation. PPGIS uses and produces digital maps, satellite imagery, sketch maps, and many other spatial and visual tools, to change geographical involvement and awareness at a local level. The local participatory management of urban neighbourhoods usually comes from "claiming the territory", and has to be made compatible with national or local authority regulations in managing and planning urban territory (McCall, 2003).

The second methodological step combines Multi-Criteria and Multi-Group Decision Support Systems with GIS in order to overcome the limitations of specific techniques through the application of different methods, coming from different disciplines and define a more complete and integrated framework of analysis and evaluation. Many experiences of integration of Multi-Criteria Analysis, Multi-Group Analysis and GIS have been developed referring to different sectors and using different evaluation methods. This type of integration creates a "spatial multi-criteria and multi-group analysis". Spatial multi-criteria decision-making problems typically involve a set of geographically defined alternatives from which a choice of one or more alternatives is made as respect to a given set of evaluation criteria (Jankowski, 1995; Malczewski, 1999). Spatial multi-criteria analysis is very different from the conventional multi-criteria techniques due to the inclusion of an explicit geographic component. It requires information on criterion values and the geographical locations of alternatives in addition to the decision-makers' preferences for a set of evaluation criteria. This means that analysis results depend not only on the geographical distribution of attributes, but also on the value judgments involved in the decision-making process. Therefore, two considerations are fundamental for spatial multi-criteria analysis: the GIS component (i.e., data acquisition, storage, etc.); and the multi-criteria analysis component (i.e., aggregation of spatial data and decision-makers' preferences into discrete decision alternatives) (Al-Shalabi et al., 2006). Spatial analysis combined with multi-criteria methods has been used in recent years to support evaluation,

especially in the field of land-use planning. For example, GIS technology was used to assess the criteria requested to determine the suitability of land for housing. Because the required criteria were heterogeneous and measured on various scales, GIS was integrated with an outranking multi-criteria method called ELECTRE-TRI (Joerin et al., 2001). Integration between GIS and multi-criteria analysis using Analytical Hierarchy Process (AHP) was applied in selecting the location for housing sites in a complex process, involving not only technical requirements, but also physical, economical, social, environmental and political requirements (Al-Shalabi et al., 2006). GIS and Multi-Criteria Analysis provided also a better insight into the consequences of alternative water regimes on the performance of wetland functions, supporting stakeholders participation. In particular, Multi-Criteria Analysis was performed using the software package DEFINITE (Janssen et al., 2005).

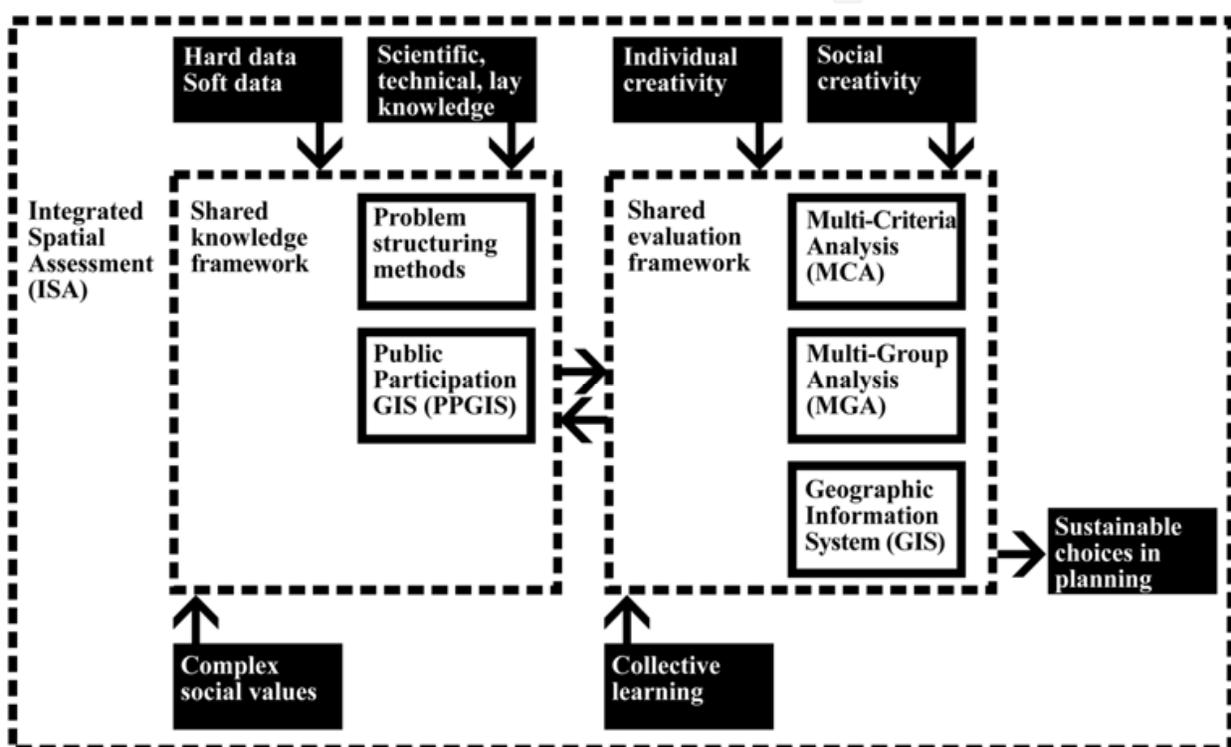


Fig. 14. Integrated Spatial Assessment approach

In general, in the last decade, a wide range of applications was experimented for decision-making, linking multi-criteria assessment and GIS, considering both different methods and different fields: urban and territorial planning, nature conservation, risk management, etc. (Chen et al., 2001; Geneletti, 2004; Malczewski, 2004).

We propose to extend this integration in the perspective of "Integrated Assessments" in order to consider not only the technical aspect of the decision-making problem but also the involvement and participation of the local community in planning choices. Indeed, integration between Multi-Criteria Analyses, Multi-Group Analyses and Geographical Information Systems can be useful when facing conflicts, keeping in mind the local agents' role, the existing relationships and the pre-selected objectives as a structural part of the information building process within a spatial and dynamic evaluation model. As respect to the traditional use of GIS we are able to take into account not only the status-quo data, but

also the spatial characteristics of the proposed options, the changing data over time, the elicitation of agents' preferences, the conflict analysis, the impact assessment of the different options (Fusco Girard et al., 2008).

Therefore, it is possible to structure a decision support system that includes "social creativity" (Fischer et al., 2005) as the key component for the decision-making process, and considers the "reflexive community" as a necessary interlocutor to interact with. In this way, individual and social creativity can be integrated to face complex problems through innovative approaches. In this perspective, "Integrated Spatial Assessment" (fig. 14) – which is a participative approach – is a useful tool for decision-making, including technical and political evaluations. Furthermore, it refers to articulated and complex value systems, inserted in conflicting and changing realities, where it is necessary to operate consistently with sustainability principles.

The integration of Problem Structuring Methods, Public Participation GIS, Multi-Criteria and Multi-Group Decision Support Systems and Geographic Information Systems identifies a decision-making process that allows the analysis of the complexity of human decisions for a flexible environment in which collective knowledge and learning has a significant role in decisional processes, and the possibility to explore the transformation strategy definition in spatial planning field according to sustainable and complex values.

4. Cava de' Tirreni Masterplan: An example of Integrated Spatial Assessment (ISA) application

For the Masterplan of Cava de' Tirreni¹, in the Province of Salerno (Italy), the Strategic Environmental Assessment (SEA) process was elaborated to give significant support to planning activity and to help the local government building the suitable choices for the territory. The SEA was seen as an interactive and dynamic approach throughout the whole planning process (Fischer, 2007), allowing to:

- define the status and the evolution trends of human and natural systems, including *hard* (objective, related to real world stuff where things are measured, are fixed in dimensions and location in space) and *soft* (subjective, related to the world of ideas, where the characteristics of a thing can change and specifications are malleable) data, thus creating a complete frame of their interactions to support decision-making process;
- assume the environmental, territorial and social goals, the landscape restoration and environmental protection as stated in the current law and territorial plans, and to find goals and main strategic choices according to a bottom-up approach in planning;
- evaluate the effects of protection policies and significant transformations of territory designed in the plan, and consider the possible alternatives;

¹ The working group was thus organized: Urban planning and scientific coordination, Carlo Gasparri with Cinzia Panneri, Paolo D'Onofrio, Mirella Fiore, Vincenzo Rizzi, Luigi Innamorato, Alessia Sannolo, Anna Terracciano, Pasquale Inglese, Daniele Cannatella; Geomorfology, Silvana Di Giuseppe; Agronomy, Maurizio Murolo; Landscape, Vito Cappiello with Anna Aragosa; Economic-financial feasibility, Ettore Cinque with Andrea Mazzella; Infrastructures and Mobility, Giulio Valfrè with Vincenzo Cerreta (D'Appolonia SpA); Strategic Environmental Assessment, Maria Cerreta, Pasquale De Toro, Saverio Parrella. We thank for support and collaboration the technical staff of Cava de' Tirreni Municipality.

- find the measures to avoid the possible negative effects and to mitigate, reduce and/or compensate the impacts of the preferable planning choices;
- define the pressure factors and the necessary indicators to evaluate and control the plan effects referring to the goals and the expected results.

In the Cava de' Tirreni case SEA process was carried out to support the development of the Masterplan and was a practical opportunity to test the Integrated Spatial Assessment (ISA) approach (Fusco Girard et al., 2008). This approach was developed to integrate multi-dimensional aspects within a complex development of strategies and choices in planning, acknowledging the importance of the environmental, social, and economic effects of a decision-making process focused on the creation of alternative transformative options (fig. 15).

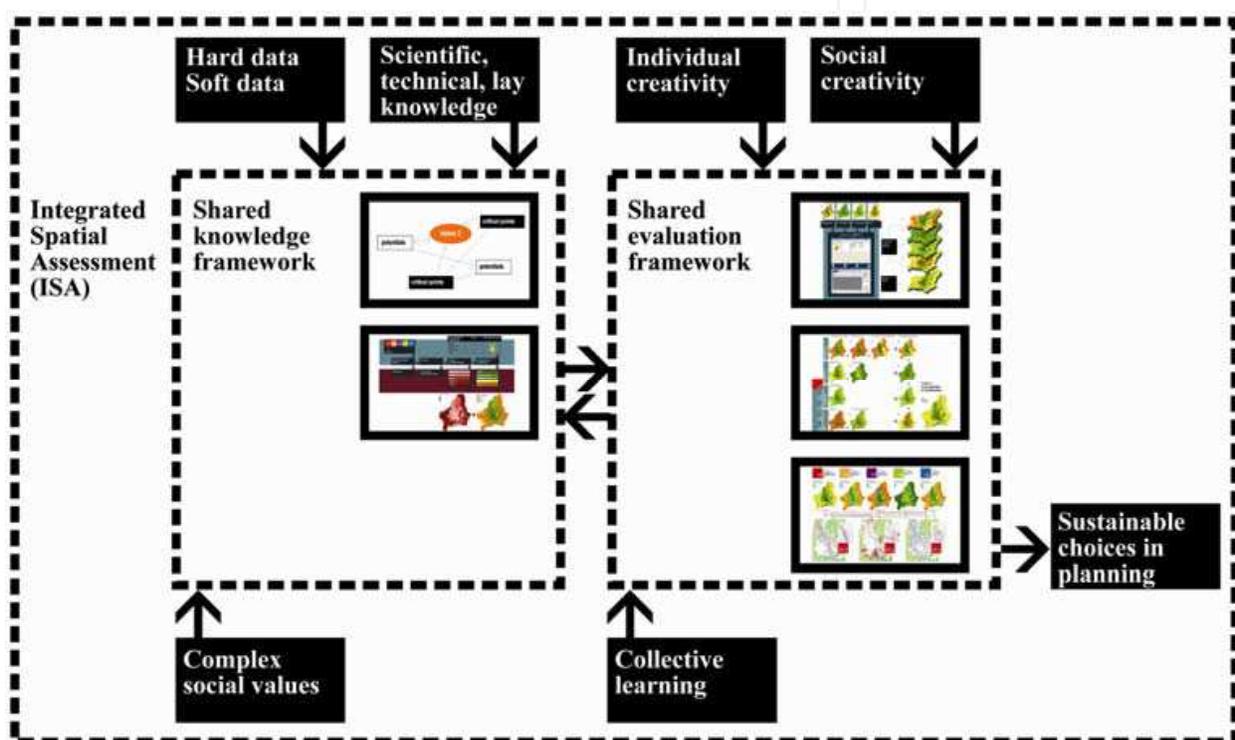


Fig. 15. Integrated Spatial Assessment approach in Cava de' Tirreni Masterplan

In ISA, the recognition of complex social values (Fusco Girard & Nijkamp, 1997) is the basis for a collective decision-making process, that includes the steps of problem-setting, problem-posing and problem-solving, and the sharing of different forms of knowledge, and that takes into account issues of justice and equity. Different analyses are combined to manage conflicts and include various levels of uncertainty.

For the Cava de' Tirreni Masterplan there was a continuous and dynamic interaction between assessment context and assessment process during the whole decision-making process, allowing to select each time the most appropriate methods and techniques based on the goals and considering the results of each step.

Public meetings, in depth interviews, and data and information collection were implemented, mainly aimed at defining a permanent interaction "platform" supporting dialogue and mutual learning between citizens, experts and administrators, in coherence

also with the national and European guidelines on Strategic Environmental Assessment. The interaction platform is based on a relational frame supported by a Geographic Information System (GIS); it evolves together with the planning process and allows the creation and development of all plan-related decisions. The participation and consultation steps were fundamental for the application of a sustainable territorial development principle, since finding and recognizing values and resources is vital to enhance local potentials and select approaches and tools for a good governance process. Public meetings created a direct dialogue with citizens and stakeholders and a constant common ground of discussion among citizens, professionals and Municipality.

The main goal was to broaden the knowledge of Cava de' Tirreni, with a special care for the most relevant issues in future urban, social, economic and cultural transformations of the territory, and to single out the collective needs. Thus, there was a continuous interaction process between "common knowledge" (citizens, associations, civil society, etc.) and "expert knowledge" (technicians and administrations), considering SEA as a "joint factor" among the actors. Three main topics were considered during the meetings about the territorial development of Cava de' Tirreni: What is the vision of future? Which strategies to use? Which actions to undertake? In the long run, it is very important to decide how to direct future development, considering not only the scenarios coming from collective expectations, but also significant strategies and actions, to find the best ways of intervention on the territory. For the public consultation a questionnaire was formulated through which associations and citizens could express their point of view regarding present and future of the city. Starting from ten visions designed in earlier meetings, the discussion focused on five main topics: "Cava as a beautiful and identity-bearing city", "Cava as a regenerated and friendly city", "Cava as a modern and productive city", "Cava as a territorial hub city", "Cava as a ecological city". The visions reflect the community perception of complex social values of territory and express the relevant resources at different levels. They were examined with the Strategic Options Development and Analysis (SODA) approach (Rosenhead & Mingers, 2001), a decision-support system that allows to face complex problems with non-structured qualitative data starting from the elaboration of "cognitive maps". Using the software Decision Explorer 3.1.0, cognitive maps were elaborated starting from verbal protocols, structuring the contents under a formal and methodological point of view (fig. 16). The elaboration of the cognitive maps explained the structure of argumentations carried out during the meetings, keeping the rich amount of data and managing the complexity of information. Through different links identifying the connections of concepts, the main issues were related to one another distinguishing among "visions", "potentials", and "critical points". The kind and number of each link express the importance given to the topics by the different groups. The chain of argumentations allowed to express the expectations, the preferences and the critical points singled out during the meetings, through a "strategic cognitive map", whose topics were classified according to a chromatic scale:

- orange: visions of the future;
- green (three different shades): environmental, infrastructural and settlement potentials;
- purple (three different shades): environmental, infrastructural and settlement critical points.

Starting from the argumentations and the identification of the links in the strategic cognitive map, the whole cognitive model was analyzed to find the preferable vision. Through the

Domain Analysis and the Central Analysis it was possible to evaluate recurrent topics that are relevant to decide the guidelines of future scenarios.

The final rank was obtained comparing the results of Domain Analysis and of Central Analysis. The favourite vision is "Cava as a ecological city", followed by "Cava as a modern and productive city", "Cava as a territorial hub city", "Cava as a regenerated and friendly city" and "Cava as a beautiful and identity-bearing city". Indeed, the different visions are related to one another and can be seen as complementary and synergic in a Plan that cares for the complex objectives of sustainability. Potential and critical points were analyzed in the same way, highlighting the most significant ones to solve or enhance. The results identify some essential issues useful to define the transformations to be included in the Masterplan.

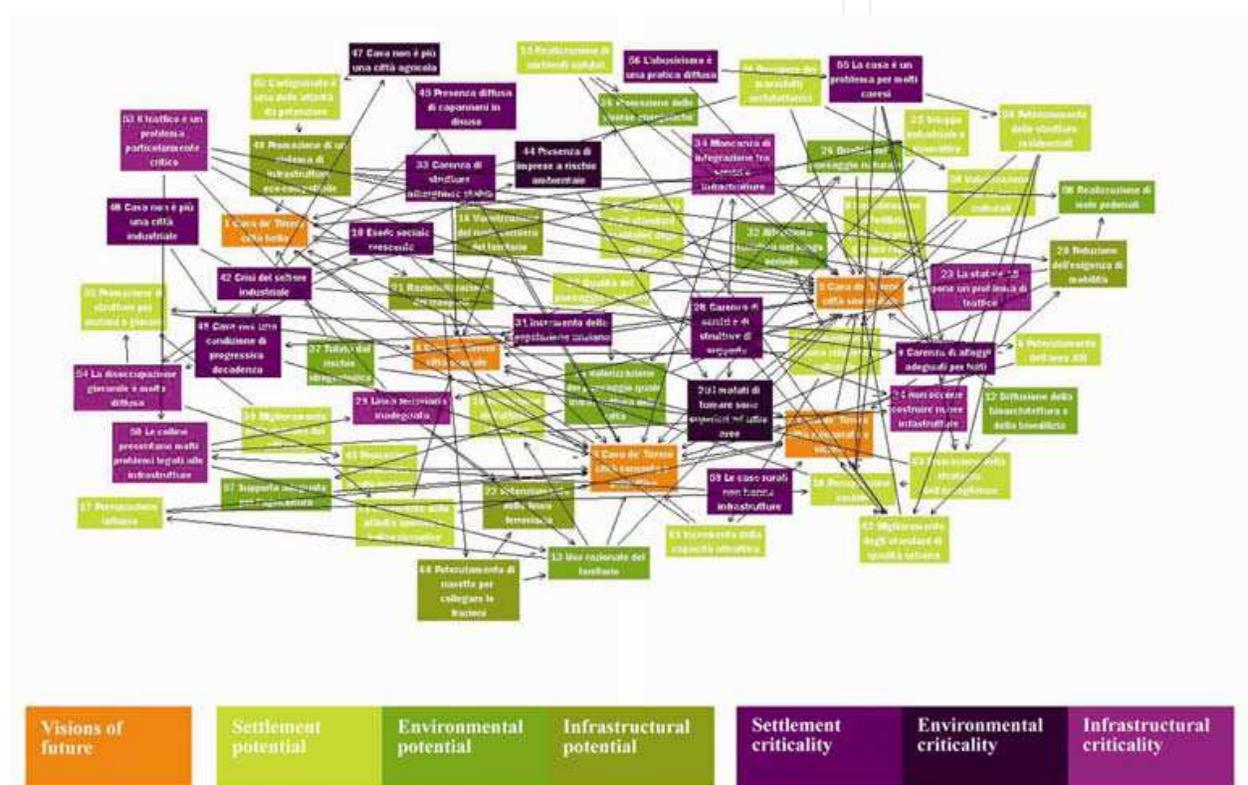


Fig. 16. An example of cognitive map: visions, potentials and criticalities

Consistently with the hierarchical structure of the decision-making process, the visions were articulated into general goals, strategic lines, and strategic actions. In details, strategic actions were linked to three guide-projects that are the main reference to direct planning in the operative phase. The guide-projects are the synthesis of issues coming from the participative and consultative process and they identify the most relevant transformation and conservation interventions within an infrastructural, spatial, functional and symbolic relations system.

To decide the possible placement of different planning choices, the multicriteria method called Analytic Hierarchy Process (AHP) (Saaty, 1980, 1992) was used in combination with Geographic Information System (GIS) elaborations (Marinoni, 2004). The application of AHP into GIS allowed to go beyond the simple overlay of different themes, making a pairwise comparison of the criterion of each hierarchical level. For each of the five visions a

"susceptibility map to localization" was generated, expressing the attitude of the territory to accept a given strategic action, considering potential impacts. The lower are the territorial and environmental impacts caused by an action, the higher the susceptibility of the territory to receive that action.

To find alternative locations of strategic actions and of related guide-projects, a three level hierarchical structure was made for each vision ("environmental themes", "criteria" and "values/characteristics") expressing the last level through a five points scale associated to a chromatic one. The criteria were given the same weight for all the visions, while the environmental issues were compared in pair creating five matrixes, one for each vision. The AHP method allows to combine the weights of the criteria coming from the comparisons with the scores associated to different classes of susceptibility to localization obtaining, within GIS, the susceptibility maps of each planning action (fig. 17).

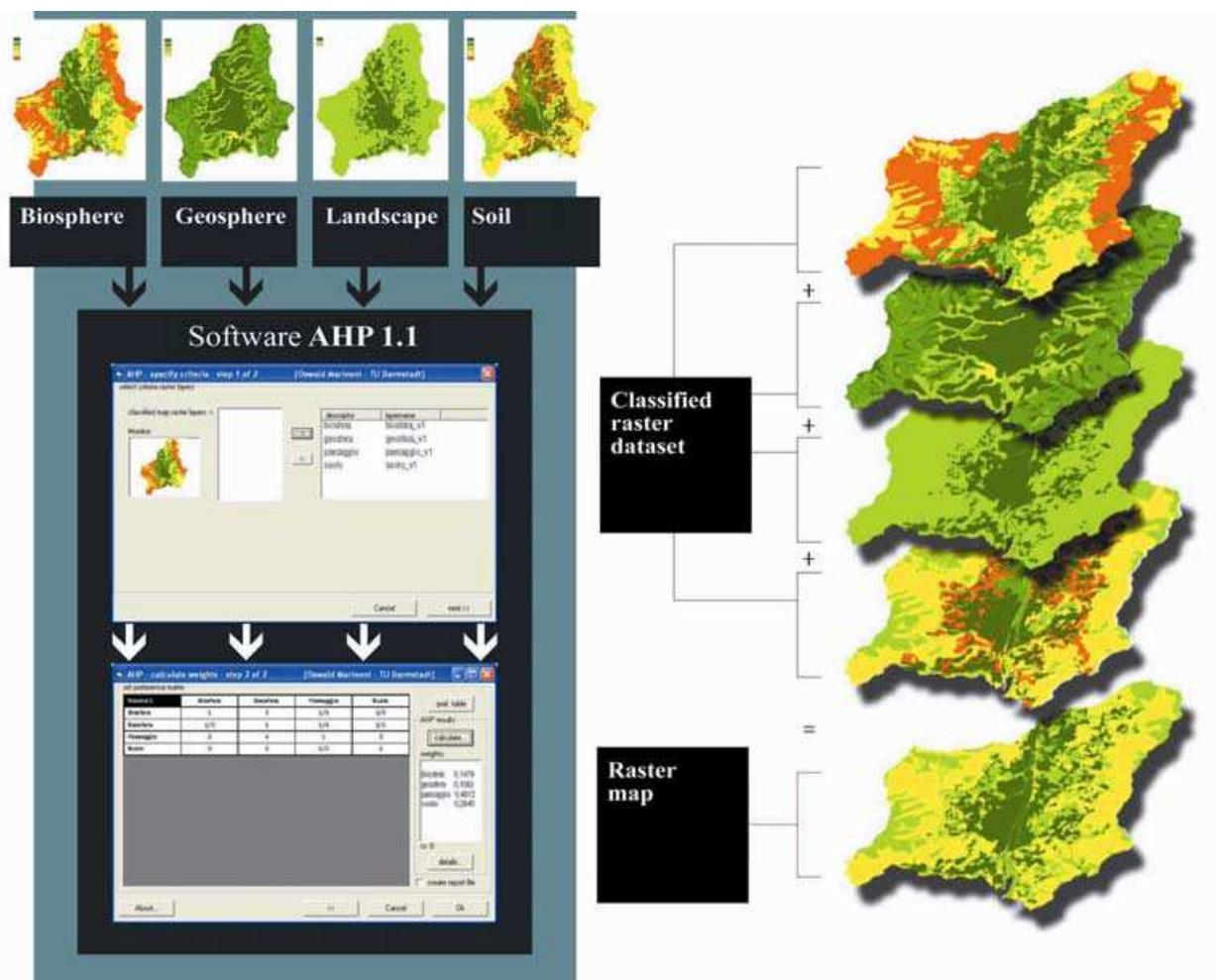


Fig. 17. The elaboration of maps of susceptibility to localization

For each Vision we have obtained the susceptibility map to localization related to *biosphere* (territorial biopotential index, biodiversity degree, infrastructural fragmentation index); *geosphere* (slopes stability, seismic zoning); *landscape* (landscape units); *soil* (land use, cultivations productivity); and overall susceptibility map to localization. The indicators selected for each environmental theme were elaborated starting from the studies and

analysis made by the different experts of the working group and the database structured by the technical staff of Cava de' Tirreni Municipality.

Therefore, for each vision, it was possible to have the relative map of susceptibility to localization and it was possible to pass from the Visions to three technical "Guide-projects" oriented to the city transformation (fig. 18). It is clear that the evaluation supported the planning phases enhancing the characteristics of each area and, most of all, placing activities where it is pre-emptively possible to minimize territorial and environmental impacts, creating the whole strategic planning frame. Through the interaction among visions identification and maps of susceptibility to localization it has been possible to develop shared and complementary guide-projects, where the use of a combination of techniques penetrates and includes informal, 'soft spaces' of decision, able to complement the more formal process, combining flexible and functional approaches with formal development plan strategies (Allmendinger & Haughton, 2009; Cerreta, 2010). In the Cava de' Tirreni masterplan, the opportunities that emerged from the interactions focused mainly on the preservation of the identity of a context wishing to regenerate itself. The integrated use of SODA, MCDA and GIS shaped the different phases, acting as a powerful combination for providing decision support in strategic decisions. SODA helps decision-makers in devising visions and exploring possible effects, while MCDA and GIS support an in-depth performance assessment of each strategic vision and related actions, as well as the design of more robust options.

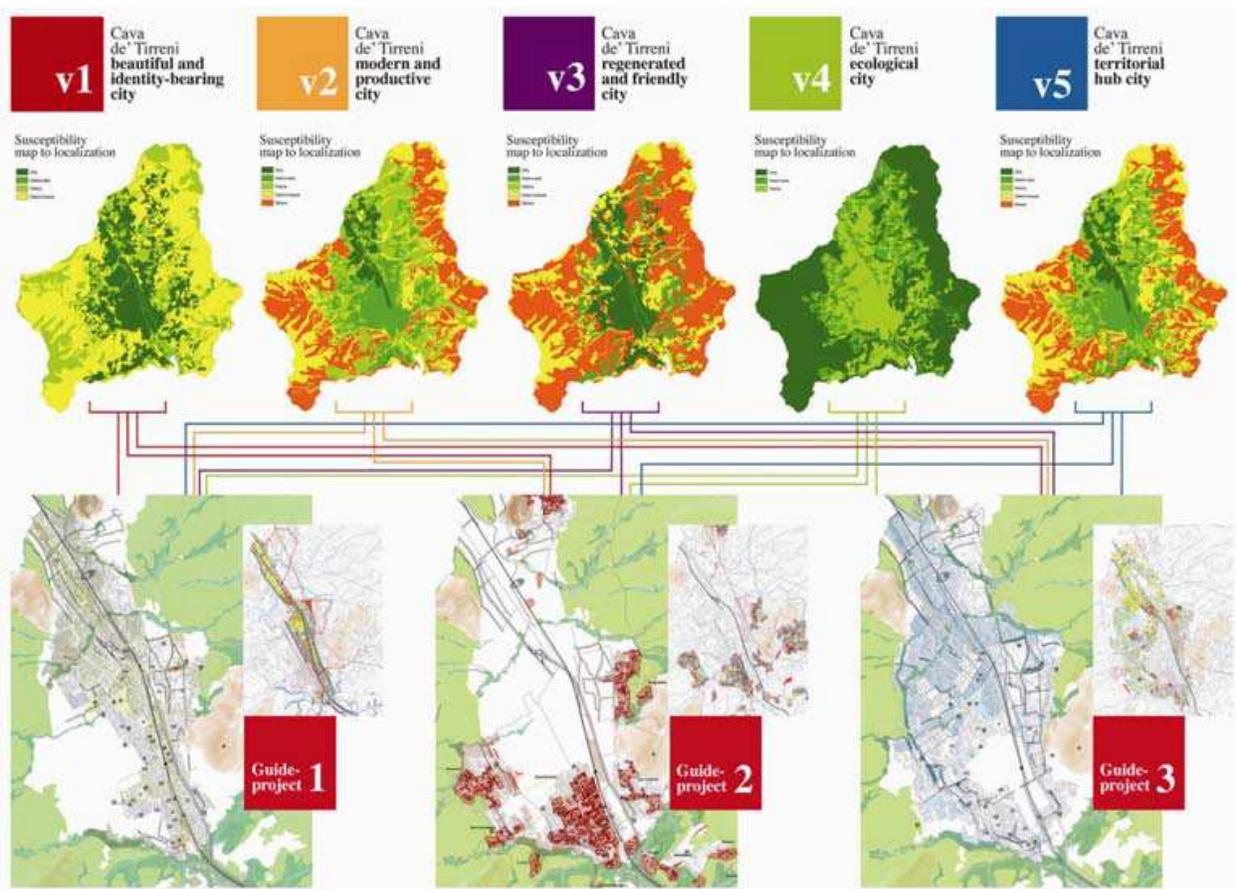


Fig. 18. The maps of susceptibility to localization and the three guide-projects

The implementation of ISA approach helps to overcome the limits of each single method, to accommodate a multi-dimensional and plural perspective and improve the quality of the decision-making process. Indeed, by using the ISA approach, we aimed to integrate social, territorial and environmental aspects in the development of strategies and planning choices, while recognizing the important role of stakeholder perceptions and environmental effects within the collective decision-making process for the creation of alternative opportunities. ISA approach may enable the interpretation of material and immaterial relations characterizing a context, the acknowledgement of existing tangible and intangible values, and the creation of strategies aimed at the production of new values and at the sustainable development of many local resources in a multi-dimensional perspective.

5. Conclusion

The selection of models illustrated highlights that many computer based tools and instruments have been developed to try and provide a common language for integrated visioning or strategy development in planning, even if these instruments face serious implementation problems in overcoming the gap between instrument development (by consultants and/or universities) and daily planning practice.

In most cases, the present technology focus produces instruments based above all on scientific rigor rather than also on practical relevance; not adapted to the complex and dynamic planning context; not transparent; not user friendly and not flexible (Te Brömmelstroet & Bertolini, 2010). Therefore, such instruments cannot link-up with the context specifics and do not contribute to implement the Planning Support Systems (PSS) (Geertman, 2006; Uran & Janssen 2003; Vonk et al., 2005) and to improve communicative planning practice (Timms, 2008; Willson, 2001).

In order to understand how to structure and improve integrated planning-evaluation processes, it is relevant to analyze how it is possible to implement the interaction among the assessment context, the assessment process and the assessment methods, how to select different approaches and techniques, and how to choose them considering the decision context specificity and the type of plan or project.

The ISA approach (Cerreta & De Toro, 2010) proposed let us explore the tools of the integrated evaluations helping to recognize their technical effectiveness and, at the same time, improving the transparency of evaluation process, to build the decision able to reflect the different needs and expectations. Through such planning-evaluation, it is possible to help communities become more aware not only of their own opinions and preferences, but also of those of other subjects, helping to find participated and shared solutions.

In this perspective, ISA can be a useful tool for decision-making, including technical and political evaluations and referring to articulated and complex value systems, in a conflicting and changing reality. The integration of Problem Structuring Methods, Public Participation GIS, Multi-Criteria and Multi-Group Decision Support Systems and Geographic Information Systems identifies a decision-making process that allows the analysis of the complexity of human decisions for a flexible environment in which collective knowledge and learning assume a significant role in decisional processes, and the possibility to explore the transformation strategy definition in spatial planning field according to sustainable and complex values.

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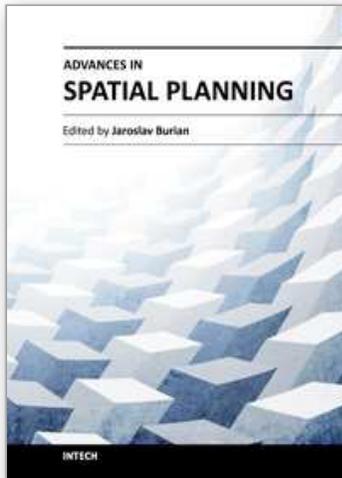
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Spatial planning is a significant part of geosciences that is developing very rapidly. Many new methods and modeling techniques like GIS (Geographical Information Systems), GPS (Global Positioning Systems) or remote sensing techniques have been developed and applied in various aspects of spatial planning. The chapters collected in this book present an excellent profile of the current state of theories, data, analysis methods and modeling techniques used in several case studies. The book is divided into three main parts (Theoretical aspects of spatial planning, Quantitative and computer spatial planning methods and Practical applications of spatial planning) that cover the latest advances in urban, city and spatial planning. The book also shows different aspects of spatial planning and different approaches to case studies in several countries.

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