INTEGRATED SPATIAL ASSESSMENT IN PLANNING: STRATEGIC CHOICES FOR CAVA DE' TIRRENI MASTER PLAN

Luigi Fusco Girard
Department of Conservation of Architectural and Environmental Heritage
University of Naples Federico II, Italy
girard@unina.it

Maria Cerreta*
Department of Conservation of Architectural and Environmental Heritage
University of Naples Federico II, Italy
cerreta@unina.it

Pasquale De Toro
Department of Conservation of Architectural and Environmental Heritage
University of Naples Federico II, Italy
detoro@unina.it

ABSTRACT

The integration of Analytic Hierarchy Process (AHP) 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. Spatial analysis combined with AHP has been used in recent years to support evaluation, especially in the field of land-use planning. The paper proposes 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.

Keywords: Strategic Environmental Assessment, Integrated Assessment, Multiple Criteria Analysis, Analytic Hierarchy Process, Geographic Information System.

1. Introduction

The integration of Analytic Hierarchy Process (AHP) 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 (Al-Shalabi, Bin Mansor, Bin Ahmed, and Shiriff, 2006). 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. Spatial analysis combined with AHP has been used in recent years to support evaluation, especially in the field of land-use planning. The paper proposes 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.

* Corresponding author

Indeed, integration between multicriteria analyses, multigroup analyses and geographical information systems can become 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 construction process within a spatial and dynamic evaluation model. With respect to the traditional use of GIS we propose 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. Therefore, it is possible to structure a decision support system which includes 'social creativity' as the key component for the decision-making process, and considers the 'reflexive community' as an interlocutor necessary 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 (ISA) (Cerreta and De Toro, 2010), can be a useful tool for decision-making, including technical and political evaluations and referring to articulated and complex value systems, inserted in conflicting and changing realities. 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. Indeed, combining Analytic Hierarchy Process (AHP) with Geographic Information Systems (GIS) overcomes the limitations of specific techniques through the application of different methods, which derive from different disciplines and defines a more complete and integrated framework of analysis and evaluation. This type of integration gives rise to a 'spatial multicriteria and multigroup analysis'. Spatial multicriteria decision-making problems typically involve a set of geographically-defined alternatives from which a choice of one or more alternatives is made with respect to a given set of evaluation criteria. Spatial multicriteria analysis is widely different from the conventional multicriteria 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 of fundamental importance for spatial multicriteria analysis: the GIS component (i.e., data acquisition, storage, etc.) and the multicriteria analysis component (i.e., aggregation of spatial data and decision makers' preferences into discrete decision alternatives).

2. Integrated Spatial Assessment (ISA): a multidimensional approach for the Master Plan of Cava de' Tirreni[1]

The ISA approach has been applied to the elaboration of the new Master Plan of the municipality of Cava de' Tirreni, in Southern Italy, Province of Salerno. Throughout the experimentation, the aim was to build a methodology of approach useful to recognize the stakes, to create a bigger cohesion about environmental protection and the safeguard of cultural heritage, to stimulate the usability of the territory while respecting the existing resources, creating and identifying the territorial impacts due to the strategies and the actions of the Master Plan. In particular, through the multicriteria assessment (AHP)

[1] The working group was thus organized: Urban planning and scientific coordination, Carlo Gasparrini 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 and 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.

integrated in the GIS, the maps of the "susceptibility to localization" have been defined, in order to express the attitude of the territory to "receive" a given function, considering its potential impacts.
Using the typical approach of the Strategic Environmental Assessment (SEA), but translating it into a more articulated evaluation process defined ISA, we aimed at integrating territorial and environmental aspects within the elaboration of strategies and planning choices, while recognizing the important role of environmental effects within the decision-making process and the selection of alternative options. In this perspective, the use of multicriteria assessment has a privileged role as decision-making tool. Within Strategic Environmental Assessment (SEA) structure, ISA can be considered as a 'tool' to create and identify the territorial impacts due to the strategies and the actions of the Master Plan. Therefore, ISA can be considered a learning process aimed to build choices and decisions in flexible, inclusive and participative terms, to discover clear and hidden conflicts and interests, and to enhance the local potentialities. We have elaborated a GIS aiming to an effective integration of different information emerged during the decision-making process. In particular, for the assessment of the plan alternatives, the multicriteria method of Analytic Hierarchy Process (AHP) (Saaty 1980) was integrated within the GIS to foresee, in spatial terms, the impact of the plan on the different environmental characteristics.
In participative phase five shared "visions" of the future were built. In order to further broaden the participation, the municipality sent a survey to all the families of the city to discover the needs of the citizens and the force-ideas to enhance and develop the territory. Visions, articulated in strategic objectives and strategic actions, were organized in a hierarchical structure and for each vision, using the Analytic Hierarchy Process (AHP) integrated with the GIS tools (Chen, Blong, and Jacobson, 2001; Malczewski, 2004), "susceptibility to transformation" maps were built. By considering the typical approach of SEA, translating it into a more articulated evaluation process defined ISA, 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.

3. Application of the AHP method

The analytic hierarchy process (AHP) structures the decision-making process in hierarchical form. From a procedural point of view this approach consists of three main phases: 1. construct a suitable hierarchy; 2. establish priorities between elements of the hierarchy by means of pairwise comparisons; 3. check logical consistency of pairwise comparisons (Saaty and Peniwati, 2007; Saaty and Vargas, 2001). In the present case-study, each vision produced in participative phase has been organized according to a three levels hierarchical structure: 1. environmental theme; 2. criteria; 3. values/characteristics. To the values/characteristics of the third hierarchical level have been associated some spatial indicators referred to the nature of the areas linked to a value judgement, expressed through a five points scale: high susceptibility to localization; 2. medium–high susceptibility to localization; 3. medium susceptibility to localization; 4. medium–low susceptibility to localization; 5. low susceptibility to localization. To perform the "spatial assessment" it was used an extension of the AHP method within ArcGIS (Marinoni, 2004), obtaining "susceptibility maps" to localization. This has made it possible to obtain not only a simple overlay of the different themes, but to make a pairwise comparison of the criteria of every hierarchical level. In order to apply the AHP method to each class of susceptibility to localization, a numerical value (score) and a chromatic scale have been associated to the five judgments. Indeed, in order to have a graphical representation of the results, to every score is related a color, to be given to every pixel, according to the convention that goes from dark green to orange. We have selected four main "environmental themes" and for each one we have identified some relevant criteria related to territorial analysis.
To each criterion has been assigned the same weight for all the visions, while for each environmental theme pairwise comparisons have been made building five matrices for every vision (Table 1). As regards to the "environmental themes" of the first level, according to the judgements from the experts of the

working group and the values/characteristics, we have a pairwise comparison among the following themes: biosphere, geosphere, landscape and soil. The priority vector, expressing the weight of the "environmental theme", for each vision is illustrated in Table 2. The consistency ratio for each vision goes from 0,0000 to 0,0572 and, being smaller than 0.10, is acceptable. By the AHP method application it is possible to combine the weights of criteria obtained through pairwise comparisons with the scores associated to the different classes of susceptibility to localization, obtaining, in synergy with GIS, the related "susceptibility maps" to localization. For every pixel it is possible to obtain a total value as a linear combination of weights of criteria by the score related to the susceptibility to localization taking into account the specific values/characteristics. For example, for Vision 5, we have obtained the following "susceptibility maps" to localization (figure 1):

1. classification map of values/characteristics for biosphere (territorial biopotential index, biodiversity degree, infrastructural fragmentation index);
2. susceptibility map to localization for biosphere;
3. classification map of values/characteristics for geosphere (slopes stability, seismic zoning);
4. susceptibility map to localization for geosphere;
5. classification map of values/characteristics for landscape (landscape units);
6. susceptibility map to localization for landscape;
7. classification map of values/characteristics for soil (land use, cultivations productivity);
8. susceptibility map to localization for soil;
9. overall susceptibility map to localization.

Considering all the environmental themes and criteria of the hierarchy and putting together the data of all criteria belonging to the first hierarchical level, we can have the map of Figure 1, in which the colours from dark green to orange express the susceptibility to localization (from high to low) of strategic actions of Vision 5. The same process was applied to all the other visions obtaining, for each one, the map of the susceptibility to localization. In this way, the assessment can really support planning, enhancing the inclination of each area and, most of all, localizing strategic actions where territorial and environmental impacts can be minimized. Therefore, the logic of the operation was the "sustainable spatial planning" of territory but it must be noticed that the Master Plan is not an automatic output of the susceptibility maps. The planner takes into account the susceptibility maps obtained and designs the Plan in conformity with them but, of course, it is possible to find many solutions congruent with the susceptibility maps of each function.

Table 1. Pairwise comparisons matrix for Vision 5.

Vision 5	Biosphere	Geosphere	Landscape	Soil
Biosphere	1	2	2	1
Geosphere	1/2	1	1	1/2
Landscape	1/2	1	1	1/2
Soil	1	2	2	1

Table 2. Priorities vectors and consistency ratio for each vision.

Environmental theme	**Vision 1**	**Vision 2**	**Vision 3**	**Vision 4**	**Vision 5**
Biosphere	0,1479	0,1667	0,1891	0,3511	0,3333
Geosphere	0,1063	0,3333	0,1091	0,1609	0,1667
Landscape	0,4612	0,1667	0,3509	0,3511	0,1667
Soil	0,2845	0,3333	0,3509	0,1368	0,3333
Consistency	0,0437	0,0000	0,0038	0,0572	0,0000

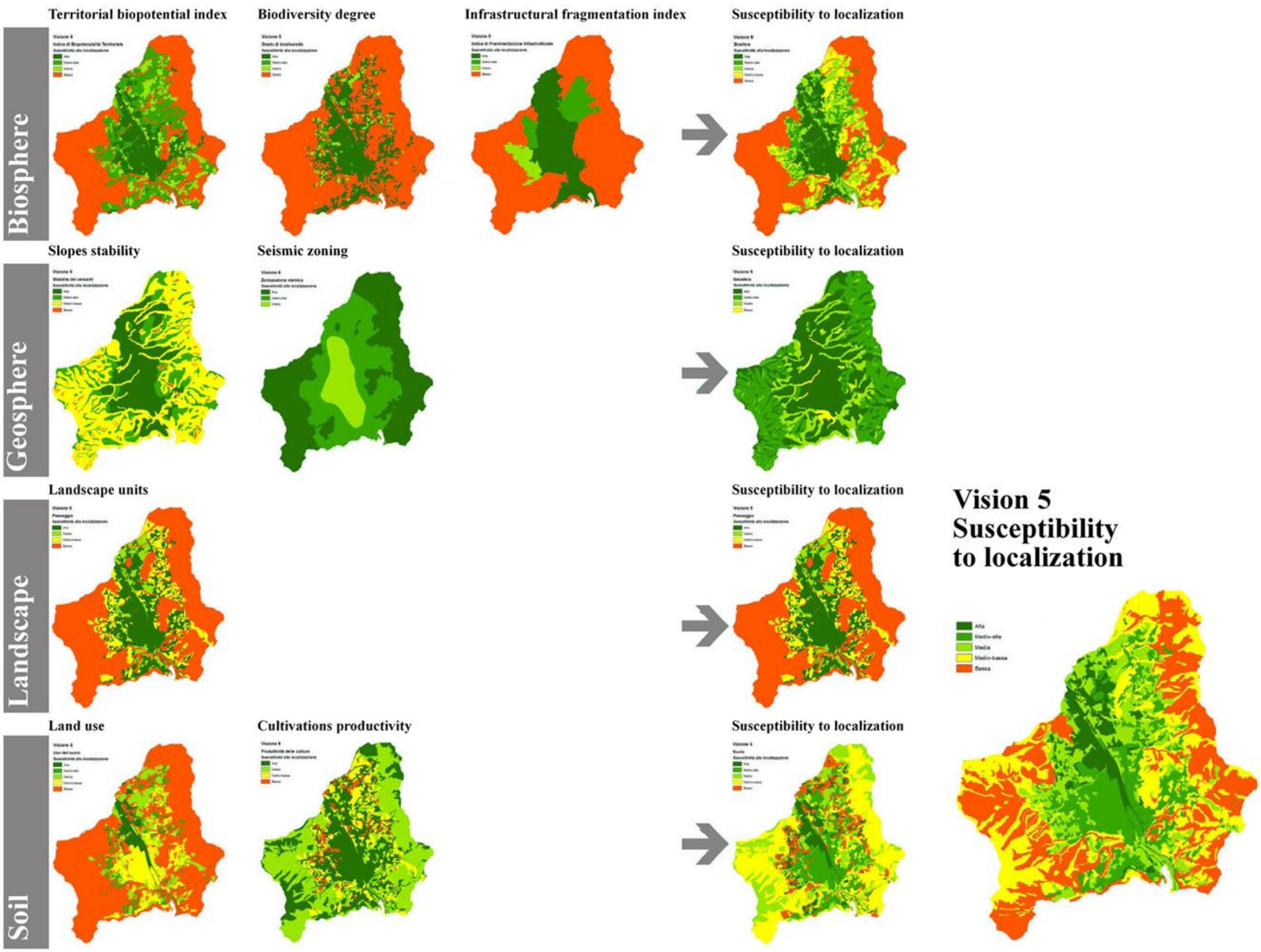

Figure 1. Susceptibility to localization for Vision 5.

3 Conclusions

Recognizing the important role of environmental effects within the public decision-making process and the selection of alternative options, we used the typical approach of the SEA translating it into a more articulated evaluation process defined ISA, in order to integrate territorial and environmental aspects within the elaboration of strategies and planning choices. An integrated evaluation approach can make us go beyond space and hierarchical limits, considering the different components (historical, cultural, environmental, economical, social, anthropological, etc.), making clear the weights and recognizing priorities, and finding the proper strategies, able to consider social participation, interdisciplinarity and integration. In this perspective, the use of multicriteria assessment has a privileged role as decision-making tool. Indeed, through the hierarchical construction of decisional objectives was easy to involve the local community and different experts and obtain a shared elaboration of visions, strategies and actions. This has contributed to the creation of a richer and complex knowledge framework of the territory and a construction from the bottom of planning ideas. Indeed, the different maps obtained from the GIS were the expression of multidimensional interaction about the meaning and the role of the different evaluation criteria, contributing together to the plan design. They help 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 evaluation processes it is possible to help communities and experts become more aware not only of their own opinions and preferences, but also of other subjects' ones, helping to find participated and shared solutions. In this way assessment has become a fundamental part of planning choices elaboration, and ISA can be seen as a preventive check of environmental and territorial sustainability and, at the same time, a tool for stimulating the identification of alternative solutions in the spatial decision-making process.

REFERENCES

Al-Shalabi, M.A., Bin Mansor, S., Bin Ahmed, N., & Shiriff, R. (2006), GIS based multicriteria approaches to housing site suitability assessment, paper presented to the XXIII FIG Congress, *Shaping the Change*, Munich, Germany, October 8-13.

Cerreta, M., & De Toro, P. (2010), Integrated spatial assessment for a creative decision-making process: a combined methodological approach to strategic environmental assessment, *International Journal of Sustainable Development (IJSD), 13 (1/2),* 17–30.

Chen, K., Blong, R., & Jacobson, C. (2001), MCE-RISK: integrating multicriteria evaluation and GIS for risk decision-making in natural hazards", *Environmental Modelling and Software, 16,* 387–397.

Malczewski, J. (2004), GIS-based land-use suitability analysis: a critical overview, *Progress in Planning, 62,* 3–65.

Marinoni, O. (2004), Implementation of analytic hierarchy process with VBA in ArcGIS, *Computational Geosciences, 30*, 637–646.

Saaty, T.L. (1980), *The analytical hierarchy process*, New York, NY, McGraw Hill.

Saaty, T.L., & Peniwati, K. (2007), *Group decision making: Drawing out and reconciling differences*, Pittsburgh, PA: RWS Publications.

Saaty, T.L., & Vargas, L.G. (2001), *Models, methods, concepts and applications of the analytic hierarchy process*, Dordrecht, The Netherlands: Kluwer Academic Publisher.