Faculteit der Economische Wetenschappen en Econometrie

SERIE RESEARCH MEMORANDA

New Perspectives on Urban Sustainability Analysis: Space-Time Evaluation in the context of Multicriteria Decision-making

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Research Memorandum 1999-54

November 1999

vrije Universiteit amsterdam

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Abstract

In the last decades researchers have emphasized the link between evaluation and planning, as an indispensable component in seeking reasonable and balanced choices for regional planning and economic policy. According to these scholars, evaluation becomes part of planning throughout the whole process of policy preparation.

Multicriteria analysis (MCA) is one of the most utilized techniques for performing evaluation studies dealing with the ranking of alternatives in the presence of conflicting objectives. It plays also a key role in urben sustainability analysis.

After a critical judgement of the potential of MCA methods, this paper seeks to explain in which way MCA can be modified in order to become a flexible tool for urban decision-making and to propose how this task may be accomplished by means of an integration between spatial analysis and MCA with a view to sustainable cities.

SUMMARY

1. A New Scene

In the past decades urban, regional and transportation planning has gone through a major transition. The traditional engineering-oriented approach has increasingly been substituted by broader social science based approaches which encapsulate a wide range of policy objectives related to a multiplicity of phenomena in a complex spatial reality. Conventional land use modelling appeared not to offer satisfactory tools and new evaluation frameworks have come to the fore. The complexity and the variety of planning tasks have also prompted a development toward a set of complementary analytical frameworks ranging from efficiency-based principles (such as social cost-benefit analysis) to broad social utility based principles (such as multi-criteria analysis). Despite differences in methodology and the underlying economic basis of these frameworks, they have all in common that in performing planning tasks due attention has to be given to all relevant aspects which have an actual or potential impact on decision-making being it directly measurable in monetary terms or not.

The main background for the emergence of interest in integrated forms of evaluation is the fact that in a modern planning setting a simple resort to market based principles does not seem realistic. Policy interventions, spatial developments and responses of stakeholders generate a wide variety of market externalities – of both a quantitative and a qualitative nature – which cannot be incorporated in unambiguous price indicators. In particular, the link between environmental quality and spatial development is of critical importance here and has drastically changed the nature of modem spatial planning. Therefore, in the present contribution the issue of environmental sustainability will play a central role, with a particular view to urban sustainability.

Environmental concerns have been with us for several decades already. Since the publication of Rachel Carson's 'Silent Spring' (1962) an avalanche of public statements, scientific studies and policy proposals has been launched. Ecological decay has been one of the most severe issues in the second part of the 20^{th} century. In a way, one might argue that the disturbance of the earth' ecosystem is one of the most risky experiments mankind has ever undertaken, in particular as there is no guarantee that the experiment will ever be successfully concluded.

Admittedly, the environmental case is not a hopeless one. The awareness of environmental decay has grown drastically and our scientific insights into the causes of and remedies against this disturbance have led to many new findings and policy initiatives. As a consequence, human behaviour has turned into more environmentally-benign ways of living, industrial activities have become far less polluting, more resource-saving and more energy-efficient, while environmental policy has become an established part of public policy. Especially in modem cities many achievements have been made.

Against this background of doomsday scenario's and signs for hope, Hempel (1996) has written an interesting study on new forms of environmental policy needed to cope with the challenges of the next millennium. His main focus is on the identification and management of transboundary and trans-generational environmental change. Rather than government, he advocates governance; rather than policy analysis, he proposes policy synthesis. He advocates new frameworks for a better understanding, as well as for more effective political and economic reforms that are necessary to ensure sustainable development. This requires a devolution of power and authority away from the nation-state and toward greater reliance on supranational,

regional and local levels of governance, leading to so-called 'glocal' institutions which have a long range and transboundary interest. Clearly, in this approach cities may become "signs of hope".

In the framework of our paper we will address similar issues, but with a main focus on analytical and methodological questions. In particular, we will address the question whether evaluation - as a scientific investigation of policy options and choices - and planning - as an action-oriented approach with a view to policy implementation - have not grown too much apart.

Nowadays, evaluation and planning are indispensable and mutually intertwined complementary tools in the decision-making process. Evaluation follows planning and vice-versa in a cyclical scheme throughout the whole trajectory - survey, analysis, design and monitoring - of planning. Recent research (Lichfield, 1996) has pointed out that evaluation tests allow planners to seek the best possible analysis tools and procedures for plan implementation and monitoring. Evaluation becomes increasingly not only a control framework, but also an essential component in planning (Lombardo, 1995).

Recently, Ferraro (1998) issued the complaint that planners and scholars do not delve sufficiently into the topics of evaluation of the planning system and of monitoring of the results. In the last decades the implementation of regional policies and urban plans has been affected by many bureaucratic flaws and sometimes also by wrong development indications. These shortcomings have been mostly due to a lack of correspondence between objectives of plans and the real outcomes. It is clear that this remark sheds also light on the problem of the efficiency of planning, which is an important aspect related to evaluation and planning.

The notion of perfect prediction or of a 'makeable' society is increasingly criticized. During the eighties urban and regional planners reacted sharply against the so-called rationality paradigm. According to this approach which had been widespread among practitioners during the sixties and the seventies, it was possible by using simple basic principles to outline and even prescribe how planning should be done (Richfield, 1996). This deterministic approach to planning has proved to be elusive, because of many failures in proposing efficacious solutions. It appeared to be deceptive to rely on a single scientific method in order to solve a multi-faceted, complex problem of planning. What planners at best can supply is only an incremental series of methods; by means of such tests they are able to check each phase of their scientific work, from the preliminary study, through analysis, to plan monitoring. In this way, one may agree with Karl Popper (1959) in saying that it is necessary to adopt the logic of the "falsification" test: a proposition can be considered valid until it is disproved. Others (Chadwick, 1978) go even further and call every test an evaluation.

It should be noted however, that evaluation, as it has been developed and adopted during the eighties and the nineties, stems from another logic: the planning process can be decomposed into discrete phases. Since it is difficult to verify the validity of the whole process through a one-step procedure, it is preferable to test each phase, in order to prove whether it satisfies all requirements.

Against the background of these preliminary remarks, the aim of this paper is to discuss recent findings in evaluation and to propose an integration between multicriteria and spatial analysis, with reference to urabn sustainability.

The paper is subdivided into the following parts. In the next section multicriteria analysis (MCA) methods are described and some shortcomings are pointed out. In the third section advances in MCA methods are illustrated and the integration between

MCA and spatial analysis through GIS is proposed. These methods have a particular relevance in an urban sustainability context. The final part key perspectives for future research.

2. Methodology and Techniques: Shortcomings and Benefits

Recent studies point out that *"evaluation can be defined as a set of activities to conveniently arrange the information needed for a choice in order that the various participants in the choice process are enabled to make this choice as balanced as possible"* (Nijkamp et al., 1990, p. 15). In this description the main focus is on the problem of the effectiveness of planning. It should be noted though, that, as far as evaluation is concerned, many other aspects are also involved, such as the efficiency, the performance, or the conformance (Faludi, 1995). In this perspective, *ex ante* evaluation sees it as its task to describe which effects each alternative choice possibility implies in order to make a smart decision.

In the last twenty years analysts and planners have faced the construction of a multidisciplinary evaluation methodology; one of the most widespread approaches is multicriteria analysis (MCA), which is based on the mathematical formalization of the set of preferences of decision-makers, by means of formal choice theory, structured models and computer algorithms. Apart from various differences among MCA models, the general framework of this approach is based on the articulation of a complex problem into its simple components: the aggregation of performances of each choice possibility with respect to selected criteria yields final outcomes as a recommendation to decision-makers in the urban or regional field.

In spatial and environmental planning MCA is regarded as a useful tool, since it may form a solid base for impact analysis. Nijkamp et al. (1990) state that "*impact assessment is thus a central component of evaluation research, as it provides all necessary information that serves as a frame of reference for regional, urban and transportation planning.*" And later "*consequently, spatial impact analysis is a necessary vehicle for the use of multicriteria evaluation methods in a spatial context* (p. 38)."

Recent research (van Herwijnen, 1999) has shown that it is possible to translate the aforementioned concepts by means of an integrated approach to the analysis of policy effects. This methodology is based on the combination of two different and complementary approaches: (i) spatial analysis and modeling and (ii) multicriteria decision analysis. The first approach refers to processing information, which is referring to space, in order to construct inter alia thematic maps representing the spatial distribution of important aspects of the policy choice problem at hand; the second refers to the interpretation of the maps, in order to build criteria and effectiveness scores and to aggregate them in a final ranking of choice possibilities. After the data have been processed, they become the input of MCA procedures. Different algorithms may then be used in order to compare the final resulting rankings. This part is useful from a policy perspective or the political point of view, since usually, even though technically an evaluation suggests a particular policy response, it is only the political debate or the planning team discussion, which leads to the final choice.

It ought to be recognised that in the past decade also various types of criticism have been raised against the efficacy or usefulness of MCA methods; a few remarks are in order.

First, there is the problem of the general viability and acceptability of using the multicriteria approach to decision-making. This approach has been criticised in the past and has led to accusations that it may lead planners and decision-makers to deterministic and rigid paths towards their choices. A related major criticism on multicriteria analysis has been that it is a tool that can be easily manipulated by politically biased mathematicians and analysts in order to influence administrative bodies.

A proper answer to these complaints came from Roy (1993), who investigated recent wrong interpretations of multicriteria outcomes. The key of the criticism stems mainly from the fallacious illusion that MCA results correspond to the final decision, without further reasonable interpretation. On the contrary, Roy argues that analysts can at best provide a composite set of techniques and tools in order to give advice to decision-makers. The interpretation of the political area is clearly the most important concern: the robustness (Roy, 1998) of the model as well as the values of the weights are linked to specific positions of parties involved.

Consequently, Roy (forthcoming) emphasises that collaborative behaviour between politicians, decision-makers and analysts is a sine qua non (the solving "panacea") for accepting MCA approaches as a useful instrument in evaluation and planning. According to this view, multicriteria analysis has to be interpreted more as the science of aiding decision-making than as a science of decisions per se. In other words, it does not point out which is the best alternative to choose; it states instead which advise can aid to select the best choice (Roy, 1993).

Secondly, there is no conclusive agreement about the specific MCA approach to be applied. Looking at the case studies and at the literature on MCA reviews (Voogd, 1983, Roy, 1985, Nijkamp et al., 1990, Vincke, 1992), it is possible to identify two broad categories of algorithms used.

The first class is based on multi-attribute utility theory (MAUT); according to this approach, it is possible to describe the system of preferences of individuals or decision-makers by means of a unique function, which assumes different values in regard to the fulfillment of consequences linked to various alternatives (Keeney and Raiffa, 1976, Keeney, 1996). The assessment of this function leads to a complete ranking of alternatives.

The second category is based on a system of pairwise comparisons between the alternatives, with respect to their effectiveness in the fulfilment of different criteria. The exploitation of outranking relationships leads to a ranking of alternatives, which is even not complete (Roy, 1985). Admittedly, in a qualitative measurement system numerical interpretation, REGIME methods and fuzzy logic approaches are able to handle mixed quali-quantitative information with better outcomes (Castells and Munda, 1999).

While the first approach may lead to more comfortable and ready to use outcomes, sometimes the assessment of the utility function turns out to be very difficult. On the other hand, outranking relations allow analysts to face planning problems with uncertainties and fuzziness in a more reliable, though less precise, way.

Others (e.g. Simon, 1983) have philosophized on the approach of multi-attribute utility theory by calling it the Olympian model. Subjective Expected Utility (SEU) (Simon, 1983, p. 13) theory assumptions are considered too ephemeral to produce

practical advice and viable solutions. In Simon's view, people usually take decisions according to other paradigms; these are restricted by "bounded", "intuitive" and "evolutionary" rationality. With respect to these models, decisions are then the outcomes of limited possibilities to handle knowledge, which is inherent to human behavior. Also Malczewski and Ogryczac (1995) draw the conclusion that *"in many real-life situations it is very difficult or even impossible to obtain a mathematical representation of the decision maker preference (utility) function."*

Recent research has pointed out that for environmental planning purposes the second approach is more useful (Castells and Munda, 1999). According to several criticisms, the underlying assumptions of MAUT, viz. linear aggregation, compensability and preference independence, are not satisfactory for environmental evaluation modeling, as they are not able to describe constitutive and complex phenomena, such as synergy or conflict inside the ecological systems.

On the other hand, it should be noted that many useful efforts have been made in the exploitation of assessments based on MAUT by developing easy-to-use computer software packages, which enable analysts and decision-makers to exchange views in the context of interactive systems (see Smith, 1989). Within this framework, this mathematical approach seems to favour political debate in administrative bodies of public and private organizations committed to take decisions. This can be accomplished by allowing the contextual changes in the parameters of the problems, such as the critical weights attached to the criteria for urban sustainability.

Finally, Morin (1999) compares three different group decision support systems, notably Which and Why (W&W), Expert Choice (EC) and Multi Attribute Tradeoff System (MATS), and remarks that a simple additive weighting technique, despite its shortcomings, *"has a number of merits which makes its use generally attractive [and] is simple to use, moderately flexible, the results can be easily displayed, and sensitivity tests can be readily applied"* (p. 15 1).

3. Advances in the Design of Decision Support Systems: New Research Perspectives

The wide scientific literature about MCA methods testifies that this approach has been developed by means of a sufficiently grounded mathematical basis. Research coming from different areas, such as mathematics, operational research, economics and statistics has since the beginning of the fifties made many efforts to shape what is called the discipline of decision analysis.

Yet multicriteria techniques still encounter many criticisms and show sometimes serious shortcomings, whenever they are confronted with the resolution of public issues and concerns. In these cases the political arena has proven to be a very severe test in the past, since the interaction between analysts and decision-makers has not been always characterised by collaborative behavior. This can be explained by addressing two broad concerns on evaluation analysis for sustainable cities:

- technical concerns;
- institutional concerns.

The first type of problems concerns the fact that MCA has serious limitations in the exploitation or the analysis of two categories of data:

- spatial data;

- temporal data.

The second one relates to the procedure through which society (e.g., public administrations and bodies) responds to evaluation analysis.

In the following two sections both technical and institutional concerns will be outlined with a view to urban sustainability.

Technical concerns

Multicriteria techniques have been used widely as a tool for aiding decision-makers, usually without any reference to spatial and temporal dimensions. This is probably due to the origin of these techniques, related to the field of operational research and business administration. Many procedures for aiding choice were related to the study of different choice options whose effectiveness had to be measured with reference to abstract dimensional spaces. According to this approach, the effectiveness table becomes a matrix, which does not describe physical characteristics, but only the relative performances of choice options along a system of ordered axis.

On the other hand, many choice problems have a spatial and temporal connotation. In particular, the solution of complex problems in urban and environmental planning requires that the alternatives and the effectiveness matrix be referred to space and time. This occurs because the alternatives have usually an impact highly uneven distributed in different patterns in the study area. Moreover, the time dimension is another concern, because the effects of each alternative have a dynamic evolution and cause evolving impacts on the built and natural environment.

A system, that is not able to represent the integrated impact of different alternatives in a spatial-temporal dimension, is likely not able to show to decision-makers and stakeholders practical consequences of their possible choice options. It is not capable to translate with convincing precision spatial impacts into qualitative or quantitative appraisal scores. Research has to be undertaken in the direction of the exploitation of integrated assessment systems that will be able to assess impacts by means of processing spatial data and to construct consistently an effectiveness table that is changing according to (simulated) time dimensions. In a review on progress and possibility of spatial analysis, Openshaw (1990) describes a reliable path towards to the construction of a missing link between GIS and information technology on the one hand and spatial analysis on the other. The aim of our contribution is to foster the integration of many techniques for designing a decision support system for urban sustainability planning.

According to recent findings (van Herwijnen, 1999, Fischer and Nijkamp, 1993), the integration of spatial analysis and decision support systems can be articulated in the following steps: construction of a (simulation) model, definition of criterion maps, spatial aggregation and multicriteria analysis. In some sense, the use of GIS turns out to be essential for this purpose. Besides, it is proven that GIS-assisted decisions are statistically more precise and faster than the corresponding traditionally based procedures. This is due to the capacity of restoring, manipulating and displaying data that are implemented by means of GIS. Beside of the most utilized GIS software, we should mention here the sharp increase of studies aiming at the implementation of ad *hoc* packages usually based on object-oriented programming. These tools enable users to change spatial attributes and also to shape accordingly the MAUT procedures in order to assess rankings of the alternatives.

Scenario analysis is one of the simulation models, which can help to figure out possible consequences of alternative policies. The general framework of this approach

is based on the description of the impulses and of the effects induced by each policy (Gorter and Nijkamp, 1999). This technique helps to estimate which are the alternatives' performances with respect to a set of policy goals.

Much more effort is needed for the integration of the temporal dimension into decision support analysis. The reason is straightforward: while spatial data are treated in several procedures and policy-makers relatively easy understand geographical maps, the representation of time and dynamics is still a difficult task to achieve. A review of the historic procedures to represent time (Vasilev, 1998) reveals five different modes to display the temporal dimension. The modes are the following: the dating of an event in a space (moments), the continuance of an event in a space (duration), the organization or standardization of space by time (structured time), the use of time as a measure of distance (time as a distance) and the use of space as a measure of time (space as a clock).

The aforementioned integrated packages should ideally be able to incorporate a separate routine assessing mathematical algorithms, statistical forecasts and environmental models in a dynamic perspective. An illustrative example of an attempt to display dynamic effects in order to study sustainability indicators is the assessment of cadmium accumulation in the soil (Gilbert and Feenstra, 1993). The aim of the study is to show how different paths describing the concentration of cadmium as a function of time enables analysts to offer useful insights to policy-makers.

In urban planning many statistical techniques have inter alia been applied to forecast tourist movements (arrivals and bednights) in order to design receptive settlements and to assess the impact on the aggregate change in local income. By the same token, population forecasts describe the path of residents, in order to plan new expansion areas of the city. These models have the common aim to assess the demand for services as a support for urban policy seeking.

The integration with MCA is not easy: some ideas stem from the mathematical treatment of the time paths of each key quantity measured in terms of modal value, mean value or median value. In this way it is possible to use dynamic information in a static perspective, by introducing single values as scores into the effectiveness table. Yet time is usually represented in a way that does not enable a dynamic display. Research on temporal information and GIS (Lagran, 1993) indicates that the main direction leads to organise snapshots databases so that it will at best be possible to obtain animated maps (Gersmehl, 1990 and 1992, Monmonier, 1990, Karl, 1992, Peterson, 1995). Modern spatial analysis tools will no doubt offer a new opportunity of sustainability planning for modem cities.

Institutional concerns

This issue is partly connected with the difficulties described above. As a matter of fact, technical advances and sophisticated data-processing approaches may shed light on the solution of complex choice problems. Besides, it should be admitted that these issues could even not be tackled a decade ago without the help of computer hardware.

In this context it is noteworthy that in a critical review Bürgenmeier (1999) refers to the general procedure of evaluation. He then complains: *"although the relevant literature offers many methods for weighting the variables entered in an evaluation procedure, it should be stressed that none of them attaches sufficient importance to the fact that an impact assessment is a process that also includes a learning aspect."*

Nevertheless, it seems that in policy-making seems that the main node is not the technique but the interface between the expertise and the group of stakeholders. The

integration of MCA with spatial and temporal dimension has to be realized in the recognition that the procedure should yield results in a manageable and tractable way.

In this procedure, the approach leads to a bottom-up path: decisions as conclusive outcomes of the evaluation and planning process are the product of the reflection and consideration of the main concerns of groups of society directly involved. The debate on these issues constitutes a conspicuous part of the research on strategy for consensus building (Healey et al., 1995, Healey, 1998a, 1998b).

Recent research points out the new role MCA may play in the process of learning of society (van Geenhuizen and Nijkamp, 1998 and 1999). According to this paradigm, one of the key factors of the economic development is the capability of acquire new knowledge. It can be interpreted as a typology of human capital, which has proven to be an important variable for achieving sustained and balanced economic development. For example, the literature about economic convergence explains the influence of investments in human capital (i.e., research and development) on the patterns of income growth or welfare among different regions or cities.

Recent findings (Bruinsma et al., 1999) emphasise that regional development is due to dynamic processes of learning, by means of a body of creative knowledge. Its main components can be recognised in the following series of activities: consensus among regional actors involved, networking to advance knowledge creation and flow, transformation of knowledge, management of human capital, management of (public) stocks of knowledge and identification of new learning and knowledge needs (van Geenhuizen and Nijkamp, 1998). It goes without saying that in particular learning capacity has to be stimulated in decision-making processes. There are many patterns through which learning can be activated: access to databanks, access to Internet, experts' brainstorming meetings etc.

Besides, there is a lack of models which are able to take into account the effect and behaviour of the learning capability. Still "*decision making is based on insufficient knowledge of the learning capability and of the learning itself*' (van Geenhuizen and Nijkamp, ibidem). The empirical evidence of the performance of learning actors is however, far from sufficient. For instance, recent research in OECD (1996) does not provide figures related to calculation of economic performance with a view to learning processes.

In the context of the decision "arena", it should be studied how learning capacity evolves and plays a crucial role, even when the process implies not formalised, but tacit knowledge. Implicit knowledge, embodied in a complex mixture of practice and experience, is connected with creativity and intuition and is regarded as contributing most importantly to new combinations and new applications in product, process and management innovation (van Geenhuizen and Nijkamp, 1998, den Hertog and Huizenga, 1997). In conclusion, the idea of a learning city seems to be essential for sustainable city planning.

In some cases, experimentation may lead to a model which stems from the integration between a Delphi process and scenario analysis by means of stepwise upgrading of the set of alternatives in an interactive perspective with the stakeholders (Bruinsma et al., 1999).

Recalling the theory of Simon (1983), we agree that a new approach is fostered in order to focus on the capacity of finding new alternatives in a creative, interpersonal heuristic way. "*In the Olympian model, all problems are permanently and simultaneously on the agenda (until they are solved). In the behavioral model, by contrast, the choice of problems for the agenda is a matter of central importance, and*

emotion may play a large role in that choice" (Simon, 1983, p. 30). Further research should be dedicated to the exploration of useful modes allowing stakeholders, analysts and government officials to study new alternatives for the same policy and to foster their knowledge and capability to represent new departures and instances through it.

It is opportune to draw a partial set of conclusions be drawn from the previous observations before we proceed to real-world applications. The review of recent research has led us to the main finding that MCA in its traditional framework is not sufficient as a unique mathematical procedure for decision-making. The increasing role of bottom-up planning processes and of consensus building techniques reveals how urgent becomes the problem of displaying to stakeholders the effects of a set of alternatives becomes. In other words, MCA has to be seen as a tool for communication.

Thus, analysts have to invoke methods to integrate MCA with techniques that are able to describe scenarios evolving in space and time. This system would allow analysts, stakeholders and administrative bodies to monitor and control effects of alternatives, which display a spatial distribution changing over time. According to this framework, spatio-temporal models are the basis for common debate aiming to define consensus-shared criteria hierarchies and weights. Internet can play a crucial role in fostering the exchange of information, by means of interactive protocols and GIS based two-ways interviews (Carver, 1999). In a more general sense, Figure 1 aims to describe the process of selection of the efficient alternatives and of the application of decision rules in a general case.

The following section will now offer a new framework based on modem spatial analysis techniques, with particular reference to urban sustainability planning.

4. In Search of Integration between MCA and Spatial Analysis with a View to Urban Sustainability

In our application of the framework discussed in the previous sections a qualitative decision procedure will now be outlined for aiding planners and stakeholders to choose among different alternatives for urban sustainability.

This section is subdivided into three parts. These three are designed according to Simon's (1960) view of case study analysis: intelligence, design and choice. In the first phase the geographical environment is identified with reference to the political agenda. In the second phase, alternatives are described by means of a system able to show their spatial and temporal characteristics. And in the third phase the choice of an alternative is made, according to the preference structure of decision-makers and stakeholders.

General description ("intelligence ")

Any empirical case study approach in planning concerns in general the evaluation of alternative proposals for historical conservation at the level of urban planning.

Traditional planning procedures have often faced the organisation of the expansion of the city. Cities represent the focal point of the economic, social and cultural development and have been for years the nodes of financial interests and of labour migration. The sector of building construction and of civil engineering has fostered this tendency and the planners' main focus has been the design of the new city.

During the last decades there has been a change in this trend: the population in cities is not growing with the same pace as before, and sometimes there is a tendency towards saturation or even decline. The main effect is that expansion is not the exclusive concern of planners anymore; they recognise that a main new issue is the management of already built – and sometimes - abandoned areas, historical centers, peripheral neighborhoods and old industrial areas (e.g. brownfields).

As a particular case of the new plans of the city, the recovery plans of historical centers require strategic policies for the following reasons. They attempt to find suitable economic activities for the historical built environment and to reconstruct a particular urban quality, which is embodied by the system of cultural heritage, e.g. monuments and architectural symbols.

Researchers have traditionally focused their interest on the assessment of the particular value, which is linked to the cultural heritage. Fusco Girard (1989) questions the possibility to integrate conservation and development, and emphasizes the role of the evaluation of the social complex value as a guide to recovery projects (1986b). It is noteworthy that the Italian law states that the communes exceeding a threshold of a certain population size have to compile operative plans for the recovery of the historic part of the city.

Techniques adopted ("design ")

The desired methodology for urban environmental planning can be articulated in the following main phases:

1. management of information;
2. debate of the main tasks;
3. application of spatial/MCA approaches;
4. extension to time evaluation.

In the first phase the data will be organised on a simple spatial unit (the urban block) by referring alphanumeric information to geographical and topographic space. The aim of this phase is to obtain a thematic map system that is ab le to show different data and various knowledge components to analysts and stakeholders. The identification of different dynamic paths implied by each scenario leads to the choice of the most convenient grid to which data should be referred. The assessment of effects-impacts implied by each scenario is used as a tool to identify the level of aggregation of a spatial census unit. In this perspective it is very likely that the most disaggregated distribution can not offer a valid support for the analysis. On the other hand, ideally the preferable grid structures should follow geographical sub-divisions of four historical neighborhoods, since many times policies are explicitly referred to those units by administrative bodies.

Scenario analysis may also lead to the assessment of a convenient time horizon of the evaluation, because changing conditions imply different consequences and a different performance throughout the lifetime of an urban rehabilitation project. This choice could take into account dichotomous patterns, such as short run/long run and construction/operational time horizons, or stepwise patterns, such as n-years interval instants. The time horizon, once individuated, provides a sort of snapshot whose attribute scores enter, as inputs, into multicriteria evaluation approaches.

These remarks lead to the study of the evaluation criteria, which are the core of the second phase. In this step public debate and participation are fostered by using available techniques, such as questionnaires, interviews or the Internet medium. The

contents of the inquiry refer to the availability of data, to the clearness of the project design, and to the measurability and handy-to-use quality of the variables related to each criterion. The aim is to assess the tasks of the evaluation and to build a hierarchy of several goals with a common consensus on them.

This introduces the third phase. The comparison between the scenarios and the set of criteria leads to the construction of the effectiveness table. It should be pointed out that effectiveness scores while in the traditional MCA framework do not embody any reference to space and time; in our case application on sustainable city policy, they are referred in this application to spatial location and to different time situations. The same happens to the set of weights, which is an evolving vector over time. Even the number and type of criteria can be considered as changing through the different time situations. This problem relates to the development of the fourth phase.

It should be noted that these four phases are not chronologically mapped out, even though sometimes a temporal link can be recognised. They are integrated parts of a single complex procedure.

If it is assumed that the set of criteria is the same in each time period, the weight vector may be considered as a function of time. With reference to van Herwijnen (1999), it is possible to say that the problem at hand is a two-dimensional spatial multicriteria evaluation. Each score is interpreted as a map-score; using a functional notation, the expression of the score e_{ij} is:

$$e_{ij} = f(x,y)$$

This means that the score of alternative j with respect to criterion i takes different values referred to a topology defined by the selected grid with x and y coordinates.

Adding time to the spatial distribution leads to the need to investigate the evolution of each simple grid cell over the time periods t selected. This leads to the study of effectiveness scores with a three dimensional character defined by the following simple function:

$$e_{ij} = g(x,y,t)$$

By the same token, the vector of the weights can be seen as having a spatial distribution. Given the set of criteria, it is very likely that political debate show a pattern of the set of weights that is depending on different neighborhoods in historical city centers. Therefore it is necessary to examine a map of weights for each criterion. Besides, the criterion weight has a spatial distribution, which may change over time as well. Interviews and interactive learning processes can lead to the assessment of a function, which describes the behaviour of the value of the weight over time.

According to the previous remarks, the weights may then be described as a three-dimensional function of space and time as follows:

$$w_j = h(x,y,t)$$

The procedure implies two steps: an aggregation device and a decision rule. The first one aims to process the distribution of the effectiveness scores and the weights in a two-dimensional space. This can be accomplished by means of mathematical algorithms, such as spatial weighted average based on underlying preference assumptions about the distribution of the effects and of the weights, with reference to

the political agenda. In this way it is possible to obtain scores and weights which are expressed by means of functions of the variable time; the second step, the application of the decision rule, leads to the final ranking of the alternatives.

Thus the application of the aggregation rule and of the evaluation criterion (van Herwijnen, 1999) under these assumptions yields rankings, which, regardless of their completeness, can be studied as functions of time. Time can be articulated in discrete time and in continuous time. Recent developments of integration between cartography and GIS allow the implementation and study of functional relationships with continuous time, by means of animated maps. In this case study a discrete time will be adopted and attention will be devoted to single effectiveness complex tables referring to each time period. When an urban recovery project is assessed, these periods are defined inter alia by the joint effort of administrative bodies, analysts and planners involved in the building schedule. The algorithm operates in a five-dimensional space, the dimensions being alternative, criterion, x-dimension, y-dimension and time, and yields a final ranking, that is expressed as a vector of real numbers.

In Figure 2 the main steps of the procedure are summarised.

Expected outcome ("choice ")

The expected outcome of the evaluation is the analysis of the set of resulting rankings expressed as a function of time. The ultimate product is of course the choice of the "best" alternative, while giving special concern to the dynamic interactive process in the political debate. In this phase it is essential that the process of learning and elaborating knowledge be fostered by analysts in order to achieve consensus about the results, which may, eventually, modify some leading assumptions. This could regard the choice of the criteria and the assessment of the weights. In this way, the participation of the group of stakeholders may give suitable feed-backs for better shaping the evaluation procedure in order to achieve consensus on the decisions to be made in the context of urban sustainability.

5. References

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6. Figures

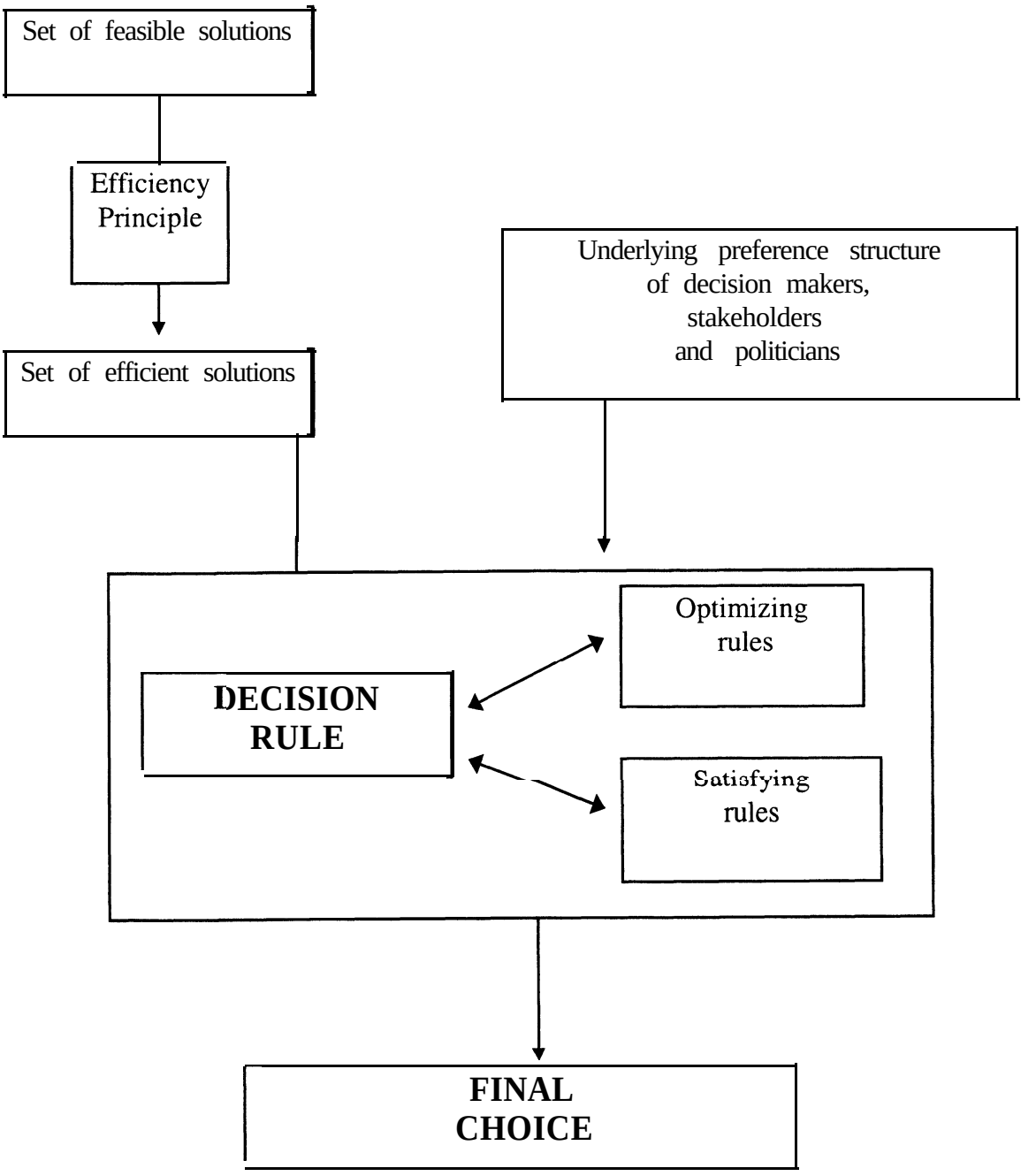

Figure 1.: Sketch of the decision making process

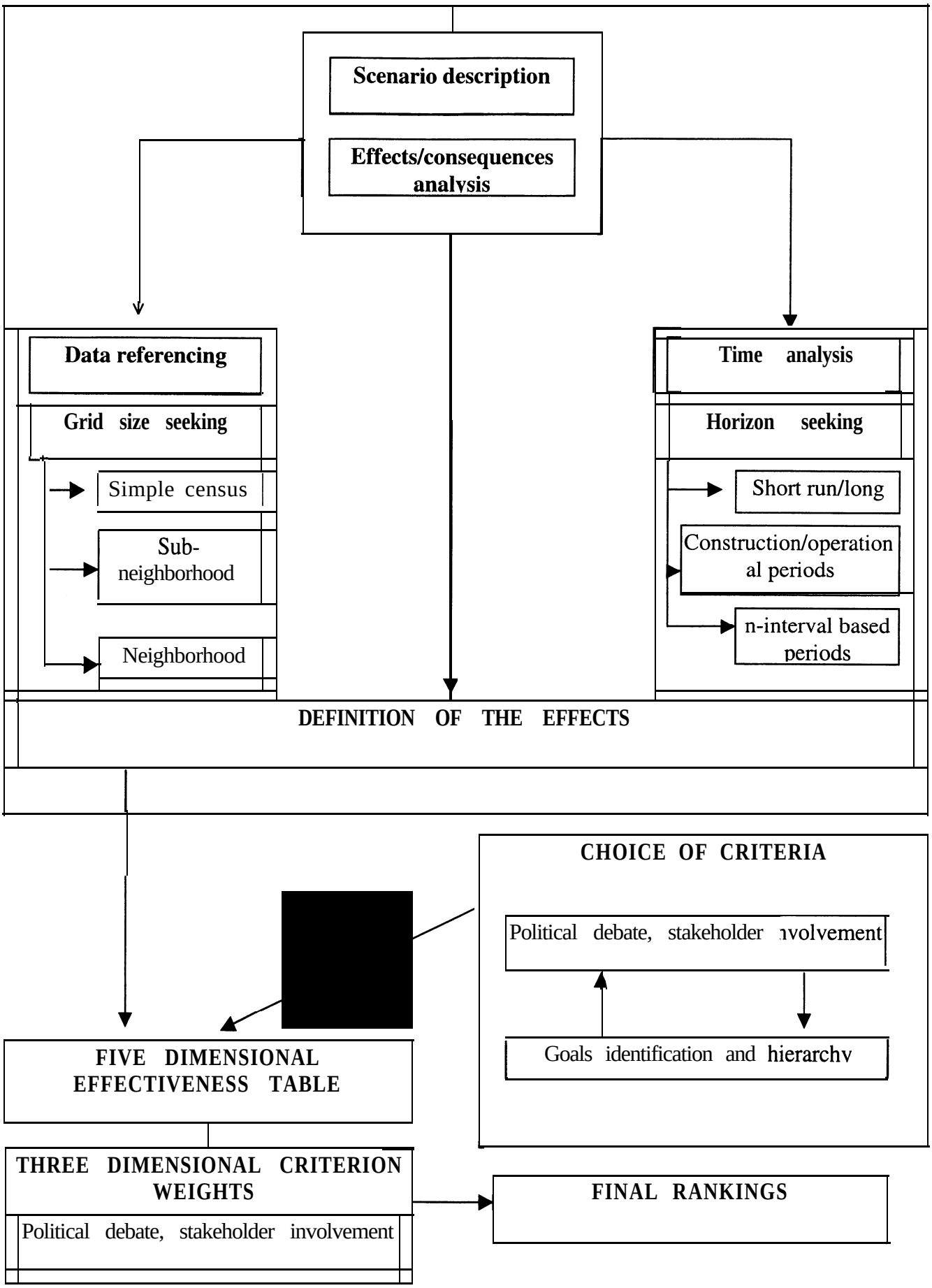

Figure 2.: Flow chart of the evaluation procedure for spacio-temporal multicriteria evaluation