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Assessing regional sustainable developments

The purpose of this paper is to provide a systematic overview of the 'modern' mathematical and methodological instruments like Environmental State Evaluation/Appraisal (ESA), Strategic Environmental Assessment (SEA), the Multi-Criteria Analysis (MCA), the GIS techniques and Fuzzy evaluation methods. We would like to provide the main issues and problems related to evaluation in general of these techniques. The first section discusses definitions, the scope of evaluation, and the tools for evaluation. The second section reviews the existing generic analytical frameworks for evaluation; the third section the state-of-the-art in this field in regional development programmes. Finally in the concluding part we reflect on the open questions that need to be addressed when developing an analytical framework for evaluation suitable for regional development programmes.

1 Introduction

The rising popularity of the notion of sustainable development has increasingly provoked the need for an operational (i.e., practical, measurable and policy-relevant) description or definition of this concept. The standard, widely-cited WCED definition of sustainable development as "a development that fulfils the needs of the present generation without endangering the future needs of future generations" is a meaningful starting point, but fails to offer manageable guidelines for sustainability strategies of (local, regional, national or international) decision-making bodies or other actors. The complementary description of sustainable development by the IUCN/UNEP/WNF emphasises from a more ecological angle the need for "improving the quality of human life while living within the carrying capacity of supporting ecosystems". Since the beginning of the world-wide debate on sustainable development, a massive volume of literature has been published on this notion. So far, no uniformly accepted definition has been offered, although the basic intentions of the sustainability concept are clear: it aims at directing decisions of policy bodies and private actors towards a joint state of the economy (or society at large) and the ecology, such that the needs of current and future generations are fulfilled without eroding the ecological basis for a proper welfare and activity level of these generations.

The normative nature of sustainability requires therefore, in general, a framework of analysis and of expert judgement which should be able to test actual and future states (or developments) of the economy and the ecology against a set of reference values.

This requires three important components in any sustainability analysis for a region:

- identifying a set of measurable sustainability indicators
- establishing a set of normative reference values (e.g., carrying capacity or critical load)
- developing a practical impact methodology for assessing future developments (as a result of changes in behaviour, exogenous developments or policy orientations).

Clearly, a major problem in operationalizing the notion of sustainable development is its lack of specificity in concrete circumstances (e.g., particular regions or economic sectors). A sustainable development in a given region or sector is not necessarily sustainable elsewhere. Thus, sustainability is context-specific and hence co-determined by needs and opportunities in a particular region or sector. This observation has in the mean time led to a more flexible delineation of sustainable development by referring to regional or sectoral

sustainable development, witness popular notions like ‘sustainable city’, ‘sustainable transport’, ‘sustainable tourism’ or ‘sustainable agriculture’.

Nevertheless, it seems plausible to describe sustainable development in a given region more precisely as a balanced development policy for all resources in a region concerned, to such an extent that a maximum level of welfare (including quality of life) – now and in the future – is achieved through a co-evolutionary strategy focused on environmental, social and economic objectives and/or constraints, while taking into consideration the impact of exogenous circumstances on the region concerned. The analytical steps, indicators, reference values and impact analysis, will play a crucial role in any attempt at assessing the degree of sustainability (or at least its qualitative direction) in a relevant area (Nijkamp and Ouwersloot, 1999).

The purpose of this paper is to provide a systematic overview of the main issues and problems related to evaluation in general, and for regional development programmes in particular. The first section discusses definitions, the scope of evaluation, and the tools for evaluation and how they can be classified. The second section reviews existing generic analytical frameworks for evaluation; the third section the state-of-the-art in this field in regional development programmes. Finally in the concluding part we reflect on the open questions that need to be addressed when developing an analytical framework for evaluation suitable for regional development programmes.

2 Requirements of the environmental state evaluation

While studying regional evaluation techniques, we can spring from an oxymoron, that sustainability appraisal is both impossible and essential. In a world of rapid change, interdependency and uncertainty, nothing can be said to be truly sustainable – so comprehensive and definitive sustainability appraisal is de facto not possible. At the same time practical methods of sustainability appraisal are clearly essential in managing the increasingly global impacts of human activity (Ravetz, 1999).

There are several methods and technologies to assess, evaluate and classify the state of the environment, to characterise the actual state and to identify the adverse effects.

Stochastic method – classical approach

It aims at the repeated survey and recording of elements of the environment. The changes can be detected by comparing succeeding dates of recording. A major disadvantage of this method is that there is no way to identify the causes responsible for the changes so it is not or to a very limited extent is suitable for making environmental prognoses.

Deterministic method

This can be eliminated by exploring the external effects, the paths and effects of polluting materials, noise and radiation in the environment. This complex type of survey does not separate the layers of the biosphere, but tries the whole transformation process on to the limits of measurement and analysis capabilities. The method, however, is still analytical, only one factor can be observed at a time and this is not sufficient to describe the real changes in the state of the system.

Holistic method

This assessment examines the interference of various activities, measures as well as the systems consisting of one or all environmental media. Integrating measurement, data management and processing, analysis and evaluation phases into a common technology implementing the above philosophy makes prognosis making possible (Bulla, 2004).

The applicability in the environmental state appraisal (ESA) of these aspects provide the solution of three further tasks:

- firstly, a set of parameters suitable for classification of the changes according to the given aspects can be specified (and the actual values of these parameters can always be obtained;
- secondly, a value-scale has to be constructed for the chosen parameters so that the environmental state can not only be described but also evaluated;
- thirdly, evaluation algorithms are to be implemented, which can carry out a reconstructable and objective evaluation. (Bulla, Széchi, 2003)

It is expedient to integrate the experience gained so far into a uniform system since both the environmental and the social interests require the co-ordination of the natural, social and economic interests, the preventive and rational management thereof and its fundamental condition is the elaboration and the implementation of a new type, integrated environmental state evaluation.

In designing models for environmental and resource policy-making, the following three main types of policy objectives may be distinguished:

- nature conservation objectives, e.g. “minimum exploitation of natural systems”, “optimum yield”;
- socio-economic objectives, e.g. “maximum production of goods and services at minimum (private and social) costs”;
- mixed objectives; e.g. “maximum sustainable use of resources and environmental services” (Munda et al, 1995).

3 The importance of evaluation methods for sustainable development planning

The awareness of actual and potential conflicts between economic progress in production, consumption, and technology and the environment has led to the concept of “sustainable development”. (Munda et al, 1995). The sustainability of any region is relative to external factors and to its trajectory in past and future. Sustainability as a practical definition is surrounded with assumptions and value judgements. As the theme of sustainability is intrinsically multidisciplinary and multisectoral, this suggests that effective appraisals should likewise be based on a holistic or integrated assessment (Ravetz, 1999).

Evaluation is not a new field: it grew in the 1950s in parallel with the implementation of large-scale programmes for urban and regional development following the end of World War II. Evaluation is in several countries well ingrained in the policy decision-making process: forerunners in this connection are the U.S. and the U.K (Giorgi and Tandon, 2000).

In the frame of regional spatial dimensions of environmental management, a meso/regional scale of analysis is desirable for the following reasons:

- environmental decision-making can be more easily guided by a regional governmental agency;
- interactions and feedback mechanism are more easily traceable at a regional than a national level,
- regions have specific problems or capacities that should be dealt within their right context and level of detail.

The assessment as well as decision-making level should be as close as possible to the (geographical) place in the object of analyses.

At a meso scale of analysis, the concept of evaluation process is of a great importance. Evaluation aims at rationalising planning and decision problems by systematically structuring all relevant aspects of policy choices (for instance, the assessment of impacts of alternative choice possibilities). Evaluation may be considered as a continuous activity which permanently takes place during the planning process. It is noteworthy that evaluation processes have often a cyclic nature. By “cyclic nature” is meant the possible adaptation of elements of the evaluation due to continuous consultations between the various parties involved in the planning process at hand. The degree of complexity of an evaluation process

depends among others on the evaluation problem to be treated, the time and knowledge available and the organisational context (Munda et al, 1995).

It should be noted that different kinds of evaluation can be distinguish in a policy analysis, one of the most important discriminating characteristics being between monetary and non-monetary evaluation. A monetary evaluation is characterized by an attempt to measure all effects in monetary units, whereas a non-monetary evaluation utilises a wide variety of measurements units to assess the effects. Cost-benefit analysis (CBA) is a well-known example of a monetary evaluation. Multicriteria methods belong to the family of non-monetary evaluation methods (Munda et al, 1995).

4 The purpose, scope, context and tools of evaluation

The sustainability of regional programmes, developments can be analysed by indicators. The evaluation of the state of the environment is one of the possibilities. Though the improvement in the state of the environment is not equal with sustainability, the counter-process – i.g. the deterioration in the state – still unanimously indicates the failure in the realisation of sustainability (Bulla, 2004).

4.1 Why evaluation?

Evaluation is “a process which seeks to determine as systematically and objectively as possible the relevance, efficiency and effect of an activity in terms of its objectives”. In other words it represents the assessment of the outputs, outcomes and processes of an activity. When tied to the original goals and objectives of public policy, evaluation represents a process of verification of the extent to which these goals were met as well as a procedure for improving the accountability of public institutions. Following from the above, it carries a normative element and has a practical orientation as it is expected to produce results that can be applied to improve policy interventions. Evaluation can have one or several objectives. It can be employed for judging whether an intervention is legitimate or not; for examining whether an activity conforms to statutory and regulatory requirements, programme designs and professional standards; to provide feedback as part of a monitoring exercise; or for assessing the outcomes of a policy intervention and, in this connection, to provide information on the use and allocation of public resources or the efficiency of a programme (Giorgi and Tandon, 2000).

4.2 Scope of evaluation

No evaluation exercise can meet all of the above objectives at the same time. This is why it is useful to determine the scope of an evaluation exercise early in the evaluation process.

The scope of the evaluation is determined by the decision-making process. There are two main aspects to this: the first is the stage of the decision process at which evaluation is employed; the second is the level of analysis. With reference to the stage of the decision process, a common reference point is that of the classical decision-making model which distinguishes between four main phases, namely the agenda-setting or problem definition stage, the policy design phase, the policy legitimation phase and the policy implementation phase. Palumbo (1987, in Giorgi and Tandon, 2000) reformulates the objectives of evaluation according to this policy cycle as follows:

- In the agenda setting / problem-definition phase, the objective of evaluation is to define the size and distribution of the problem, to forecast or determine the needs and identify the target groups or areas.
- In the policy design phase, decision analysis techniques involve the identification of alternative means of achieving programme ends with the purpose of selecting the most cost-effective alternative.

- In the policy legitimation phase, evaluation must assess the acceptance of a policy or programme by the public and stakeholders.
- Finally in the policy implementation phase, evaluation checks whether the policy is implemented properly, i.e. according to standard procedures and in line with the original objectives.

In evaluation literature (Leleur 1995, Turro 1999, Sugden and Williams 1978, Layard and Glaister 1996, Atkinson and Cope 1994, Pearce and Hett 1999 in Giorgi and Tandon, 2000) one refers alternatively to ex ante evaluation to describe evaluation that is carried out in the problem definition or policy design phases also known as appraisal; intermediate evaluation to describe evaluation undertaken during the implementation stage for the purpose of monitoring; and ex post evaluation to describe evaluation that is carried out once the implementation phase is completed and for the purpose of assessing the project or programme's impacts.

Insofar as the level of analysis is concerned, it is widespread practice to distinguish between policies, programmes and projects, where policy refers to a set of programmes or measures that have the same specific objectives, schedules and modes of management; programme, to a co-ordinated set of activities of limited scale and budget; and project, to a non-divisible action with a mode of management, a schedule and a budget that are well defined from the outset. Project evaluation tends to focus on the assessment of socio-economic viability of a distinct set of alternative options. The objective here is to determine the best option for achieving the programme or project alternatives or the most cost-efficient solution (Giorgi and Tandon, 2000).

4.3 Tools of evaluation

There are several tools that can be used for evaluation. These can be classified mainly along four dimensions:

- The analytical framework from which they emerged and within which they mostly operate;
- Their suitability for policy, programme or project evaluation;
- Their suitability for different phases of policy analysis (i.e. ex-ante, monitoring or ex-post);
- The extent they rely on statistical or mathematical methods or tools or alternatively on 'softer' methods.

Existing classifications like those proposed by government bodies tend to consider primarily the second and third dimensions above, i.e. tools are classified according to their suitability for policy, programme or project evaluation and with reference to the timing of the evaluation exercise.

Giorgi and Tandon (2000) would contend that if classification schemes are to be good more than just as an inventory, they have to consider the two other dimensions mentioned above, namely the analytical framework of the method in question, and the extent of reliance on statistical or mathematical methods. Clarifying assumptions and not just objectives. The analytical framework of evaluation is not one which is today often dealt with explicitly. Either it is taken for granted that for instance cost-benefit analysis is rooted in welfare economics, or this is assumed not to be important either for the demand or the supply side of evaluation.

5 Brief overview of mainstream evaluation techniques in regional development

This annex describes in brief the main premises and problems of the standard evaluation methods in regional development, namely environmental state appraisal (ESA), strategic environmental assessment (SEA), multicriteria analysis (MCA), the GIS techniques and Fuzzy evaluation methods.

5.1 Environmental State Appraisal (ESA)

The state of the environment is continuously changing. Partly, due to the never-ending or recurring geomorphologic and biosphere-forming events, partly due to impacts of activities of – today already prevailing – anthropogenic (social and economic) origin.

Environmental problems are complex, multiphased, stereoscopic and they have evolved from several causes. In order to handle them we should analyse the causes of state changes – effects – economic and social activities: defining and elicitating the causes, as well as the dominant effects.

The penetration of the habits of the consumer society (with the artificially induced consumption) goes together with the larger and larger concentration of the resources as well as with significant and continuous increase of end products (wastes) in the area of production, consumption and services. At the same time the demand for the adequate quality of environment is also articulated at social level.

So the emerging problem is dual one: how to maximise the use of natural resources – in order to reach a higher standard of living – and how to minimise the adverse effects on the environment. So the balance between the increasing civilisation demands and the natural resources has to be created. This is the duty of the environmental management.

In order to handle the emerging tasks it is indispensable to get to know the changes forming the quality of the environment, to explore the causes of the changes and the expectable consequences thereof.

It is necessary to have information that

- provide the actual state of the environment,
- explore the casual connections,
- indicate the probable trends of the changes (Bulla, 2004).

All these things mean that the determination of environmental policy objectives and tools, the elaboration of environmental policy are not possible without exploring the state and the changes therefore, more and more exact evaluation of environmental resources and knowing the background social information. So the first, basic step is the environmental state appraisal (ESA). In order to fulfil this task it is necessary to integrate the results of basic and applied research of different sciences in an interdisciplinary way (see Figure 1). According to the objective (examination of the sustainability of regional development) ESA is part of the comprehensive environmental management.

The method deals with the establishment and development of such modern expert system based on mathematics that is suitable to evaluate the state of the environment, in a wider sense to analyse the relationships of changes of state as consequences of (adverse) impacts on the environment, as well as the relationships of social, economic and technological processes being the source of these impacts. With the help of it the changes of state depending on the changes of environmental loadings can be forecast, the environmental and impact assessments can be expanded and further developed. In the course of the regional programmes and developments the expected impacts of political programmes aiming at the regulation of the users of the environment can be predicted so they can be implemented. Regarding the costs, it is possible to choose and elaborate the (most) favourable and proper ones (Bulla, 2004).

With the help of ESA expert system the changes in the state of the environment as well as the effects of the rational prevention (included the effects of the legal and economic regulation, too) can be modelled. This way the environmental effects can be forecasted, the necessary actions and their expectable costs can be calculated. This expert system would support both the exact implementation and evaluation of environmental impact assessments and the elaboration of regulation alternatives on emission reduction. (Bulla, 2004)

The model of the analysis of environmental management is simplified, because it does not include the natural interactions and it does not describe the details: environmental media,

effects, social and economic activities, causes, constituents of policy change, means of institutionalizing. But it is suitable to define these, namely this is the main aim of the following analysis: working out environmental protection programmes, achieving them, supervising them, summarizing the results, indicating new aims, priorities and tasks. In short: the never-ending management of environmental economy is continuous. The use of the model serves the realization of system-principled analysis. The information flow, the structures, material, energy – that is, it aims at supervising and controlling the statical, dynamical and guiding systems (Bulla, 1991, 1992, 1993, 1996).

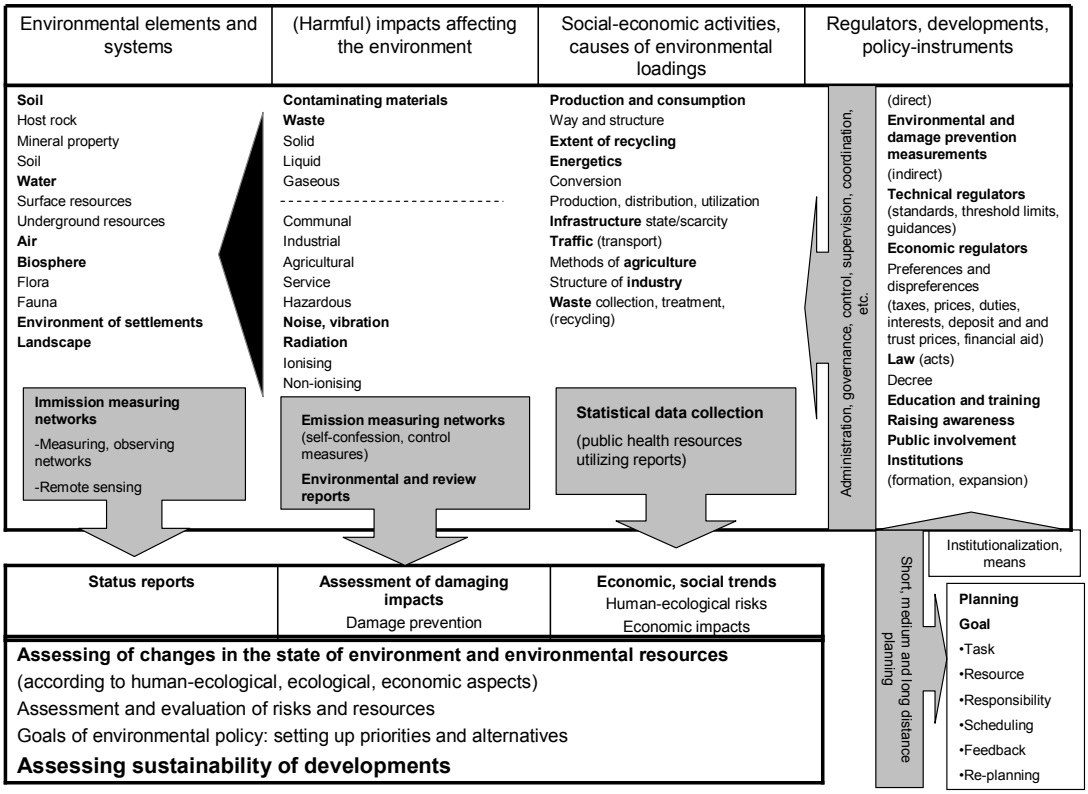

Figure 1: Model of the comprehensive environmental management and evaluation (Bulla, 1991, 1992, 1993, 1996)

Within the frame of this, it is necessary to perform the analysis of the changes in state occurring in the environmental media and systems (soil, water, air) and the economic and social processes causing them. Knowing all these things, the occurring process can be known and characterised so the effects can be calculated and forecast (Bulla, 2004). The model is same as (or similar to) the DPSIR model, only the lay-out of the components is different.

In some cases, analysis of the current situation shows that traditional planning (the planning for each economic sector taken separately) cannot manage negative processes (Ravetz, 1999).

5.2 Strategic environmental assessment (SEA)

SEA is a new framework analysis tool for assessing various networks and large scale projects. It mainly refers to the environmental assessment of programmes and policies as opposed to individual projects framework. It takes place in the context of a tiered forward planning process where policies at the international/national level are seen shaping

programmes at the regional level and the projects at the local level. There seems to be a growing consensus that SEA of policies, plans and programmes is essential to ensure that environmental considerations are incorporated at all levels of decision-making. It is also considered an effective instrument to promote sustainable development since it can handle the aggregate environmental impacts of national/regional developments and the evaluation of alternative strategies adequately.

The scope of SEA and the degree of detail of the assessment largely depend on the level of planning – environmental, socio-economic, etc. objectives by which the strategic action is led. The assessment of global/regional effects such as climate change and acidification are typically conducted on a high planning level. It also helps in estimating more local characteristics of the environment-noise, visual impact etc. as opposed to other form of evaluations.

While undertaking a SEA any of the following techniques can be used:

- techniques for EIA, i.e. multi-criteria analysis,
- techniques used in policy analysis like scenario and simulation techniques,
- regional forecasting and input-output techniques, goals achievement analysis, cost-benefit analysis,
- literature research, expert judgement.

Literature suggests that this method can be most commonly used for evaluation policies. The advantages of SEA are (Giorgi and Tandon, 2000):

- Environmental issues are given greater degree of influence of general policy formulation.
- It encourages consideration of alternatives which might be ignored otherwise.
- It allows effective analysis of cumulative effects of projects.
- It facilitates both planning and analysis of synergistic effects.
- It is capable of taking delayed impacts into account.
- It can enhance both communication between responsible and the involvement of the public.

5.3 Multi-criteria analysis (MCA)

It is clear that in policy-relevant economic-environmental evaluation models, socio-economic and nature conservation objectives are to be considered simultaneously. Consequently, multicriteria methods are in principle, an appropriate modelling tool for combined economic-environmental evaluation issues. Given the problem of the differences in the measurement levels of the variables used for economic-ecological modelling, multicriteria methods able to deal with mixed information can be considered particularly useful.

Environmental management is essentially conflict analysis characterised by technical, socio-economic, environmental and political value judgements. Therefore, in an environmental planning process it is very difficult to arrive at straightforward and unambiguous solutions. This implies that such a multi-related planning process will always be characterised by the search for acceptable compromise solutions, an activity which requires an adequate evaluation methodology. Multiple criteria evaluation techniques aim at providing such set of tools.

Multiple criteria evaluation techniques aim at providing such a set of tools. Multicriteria methods provide a flexible way of dealing with qualitative multidimensional environmental effects of decisions. However, this does not mean that multicriteria evaluation is a panacea which can be used in all circumstances without difficulties; it has its own problems.

The main advantage of these models is that they make it possible to consider a large number of data, relations and objectives (often in conflict) which are generally present in a specific real-world decision problem, so that the decision problem at hand can be studied fro multiple angles.

The main disadvantage of a multicriteria model is that an action a may be better than an action b according to one criterion and worse according to another. Thus when different conflicting evaluation criteria are taken into consideration, a multicriteria problem is mathematically ill-defined. The consequence is that a complete axiomatization of multicriteria decision theory is quite difficult (Munda et al, 1995).

MCA is also called the multi-attribute method for evaluating. It takes into account and synthesises several effects, quantitatively and qualitatively and also the views of all the stakeholders. The first step in the MCA after outlining clearly the objectives is to weigh all the criteria and then give a score to each of the criteria or even assign monetary values to it. According to Leleur (1995 in Giorgi and Tandon, 2000), determining the weights is a key factor and requires expertise from the decision-maker. MCA is particularly used for ex ante evaluation of projects.

The essence of MCA can be found in the following statement by Bouysson (1990 in Giorgi and Tandon, 2000): "in a multi-criteria approach, the analyst seeks to build several criteria using several points of view. These points of view represent the different axes along which the various actors of the decision process, justify, argue and transform their preferences". Therefore MCA has a big advantage to accommodate a wide range of non-monetised impacts and to admit interactions between impact scores that are not linear. MCA is used to rank projects, by giving separate scores on a number of key criteria.

Keeney and Raiffa (1978 in Giorgi and Tandon, 2000), describe MCA as a method that suggests or prescribes how a decision maker should think systematically about identifying and structuring objectives, about making value trade-offs and about balancing various risks. Belton (1990 in Giorgi and Tandon) suggests that MCA helps decision-makers learn about the problem situation, about their own and others value and judgements, and through organisation, synthesis & appropriate presentation of information to guide them in identifying often through extensive discussions a preferred course of action.

There are various multi-criteria techniques available, which can be classified in three clusters:

- structure: establish goals and concerns for the problem, select the criteria for the evaluation, and predict the performances of policy attractiveness.
- value analysis: study the attractiveness of individual impacts and relative importance of the criteria for the actors involved.
- recommendation for the decision: depending on the way the problem is structured, this requires some type of aggregation, leading to ranking of alternatives, or the isolation of one or more promising solution.

The most common form of the MCA is the compensation method. This method consists of attributing a weight to each criterion and then calculating a global score for each measure, in the form of a weighted average of the score attributed to that measure through different criteria. It is called 'compensatory' because the calculation of the weighted average makes it possible to compensate between criteria. For example, a measure which had a very bad impact on the environment could obtain a good global weighted score if its impact on employability were considered excellent.

Advantages of MCA are:

- It enables both quantitative and qualitative data to be combined.
- It allows a wide range of goals to be accommodated in evaluation. For example it allows for the joint analysis of both environmental and financial costs in a specific area (e.g. transport), especially when the environmental costs cannot be valued in monetary terms (Giorgi and Tandon, 2000).

From operational point of view, the major strength of multicriteria methods is their ability to address problems marked by various conflicting interests. Multicriteria evaluation techniques cannot solve all these conflicts, but they can help to provide more insight into the nature of these conflicts (Munda et al, 1995).

Disadvantages of MCA are:

- The disadvantage of MCA is that it is a subjective technique; weighting criteria are either chosen using expert judgement or dependent on policy objectives and targets.
- There is also a potential for arbitrariness in ordinal scoring for qualitative impacts.
- MCA attempts to take into account the multiple impacts of a project in a balanced manner. Impacts are weighted depending on their relative importance or priority in terms of meeting objectives. Given the interdependence of impacts, this can lead to problems of double counting (Giorgi and Tandon, 2000).

5.4 The GIS system

It is a requirement against the information system evaluating the state of the environment is to support the elaboration of the decision alternatives serving the implementation of future state(s). The final aim is the decision preparation.

In order to have the decision supporting information in the appropriate time and in the examined space at the adequate accuracy it is also necessary to take into consideration further basic principles.

It is necessary to have a network of decentralised information systems. This principle corresponds both to that political will that says that decisions have to be taken at local, regional levels where the vents occur (and where their influence is built on decision alternatives) and to that technical possibility that says that information belonging to this decision responsibility should be provided in adequate density and in time since it can only be provided like this: in the network of smaller systems.

It is necessary to have information system based on regional principle instead of systems that can answer only to sectoral and branch issues. So it is necessary to analyse the common enumeration of the factors and effects, the interactions of the given field. This principle does not negate the necessity of the branch data collection but only says that it is not necessary to have separated – and centralisable – subsystems but those ones enabling multi-purpose analysis in a given field.

In order to support the activities related to regional development, we need such an information system network that is able to ground planning, implementation monitoring, analysis of the occurring changes and the judgement of necessity and result of (sudden) interventions. The integration of knowledge is important from this point of view since these activities otherwise should be separated in terms of organisation and management.

On the one hand, most of the environmental problems have spatial dimensions. These environmental problems can be better understood through environmental modelling and it is easier to find the solution. On the other hand, the geographic information systems are able to collect, integrate, manage and analyse the spatial data with geo-reference. Such a system as general-purpose technology is able to handle the data in digital form. It renders the data stored in large sets in a pre-processed form, suitable to analysis directly supports analysis and modelling then processes the results even afterwards. With the help of it the interrelations and casual correlations can be analysed and modelled.

The Arc/Info software can serve as a basis of the environmental decision supporting system since it is one of the most known vectorial GIS system and due to its elasticity and applicability it is commonly used in environmental protection, regional development, environmental management, water management, etc.

A global decision support system should provide the widest possible range of model parameters, but is should also emphasize the factors of significant influence, and calculate the values mostly contributing to the state of environment at the same time. However, this requires the costly collection of adequate data and tools able to do the calculations. The model themselves also require their own structures, as input and output tables, maps and

model conditions are to be specified for every state of environment. The user may launch the calculations directly, or through higher level models (Bulla and Széchi, 2003).

5.5 Fuzzy Analysis

The size and scope of a regional sustainability problem is large, therefore, sustainable decision-making, which involves decisions at the local, regional and national levels, often involves complex and ill-defined parameters with a high degree of uncertainty due to incomplete understanding of the underlying issues. In order for such improvements to be successfully implemented within a region, the regional leaders must possess accurate decision-making abilities. Thus, attempting to model the sustainable development of a region, a methodology for the characterization and management of data is necessary to provide more information and is vital for improved decision-making abilities.

Although many methods for the assessment of sustainability have been already proposed, the fuzzy set theory seems to be decisive in the appraisal of regional sustainable development. The fuzzy method uses fuzzy logic reasoning and basic indicators of environmental integrity, economic efficiency, and social welfare to quantify measures of sustainability at the local, regional, or national levels, along with the sensitivity analysis of the fuzzy method, which analyzes and identifies the most important factors contributing to sustainable development. This approach can be implemented to appropriately handle the aforementioned data uncertainties and provide a sound basis for rigorous sustainability decisions to be made. Although this approach has been applied to evaluate the sustainability of an entire nation, this method can also assess the sustainability of a region.

The combined use of fuzzy logic and sensitivity analysis allows for the systematic evaluation of various sustainable management strategies and therefore permits the proposal of various strategies that successfully aid in the sustainable development of the region. In order to do so, it is necessary to have a tool capable of measuring sustainability and another able to determine the effects that a change in a decision parameter will have on system performance (i.e. assess the results of the policy and determine whether or not the region is on a sustainable path), which the sensitivity analysis provides. Sensitivity analysis is critical to successful decision-making abilities since it studies the dependency of regional sustainability indicators on various policies and regional decisions.

Fuzzy models can interface information between the society level and the production system level. If expert knowledge is thoughtfully applied to construct both the essential membership functions and fuzzy rule bases, then fuzzy models can draw valid evaluative conclusions with respect to sustainable development. The evaluative framework of sustainable development that identifies criteria on the basis of the point of view provided by the two-faces of sustainability (which provide a two-way perspective by integrating ecocentric and anthropocentric rationales on sustainability in a system imperative and societal imperative), and that gives meaning to sustainability criteria on the basis of fuzzy evaluation, provides a novel and valuable contribution to the sustainability debate (Cornelissen, 2003).

6 Concluding remarks

In general, it would be desirable to construct a comprehensive impact model which would encapsulate the complex interacting patterns of regional development and related land use in relation to social and environmental variables. Such a modelling activity could take the form of either an econometric model (validated by empirical data on solid statistical grounds) or a simulation model (calibrated at best by plausible information). In light of the near-impossibility to construct for each individual regional development plan or project a dedicated model, in practice one often resorts to an ad hoc impact assessment, based on simple cause-effect relationships. Such a more limited approach has obviously several shortcomings, but has the

advantage that it is manageable, practical and based on local expertise. In such a case, foreseeable consequences of various types of human or government intervention can be assessed by a combination of ad hoc surveys, comparative studies, simple correlation techniques and local experts' views. The uncertainties involved may then be gauged by exercising a systematic sensitivity analysis in a broad range of uncertainty intervals around the information used (Nijkamp and Ouwerslot, 1999).

The main processes of social and economic life (production, consumption, transport, etc.) fall on the environment, existential interests and way of living is closely related to it and powerful organizations support it. But environmental interests are difficult to recognize, they do not seem of vital importance at first. Fundamental changes and an intensive ecological strategy is needed which besides moderating the losses and highlight prevention.

There exist a number of methods or 'technologies' to actually qualify the state and unveil the (deleterious) processes and effects. They can be grouped according their governing ideas. The 'classical' approach characterises the changes by means of disclosing the difference between two consecutive states through gauging and recording the elements of environment (earth, water, air, flora and fauna) and the complex formations (area, settlements) on a regular basis. The fundamental defect of this approach is that it does not specify the causes of the changes, giving us very limited, if any, possibilities for prognostication, thus it does not allow for planned development or prevention.

It is essential that the analysis and evaluation necessary to realize environmental management examine, within their sphere of action, the interactions of different activities and interventions, as well as, those of environmental systems consisting of individual or the total of environmental elements. In order to do so, we need measuring-observing, data collecting and transmitting, information-creating and processing, analysing and evaluating phases to be created and organized to be technological. All these will make prognostication possible, enabling us to elaborate alternatives with predictable effects, as well as, regulating and developmental interventions so that the alternatives can be realized.

The problem to be handled is a very good example for a very complex system whose handling can only be performed by up-to-date artificial intelligence as well as with the help of soft computing or intelligent calculation systems and models-algorithms.

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