Sustainable Land Use: Methodology and Application

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**Sustainable Land Use:
Methodology and Application**

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Abstract

This paper addresses the issue of sustainable land use from two perspectives. First, a substantive and methodological discussion of sustainable development and related environmental security in the context of land use planning is offered. Second, an empirical case study on various land use options of the Po Delta area in Italy is dealt with, in which conflict resolution is analyzed by means of the use of multicriteria analysis (in particular, the regime method).

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1. Sustainable Land Use

*"The **widespread** destruction of ecosystems and the **consequent** losses in **biological** species diversity testify to the unsustainability of current human actions. Such actions form the dangerous obverse of the otherwise benevolent coin of economic and technological progress, and they cal for coordinated management among the various states and regions of the world. Environmental security is directly related to economic security in cases where countries, for economic reasons, consider themselves forced to resort to the over-exploitation of natural resources whether within state territories, shared among states, or in the global commons, Without a sustainable natural resource base to which the various nations andpeoples **of** the earth can have equitable access, economic and even military safety will remain problematic"*

(Environmental Security 1989)

In the past decade the issue of sustainable development has gained much importance (see for an overview of the current debate Manusinghe and Shearer 1995). While it started as a policy-oriented and action-based concept to alleviate and solve global environmental change issues, it was increasingly focussed on meso - mainly sectoral - issues, such as sustainable industry, sustainable tourism, or sustainable transport (see Van den Bergh 1996). Furthermore, the discussion on sustainable development was increasingly shifted towards sub-global spatial units, such as sustainable regions or sustainable cities (see Giaoutzi and Nijkamp 1994, and Nijkamp and Perrels 1994). It was also increasingly recognized that the distinction between strong and weak sustainability (see also Pearce and Turner 1990, and Van Pelt 1995) meant essentially a spatial substitution between different categories of land use. The question is here essentially whether and where the environmental decay of one area for a certain distinct purpose (e.g., industrialisation) may perhaps be compensated for by enhancing the environmental quality of another area (e.g., a tourist area).

An illustrative example can be found in agriculture, where within this sector various choice options can be imagined (such as milk production, wheat production etc.) which cannot be undertaken at the same time at the same place (see Barnett and Payne 1995). Furthermore, different types of human intervention can be envisaged, such as intensified land use, the use of pesticides, herbicides etc. (see Douven 1996 and Simmons 1997). Consequently, the question whether a certain agricultural land use is sustainable or not, is a complicated one which cannot be easily answered without a thorough knowledge of all trade-offs involved, Thus, space in a geographical sense has a multi-faceted nature. The previous considerations can be further substantiated by the following observations:

- space - and thus also land use - is the **medium** (or physical market) for environmental externalities in a broad sense; this applies to global environmental change, but also to local issues like noise annoyance or soil pollution
- space (including land) is of a **heterogeneous** nature; this means that environmental externalities have geographically discriminating distributive impacts (e.g. water pollution) in a river basin delta area

- space - and consequently also land - has both a **productive** and **consumptive** nature, so that any space consumption has welfare implications of a broader nature (including externalities); examples can be found in recreational land use and infrastructural facilities.

The above issues do not only have a local or regional meaning but are altogether also leading to global environmental issues, impacting on food supply, resource availability and climatological stability (see Cline 1992 and Fankhouser 1995). In a recent survey article by van Ierland and Klaassen (1996) the authors identify a series of research priorities on socio-economic aspects of land use and climate change. viz. a deeper analysis of

agricultural impacts in developing regions
the influence of climate scenarios on water availability in sensitive areas
socio-economic impacts of changes in human health
socio-economic impacts of environment induced migration
impacts of extreme weather events based on risk assessment
socio-economic impacts of changes in ecosystems and biodiversity.

Some of these concerns are of a long range nature and relate also to national or international security issues, such as soil erosion, chemical poisoning or nuclear waste (see also Daly and Cobb 1990). Others are more directly concerned with the daily quality of life, such as water pollution, shortage of food or resources (see Homer-Dixon 1992). Another - increasingly important - issue is the emergence of natural and environmental catastrophes which may imply floods, land slides, long periods of drought etc. (see United Nations 1997). Such events are difficult to predict and seem to gain in importance in recent years. All such cases provoke the question how land use (including agriculture) can be used as a vehicle for adaptation or resilience with respect to global change processes. This will be further discussed in the sequel of this paper,

2 Issues of Land Use: A Survey

> *"At the regional level, the notion of ecogeographical regions is a useful one in demarcating areas within which environmental inter-dependencies may be confined and within which natural resources can be taken to be relatively homogeneous. If security is threatened within such a region as a consequence of the unsustainable use of the natural resources, or because of transboundary pollution, then concerted preventive actions might be appropriate and adequate. However, as ad hoc solutions may come too late, a plea must be made for preparing an inventory of potential environmental hot spots and for the structuring of continuing exchanges of information and perhaps even of joint management. The International Commission for the Protection of the Rhine, the two international commissions for the environmental protection and sustainable utilization of the Baltic Sea, and the comparable mechanism for cooperation among most of the Mediterranean littoral states are examples of this. Similar structures could be envisaged for states in the Horn of Africa and other ecogeographical regions".*

(Environmental Security 1989)

Externalities manifest themselves often in various land use impacts, but unfortunately the interest in land use from an environmental perspective has been rather modest. A major Part of the literature in the early days of environmental economics has been devoted to valuation studies, e.g. of tourist areas, natural parks or urban monuments. Most of these studies were based on travel cost methods or willingness-to-pay methods in order to assess a monetary value for the environmental asset concerned, an approach which has set the stage for the popularity of contingent valuation studies and hedonic price studies. Cost-benefit studies were also used in this context, but they were gradually taken over by the new class of multicriteria evaluation studies (see Van Pelt 1993).

Other studies tried to link spatial-economic to spatial-ecological (or -environmental) phenomena by using either materials balance models or multi regional input-output studies. The latter category meant essentially an extension of conventional input-output analysis by incorporating also energy and materials (inputs) and environmental pollution (output) into the standard frame of a multi regional input-output model. Especially for predictive purposes of policy interventions this approach turned out to be very useful.

There were also numerous attempts to reinforce the analysis of spatial-economic and spatial-environmental linkages through the use of more integrative systems models. This was certainly a meaningful undertaking, which was unfortunately hampered by the lack of proper information and by the near-impossibility to bring environmental variables under a common monetary denominator.

Finally, there have also been various ways to improve policy analysis in the environmental field, by internalizing spatial-environmental externalities, e.g. through Pigouvian taxation schemes. This has a particular meaning in the case of land use or real estate, where a compensation scheme for spatial externalities (both positive and negative) can be envisaged. Other examples can be found in the management of common resources and agriculture.

It should be noted that in spatial-economic studies the environment is not merely to be regarded as a burden; it is also a source of opportunities and of well-being. Seen from this perspective, elements characterizing both the space-economy and the ecology may be arguments of a social welfare function for a given area. In a multi region setting this may lead to complicated trade-offs with rather severe conflicts between areas (e.g. the NIMBY phenomenon). Such substitutability issues lie also at the heart of the debate on weak and strong sustainability; weak sustainability takes for granted the possibility of a spatial substitution of economic and environmental capital (see Van Pelt 1993).

Thus, there are many intricate and complex linkages between the economy and the environment, in which land use and space are usually acting as the vehicles for transmitting externalities. There has been a great improvement in our understanding, although especially in a dynamic spatial context there are still significant gaps in our knowledge. The World Bank Annual Development Report (1992) states in this context: "*'Degradation and destruction of environmental systems and natural resources are now assuming massive proportions in some developing countries, threatening continued, sustainable development. It is now generally recognized that economic development itself can he an important contributing factor to growing environmental problems in the absence of appropriate safeguards. A greatly improved understanding of the natural resource base and environment systems that support national economies is needed if patterns of development that are sustainable can he determined and recommended to governments*".

Clearly, this lack of understanding is not surprising, because in the history of economic thinking only a few analytical attempts have been made to position natural resources at the heart of economics. Perhaps the best example can be found in the period of the Physiocrats, who claimed that the productive capacity of the natural environment was the major source of welfare. However, other periods of history of economic thinking have paid less attention to nature as an important production factor. For instance, in classical economics capital and labour, in addition to land, were regarded as the main welfare generators. Besides, classical economists assigned only a minor role to the government being an institution for establishing the framework within which market decisions have to be taken. It is interesting, however, to note that also the classical economists were certainly aware of the possibility that a stagnating economy might cause a lack of natural resources.

In the spirit of neo-classical thinking, it was believed in the post-war period that nature as such is not the source of welfare: welfare constituents are only generated by labour, capital, technology and land. Clearly, land and nature have not become irrelevant, witness also the following quotation of Randall and Castle (1985, p. 573): *"... there seemed no reason to accord land any special treatment that would suggest its role is quite distinct from that of the other factors. Land could safely he subsumed under broader aggregate of capital,... "*. In general, the role of environmental issues in traditional neo-classical economics is thus rather modest.

After the neglect of environmental issues in both Keynesian and (partly) in neo-classical economics, we are in the past decades facing a new situation where the externalities and limits to growth (with regard to both renewable and non-renewable resources) have become a new focal point of economic research. The major policy challenge is, in general, to avoid a *"tragedy of the commons"* (Hardin, 1968)in view of the long-term threats exerted by the (seemingly) inevitable and persistent changes in both local and global environmental conditions. Against this background, land use and spatial-environmental aspects of the economy deserve more profound scientific attention from the side of economists.

In conclusion, despite a great diversity of pressing regional environmental issues we still need a significant improvement of spatial-economic theorizing in this area. Admittedly, on a modest scale some progress has been made, but an operational methodology for regional and environmental analysis in view of long-term spatial sustainability analysis is still missing (cf. Pezzey, 1989). In particular, more fundamental research work at the local and regional level is needed which would lead to visible and effective action at the local or regional level of the space-economy,

In retrospect, the history and the geography of environmental economics show us that land has essentially a multi-attribute nature. It is this multi-functional feature which renders an economic value to land, such as for housing, industry, infrastructure, or agriculture. It is also noteworthy that within these major sectoral classes still several distinct subdivisions may be possible, e.g. land for forestry, cattle breeding, harvesting etc. Thus, the question whether some use of land for agricultural purposes is sustainable, does not only depend on external sustainability criteria (i.e., environmental impacts of agricultural versus alternative land use), but also on internal sustainability criteria (i.e., different uses of agricultural land). Consequently, the issue of sustainable land use boils essentially down to the question: which (package of) land use in the agricultural sector guarantees the best possible environmental outcome? In operational research terms: which environmental stress factors lead to an overall minimum environmental decay in the light of different agricultural functions (use and size), aerial attributes and policy (and price) factors? This is essentially an economic trade-off question between conflicting functions which will be analysed in more detail in the next section.

3. A Multifunctional Evaluation of Land Use

Since sustainable development is essentially a normative concept, any sustainable development strategy involves value judgements. Van Pelt (199 1) points out at least three questions. *"First, is the environment indeed considered a direct welfare attribute, as advocated above, and how are trade-offs with income treated? Second, how does the present generation, and governments in particular, view its own responsibility to future generations (i.e. inter-generational equity) ? Should they, for instance, he able to achieve at least the same welfare levels? Is the present generation willing to take certain risks in this respect, expressing confidence in man's capability to respond to ecological problems? Or should a risk-adverse strategy he pursued? Third, what are views on the environment as productive input, and particularly on the question of whether man-made capital (machines, cars, etc.) and environmental capital are complementary factors ofproduction, or substitutes".* The author also draws attention to various attributes of sustainability criteria, which have a clear spatial connotation:

- **environmental parameters;** in general, a single aggregate indicator does not exist, as targets and policy measures are usually group- or region-specific.
- **critical threshold values;** examples are safe minimum standards or carrying capacity, all of which have a clear site-specific meaning.
- **acceptable** risks; risk perception studies reveal that there is normally a geographical pattern (e.g. distance-decay) in risk perceptions of people.
- demarcation of **relevant regions;** in many environmental evaluation and impact studies the final result is dependent on the size of the area for which the impacts are investigated.

Seen from this perspective, it is clear that the policy objective of **global** environmental sustainability is difficult to operationalize (Giaoutzi and Nijkamp 1993). A more precise identification of concrete policy objectives and strategies at a **meso** level seems a more promising approach. Such a meso level may relate in particular to regions or cities in a country. By focussing on regions a much more coherent and practical policy and management strategy may be attained. Clearly, the use of regions as a focal point for sustainability policies provokes also various intriguing research problems. For instance, there may be quite some variation in economic or environmental conditions among different regions, so that quantitative reliable indicators are necessary for a proper analysis of differences between regions of a compound system.

The methodology for the integration of socio-economic variables - depicting the pattern and evolution of a local regional economy - and of ecological variables mirroring the development of ecosystems in the study area concerned is usually fraught with many difficulties. Following Brouwer (1988) it may be appropriate to design a cohesive economic-ecological structure model on the basis of the so-called **satellite** principle. This principle means that the core of interaction between the economy and the environment in a regional system is described in a compact but comprehensive way. All other (non-central) phenomena are not represented in full depth and not with all their complex dynamic interactions, but are only depicted in terms of their main linkages to the core. This core-satellite design ensures a consistent, concise and structured presentation of a compound multidimensional system for a regional economy.

Clearly, the choice of variables and indicators is of critical importance here, but the specification of variables, linkages and equations is co-determined by the methodology to be used in the analysis.

Several variables (like landscape and ecological data) can be spatially differentiated, whereas others (like socio-economic data) are only used in an aggregate manner. This means that the spatial component has to be dealt with carefully in the empirical analysis, which is also the reason why GIS (Geographical Information Systems) is an indispensable element in such information and planning studies. In general, system theory offers a fruitful background and frame of reference for assessing various effects in a compound spatial-economic and environmental system.

In order to develop an appropriate methodology for sustainability planning at the local or regional level, a set of scientific methods may be helpful. Examples are: dynamic systems analysis; impact analysis; scenario analysis; geographic information systems (GIS) analysis; multi-criteria decision support analysis. These methods will briefly be outlined here successively.

Dynamic systems analysis seeks to analyse (i.e., describe and predict) the driving forces and their interdependence in a relevant system. It is evident that this approach should investigate the guiding principles of all subsystems that make up the whole and examine the material basis on which these rules are based. It is then necessary to look at the causal linkages in a comprehensive economic-environmental-human system. Such a systems representation forms also the basis for an impact model. in which environmental and economic forces are put together in the framework of an open spatial system.

Impact analysis serves to assess and quantify the relationships between the subsystems' functions. In addition, the relationships between the principles governing each subsystem are revealed in such an analysis. Impact analysis is a scientific tool that is widely used to assess the results of policies or projects at national, regional or local levels. It is a flexible tool as it permits us to use several types of analytical methods like econometric models, input-output models, simulation and scenario methods, goals achievement methods and qualitative decision support models. It should be added that policy strategies regarding economic development are often dynamic in nature. That means that such strategies affect a system in successive interlinked time intervals. As a result, an impact analysis must be able to assess the impacts over time, and under successive development policies. Especially in studies concerning environmental impacts which manifest themselves in the long run, a dynamic approach to impact analysis is necessary. In many cases dynamic models are used to assess the various effects in an impact chain of a complex system. In this respect. it is necessary to use plausible parameter values (either statistically - econometrically estimated or otherwise calibrated) in order to trace the multi-period consequences of changes in external conditions or policy controls for the system at hand. In this context, the openness of spatial systems is worth emphasizing.

Scenario analysis tries to develop and judge a set of hypothetical development alternatives for a compound and complex system, in order to generate a rational frame of reference for evaluating different development alternatives. It may play an important role as a learning mechanism for decision-makers. By assessing all foreseeable and expectable impacts of various development strategies (scenarios), we may identify a policy strategy which may fulfil the aim of an ecologically sustainable economic system. It goes without saying that this idea is also of utmost importance for the development of regional or local economies. Clearly, one has to keep in mind that a scenario analysis often means the construction of hypothetical development alternatives, which however after solid empirical work may finally lead to the construction of feasible and desired choice alternatives. In order tot create realistic choice alternatives, it is necessary to generate relevant information.

Effective and accessible information systems are vital to economic performance and strategic decision-making. The rapid development of digital and electronic technologies, for instance, in the form of digital recording and transmission of sound and pictures, optical fibres for the high speed of transmission of information, super-fast computers, satellite broadcasting and video transmission offers a new potential for sophisticated voice, data and image transmission. From a geographical viewpoint the trend towards advanced information systems has led tot the design and use of **geographic information systems** (GIS). A GIS serves to offer a coherent representation of a set of geographical units or objects which - besides their locational position - can be characterized by one or more attributes (feature, label or thematic compound). Such information requires a consistent treatment of basic data, from the collection and storage stages to the manipulation and presentation of such data. All such information systems may be highly important for the planning of our scarce space, not only on a global scale (e.g., monitoring of rain-forest development), but also on a local scale (e.g., physical planning). Within this framework, spatial information systems are increasingly combined with pattern recognition, systems theory, topology, statistics and finite element analysis. The past twenty years have witnessed the development of various computer-based applications of information systems which have changed the activity patterns and decision modes of people.

Finally, the problem remains to evaluate the outcomes of alternatives and possibly to choose certain best alternatives based on a set of criteria and solid evaluation methods. **Multi-criteria evaluation analysis** appraises the effects of each (hypothetical) scenario on all relevant subsystems. To perform these appraisals this analysis uses the relationships revealed by the impact analysis. Such evaluation is also performed in order to choose which of these scenarios may result in an ecologically sustainable evolution of an economic system. Or to put it differently: which of these scenarios does ensure the condition that an economic system in evolution considers our economies as a subsystem of a biosphere system, so that this evolution does not disturb the function of the natural system? A basic notion is that the effects and the information concerning policy decisions are multi-dimensional in nature. Effects presented in the form of monetary units, physical units, survey measurements etc., have to be included and to be comparable in the frame of a suitable methodology. Multi-criteria evaluation serves to meet all the above requirements to a large extent, as this methodology takes into account, in an applicable decision framework, different and conflicting objectives, while it is also able to evaluate soft qualitative data; hence it forms in principle a suitable tool for environmental policy analysis, not only at global but also at local levels. Especially for land use evaluation issues such methods turn out to be very appropriate. In the next section, we will address the use of multicriteria analysis for sustainable land use in a somewhat more detailed manner.

4. Evaluation for Land Use Sustainability

Sustainable land use is an ambiguous concept which cannot be operationalized in a straightforward way, unless we would be able to identify measurable sustainability indicators which might be confronted with a priori defined critical threshold levels (based e.g. on carrying capacity levels or environmental utilisation; see Nijkamp and Ouwersloot 1997). A major analytical problem is that sustainable land use is a multi-faceted concept which comprises many dimensions of economic activity in relation to land use and environmental quality. As mentioned in Section 3, multicriteria analysis may be very helpful in this framework, as it enables us to encapsulate a diversity of elements which altogether make up for sustainable development, Multicriteria analysis has various major advantages in a sustainability analysis:

- it is able to take into account a diverse set of **different criteria** which altogether play a role in the assessment of the sustainable state of an environmental-economic system.
- it is also able to take into consideration - besides quantitative, numerical aspects - various **qualitative** aspects, even of a fuzzy nature (see Munda 1995)
- it allows for a **structured communication** with decision-makers and policy-making bodies (e.g., through the use of a range of policy weights for relevant choice criteria)
- it has the potential to address future uncertainties by including **also scenario experiments** in the analysis.

We will not discuss the technical principles of multicriteria analysis any further here, but refer at this stage to Nijkamp et al. (1995). In Figure 1 we have presented an illustrative full scheme of all steps involved. The following observations may be made.

Evaluation methods - in particular, multicriteria methods - aim to identify the best possible alternative (or the most plausible ranking of alternatives) out of a set of distinct choice possibilities (see also Janssen 1992). In practice, a wide range of multicriteria methods does exist, depending on: the level of measurement of the information used, the formal relationship between policy objectives and choice attributes, the use of weights in the trade-off analysis for different criteria, the treatment of outcomes of alternatives in an impact matrix (e.g. pairwise comparison), the specification of decision rules, and the standardisation of criteria outcomes, The applications of different methods may sometimes lead to differences in results, in particular if a complete ranking of alternatives is aimed at.

In case of **quantitative** criteria outcomes (i.e., measured on a cardinal scale) several multicriteria methods can be used, such as weighted summation, multi-attribute utility approach, ideal point method, and concordance (or Electre) method, Details can be found in Janssen (1992) and Nijkamp et al. (1995).

If a multicriteria evaluation problem is characterized by **qualitative** information (e.g., ordinal or binary), different methods may be applied. Examples of such methods are: permutation method, evamix method, analytical hierarchy process method, (expected, extreme and random) value method, and regime method.

For our case study (see Section 5 and 6) we have a mix of quantitative and qualitative information. Under these conditions the **regime method** is particularly appropriate, as it is able to treat simultaneously quantitative and qualitative data, without losing the essential contents of these two types of data. The regime method has been extensively discussed in Nijkamp et al. (1995); here we will only offer a few concise elements of the regime method.

A regime method presupposes a distinct set of a priori defined alternatives and a distinct set of a priori defined evaluation criteria, which are put together in a so-called **impact matrix (see** for an illustration Table 1 of our case study). Furthermore, it assumes a set of policy weights ('shadow prices') for each of the evaluating criteria, put together in a so-called **weight vector.** In case of multiple criteria weights (i.e. different weight vectors depending on political priorities), we will get a **weight matrix** (see for an illustration Table 2). The impact matrix and the weights constitute the basic ingredients of the regime method (and for any other multicriteria method).

The regime method is based on a pairwise comparison of alternatives. For each pairwise comparison a dominance indicator (quantitatively or qualitatively) is calculated. For all criteria together this leads then to a so-called regime matrix. By adding next a weight vector, the relative dominance of each alternative can be assessed in the form of a performance (or success) indicator. The regime method leads to an unambiguous quantitative ordening of all choice alternatives. This method will also be used for our case study from Italy on the land use alternatives of the Falce Valley in the Po Delta area (see Section 5 and 6).

5 Description of the Case Study

6. Results of the Regime Analysis

The principles of the regime method outlined in Section 4 have been applied to the case study described in Section 5. The number of possible policy intervention strategies for the Falce Valley is equal to 5, while the number of relevant evaluation criteria is equal to 6. The resulting impact matrix is represented in Table 1. The policy weights for the criteria concerned could not unambiguously be assessed, and therefore a sensitivity analysis based on four policy scenario's has been undertaken (see Table 2). Thus, Table 1 and 2 formed the foundation stones for the application of the regime method. The 4 types of results based on the 4 policy scenario's are presented in Table 3, where the entries of the matrix refer to the performance index (or success index) of each of the 5 policy intervention strategies distinguished.

The results can be interpreted in a straightforward way. The performance (or success) scores show that for all four policy scenarios envisaged (i)-(iv) there is clearly one dominant alternative, which may be regarded as the most preferred intervention strategy, viz. decision (c). This means that a flooding of the area in order to favour fishery farms is superior to any other strategy.

It is also interesting to observe that there is a very robust second-choice alternative, viz. (e), which is a mix of alternative (b) and (c). This has a very clear second position for all policy scenarios. Two other policy strategies, i.e. (b) and (d) have varying rank orders, depending, on the policy priorities concerned. Finally, there is apparently one robust inferior solution, viz. alternative (a), which is the business as usual scenarios.

It should also be mentioned that our results are in conformity with the findings of the original Munda study (see Munda 1995), who also concluded on the basis of the Naiade model for fuzzy data that alternative (a), (b) and (d) would be inferior and that (c) and (e) would be the best candidates, their relative preference depending on the underlying attribute values and their weights.

7. Conclusion

Land use changes have a vast range of implications for economic productivity, environmental quality, human security and welfare of all people involved. Policies to encourage human behaviour towards more sustainable development are multidimensional in nature and hence have to be judged from a balanced perspective. The present paper has argued that land cover change means an alteration in a complex and interactive system linking human action to biophysical systems. Given the complexity involved, there is need for a structured analysis of ‘what-if questions. The paper has tried to systematically develop an analytical framework in which alternative choice options are combined with various policy perspectives. The regime method utilized here appeared to be a meaningful vehicle for creating a structured investigation of relevant choice options, even in cases where the level of information was rather poor. Needless to say that there is scope for more rigorous research on the fascinating issue of sustainable land use.

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A. PROBLEM IDENTIFICATION

1	Demarcation of relevant region and identification of land use
2	Identification of relevant agricultural sectors
3	Identification of environmental sustainability problem of land use

B. IMPACT ASSESSMENT

1	Design of impact system or model for regional land use
2	Assessment of (state, target, instrument) variables
3	Selection of sustainability indicators or threshold values

C. SCENARIO ANALYSIS

1	Identification of alternative futures for the relevant area
2	Identification of policy strategies
3	Assessment of behavioural responses via impact model

D. POLICY EVALUATION

1	Identification of weights for policy criteria
2	Sensitivity analysis on weights or thresholds
3	Multicriteria evaluation of policy options

Figure 1. Steps in Sustainability Analysis for Land Use

alternatives / criteria	business as usual (a)	optimised agriculture (b)	flooding for fishery (c)	mix of (a) and (c) (d)	mix of (b) and (c) (e)
(1) net profits (10^6 lire)	64	159	143	95	147
(2) employment (number of jobs)	8	20	9	8	14
(3) tourist attractiveness (ordinal number)	1	1	3	2	2
(4) recreational attractiveness (ordinal number)	2	2	3	2	2
(5) ecological equilibrium of forest (ordinal number)	1	1	3	3	3
(6) security on ecological damage (ordinal number)	2	1	3	1	1

Table 1. Impact matrix of different policy strategies for land use development in the Falce Valley
Legend: ordinal numbers are to be interpreted as: 'the higher the better'

weights / criteria	uniformity (i)	(socio-)economic interest (ii)	environmental interest (iii)	security interest (iv)
(1) net profits	1	2	1	1
(2) employment	1	2	1	1
(3) tourist attractiveness	1	1	2	1
(4) recreational attractiveness	1	1	2	1
(5) ecological equilibrium of forest	1	1	2	1
(6) security on ecological damage	1	1	1	2

Table 2. Indicative ordinal weights for different interests (policy scenarios) regarding the policy criteria for land use development in the Fake Valley
Legend: ordinal numbers are to be interpreted as: 'the higher the better'

alternatives policy interest scenario	(a)	(b)	(c)	(d)	(e)
(i)	.102	.337	.996	.359	.666
(ii)	.067	.480	.979	.313	.660
(iii)	.117	.253	.999	.482	.650
(iv)	.128	.450	.992	.291	.639

Table 3. Results of regime analysis (in terms of performance or success scores) for intervention alternatives for land use development in the Fake Valley, based on four policy interest scenarios