Claudia Cassatella
Attilia Peano
Editors

Landscape Indicators

Assessing and Monitoring Landscape Quality

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Foreword

Landscape policies and planning have been developed increasingly in Europe over the last decade, especially due to the European Landscape Convention (Florence, 20 October 2000). The ELC promotes landscape knowledge, assessment, policies, planning and the creation of Observatories or Centres for the landscape. Consequently, the need for indicators to evaluate and monitor the effects of landscape policies and plans is pressing. As a matter of fact, studies concerning landscape indicators are rare and recent. This book presents an exploration of the issues and options for landscape assessment and monitoring, bringing together the results of the research carried out by our experts and key findings from other important works.

The contents of the book are the result of academic research carried out by the Inter-University Department of Urban and Regional Studies (Diter) of the Polytechnic and University of Torino (Italy) under the scientific direction of Prof. Attilia Peano and the patronage of the European Network of Local and Regional Authorities for the Implementation of the European Landscape Convention (ENELC). The research was made possible through funding of Fondazione CRT Torino—Progetto Alfieri; additional support for the project was provided by the Piemonte Regional Authority—Landscape Planning Department.

The volume deals with the definition and use of specific indicators for landscape assessment and monitoring. In order to deal with the complexity of the landscape, the subject was developed by a multidisciplinary team of experts in landscape ecology, landscape history, landscape perception, territorial planning, strategic environmental assessment and environmental impact assessment procedures, and multi criteria assessment methods.

The book is addressed, in particular, to European researchers, scholars, practitioners in landscape and territorial planning, and regional and local government officials who are responsible for landscape and planning, Strategic Environmental Assessment, and Environmental Impact Assessment. Moreover, it provides key references for studying landscape from a multidisciplinary perspective. Book and research scientific direction by Prof. Attilia Peano.

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Abbreviations

AAA	Association of Environmental Analysts
ADBPO	Basin Authority of Po River
APAT	Italian Environmental Protection Agency and Technical Services
ARPA	Regional Environmental Protection Agency
BTC	Biological and Territorial Capacity
CATAP	Co-ordination of Technical and Scientific Associations for Environment and Landscape
CBCP	Italian Cultural Heritage and Landscape Code
CED-PPN	European Documentation Centre on Natural Park Planning
CIVILSCAPE	Civil Society Network for the European Landscape Convention
CMEF	Common Monitoring and Evaluation Framework
CNR	Italian National Research Centre
CoE	Council of Europe
CORINE	Coordination de l'Information sur l'Environnement
CQC	Countryside Quality Counts
CTN-NEB	National Thematic Centres, Nature and Biodiversity
DESDA-CSD	Department of Economic and Social Affairs, Commission on Sustainable Development
DPSIR	Driving Forces, Pressure, State, Impact, Response
ECC	European Economic Community
ECI	European Common Indicators
ECNC	European Centre for Nature Conservation
EEA	European Environment Agency
EIA	Environmental Impact Assessment
ELC	European Landscape Convention
ELCAI	European Landscape Character Assessment Initiative
ELISA	EnvironmentaL Indicators for Sustainable Agriculture
ELPEN	European Livestock Policy Evaluation Network
ENEA	Italian Body for New Technologies, Energy and Environment

ENELC	European Network of Local and Regional Authorities for the Implementation of European Landscape Convention
ENRISK	Environmental Risk Assessment for European Agriculture
ESDP	European Spatial Development Perspective
ESL	European Statistical Laboratory
ESPON	European Spatial Planning Observation Network
EU	European Union
EUROSTAT	Statistical Office of European Communities
GIS	Geographical Information Systems
IFEN	Istitut Français de l'Environnement
INEA	Italian National Institute of Agrarian Economy
IRENA	Indicator Reporting on the Integration of Environmental Concerns into Agricultural Policy
ISTIL	Italian Institute of Science and Technology on Light Pollution
IUCN	International Union for Conservation of Nature
JCR	Joint Research Centre of the European Commission
JNCC	Joint Nature Conservation Committee
LCA	Landscape Character Assessment
MCPFE	Ministerial Conference on the Protection of Forests in Europe
MiBAC	Italian Ministry on Cultural Heritage and Activities
MTT	Agrifood Research Finland
NIJOS	Norsk Institutt for Jord Og Skogkartlegging
OCS	Turin Polytechnic Observatory on Sustainable Cities
OECD	Organization for Economic Co-operation and Development
PECSRL	Permanent European Conference for the Study of the Rural Landscape
PPR, PTR, PTPR	Regional Landscape Plan, Regional Territorial Plan, Regional Territorial and Landscape Plan
PSR	Rural Development Plan
SEA	Strategic Environmental Assessment
SIC	Site of Community Importance
SPA	Special Protection Area
SPES (NORDREGIO)	Study Programme on European Spatial Planning
TEPI	Towards Environmental Pressure Indicators for the European Union
UN	United Nations
UNCHS	United Nations Centre for Human Settlements
UNESCO	United Nations Educational, Scientific and Cultural Organization

UNISCAPE	European Network of Universities for the Implementation of European Landscape Convention
USDA	United States Department of Agriculture
USDI	United States Department of Interiors
VALSAT	Environmental and Territorial Sustainability Assessment
WHS	World Heritage Sites

Chapter 1
Landscape Assessment and Monitoring

Attilia Peano and Claudia Cassatella

Abstract What is the purpose of landscape indicators? Can we "measure" the quality of landscape? And if landscape as a whole is impossible to assess from a holistic point of view, can we break it down into simpler elements to analyse and monitor? These questions are becoming more and more pressing, as a result of two concomitant movements: the development of landscape policies, encouraged by public opinion, and the spread of the culture of assessment in all fields of public policies and in particular in territorial government. In Europe, these dynamics are well represented by two international regulations: the European Landscape Convention (CoE 2000) and the Strategic Environmental Assessment Directive (2001/42/EC), regulating any plan or programme affecting the environment. The European Structural Funds, and in particular EEC Agricultural policy are also subject to intense activity of assessment and monitoring, in relation to the environment and landscape (cf. the Common Monitoring Evaluation Framework). This volume is dedicated to indicators that can be used to monitor policies, plans and programmes that have an impact on landscape, with particular focus on town planning schemes, territorial and landscape plans, which have a more direct effect on land use.

Keywords Landscape assessment • Landscape monitoring • Landscape indicators

1.1 Landscape Assessment

The landscape is considered one of the key themes of policies for environmental and territorial sustainability: in fact it concerns environmental, cultural, social and economic matters and also affects populations, as it represents the way in which they perceive their living environment, and is therefore a hot "political" theme. For many years International bodies, striving to promote sustainable development,

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have included landscape amongst the themes of their policies, but at the same time complain of insufficient techniques to allow for landscape in the assessment framework, in particular due to the heterogeneity of the approaches and a lack of common methods (and indicators). See, for example, the OECD web site, in the section "Theme: landscape":

> Many OECD countries have legislation which acknowledges the importance of societal values embodied in landscapes and internationally some are also attracting attention, such as the designation by Unesco of cultural landscape sites. But because landscapes are not valued, the challenge for policy makers is to decide which landscape features society values, and assess to what extent policy changes affect agricultural landscape.[1]

In Europe, landscape has often been the subject of declarations and conventions affirming its value as natural and cultural heritage, emphasizing how the richness of European landscapes represents the symbol of various continental identities (CoE 1995). Each act has always been accompanied by the recommendation to increment the knowledge and methods of study pursuant to landscape, also through international collaboration. The Dobris Assessment (EEA 1995) has influenced many European policies, and also those not specifically pursuant to landscapes:

> Landscapes can be valued for a variety of reasons and they also provide a series of important functions. Five such values and functions are identified below: the role of landscapes in the sustainable use of natural resources, as wildlife habitats, providing economic benefits, scenery and open spaces, and possessing cultural heritage". It also recommends studies: "To ensure the success of landscape planning and management, the following approaches are considered important: - to study, record and monitor European landscapes for their ecological, social, cultural and economic values; (…).

Therefore, in recent years landscape has been on the political agenda of European countries, resulting in innovations in Land and Spatial Policies and in specific sectors such as agriculture and cultural heritage. The process culminated with the adoption of the European Landscape Convention (Florence, October 20th 2000) providing considerable impetus for the growth of landscape policies and planning: the Convention obliges the signatory countries to acknowledge, assess and draw up specific policies on their landscapes, establishing quality objectives. These actions must concern the entire territory, both the "excellent" landscapes and ordinary or degraded landscapes, justifying a gradation of policies for the protection, management and planning, as long as the creation of new landscapes. Furthermore, "Public authorities at national, regional and local levels should integrate the landscape dimension and allow for it in their policies in different sectors with possible direct or indirect impact on landscape" (CoE 2008).

Much has already been said and written on the innovative character of the approach proposed by the Convention; in this work we will consider the fact that the Convention encouraged European countries, which have always had quite a variety of traditional views on this theme, to exchange views on the best methods to use, also in consideration of the necessary interrelation between humanistic traditions

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[1] Organisation for Economic Co-operation and Development, http://www.oecd.org/document/34/0,3343,en_2649_33793_1889762_1_1_1_1,00.html. Accessed October 2009.

and those associated with natural sciences. While the operating methods for planning are inevitably associated with the institutional and regulatory functions of each single country, the level of analysis and assessment offers greater possibilities for cultural exchange and utilization also in the policies of international bodies, such as those in the agricultural sector. For example, the numerous “landscape atlases” drawn up in the last decade are some of the results of the international research activities on description systems.

European institutions also provide another powerful incentive to renew political and planning culture: the introduction, in a structural way, of assessment and monitoring. Subsequent European directives first introduced Environmental Impact Assessment (Directive 85/337/EEC, EEC 1985) for intervention projects, and then Strategic Environmental Assessment (Directive 2001/42/EEC, EC 2001) for plans and programmes with an effect on the environment—and therefore for all territorial and landscape plans[2]. In these assessment systems, the landscape is considered one of the environmental components subject to possible impact.

The principle of the SEA is simple: the environmental system must be assessed before the plan/programme, during and at the end of its period of validity, for the purpose of retroaction and learning. In general, environmental reporting has become a key instrument for sustainability policies used at a global level by organizations such as the United Nations and the OECD; in the European Union it is closely associated with urban or agricultural policies; in fact, contributions and incentives are granted with the request for monitoring the direct and indirect effects on the environment[3]. Monitoring is now considered an activity ingrained in the management of resources; another example is represented by management plans for sites registered in the UNESCO World Heritage List: to maintain the acknowledgment an assessment must be used to verify the conservation of acknowledged values in time; in the case in which the Sites are “natural or cultural landscapes”, it is obvious that the monitoring concerns our themes.

These procedures require the use of qualitative and quantitative indicators, in other words parameters able to provide information on the characteristics of phenomena, which cannot be measured in their entirety. Identifying indicators for the environment requires notable work—a considerable commitment in terms of time for the international scientific community, and identifying indicators able to interpret landscape in its entirety seems all but impossible. The ELC definition of landscape shows the complexity of the phenomena to “measure”:

> ‘Landscape’ means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (Art. 1).

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[2] Directive 2001/42/EC (best known as SEA Directive) includes plans and programmes for “agriculture, forestry, fisheries, energy, industry, transport, waste management, telecommunications, tourism, town and country planning or land use and which set the framework for future development of projects listed in Annexes I and II to Directive 85/337/EEC, or which, in view of the likely effects on sites, have been determined to require an assessment pursuant to Art. 6 or 7 of Directive 92/43/EEC [Habitat Directive]” (Art. 3.2).

[3] See, in particular, the Common Agricultural Policy (CAP) and the relevant Common Monitoring Evaluation Framework (CMEF): EC DG AGR 2006.

Nevertheless, when broken down into its different dimensions, in other words analysed from sectorial points of view, landscape can be dealt with using formalized methods of assessment. Some branches of the subject, such as landscape ecology or environmental psychology, today have a wealth of applicative experiences that date back to the 1960s. An important part of landscape studies however derives from humanistic tradition, ill-suited to the quantitative formalization of the phenomena studied, or rather, when there are also quantitative methods, for the quantification of the value. Consider the case of studies on cultural heritage: the idea of a value hierarchy is so foreign to their conceptual paradigm, that the use of expressions such as "exceptional assets" or "excellences" (with a contrast for example, between the concept of "cultural landscape" of the Unesco Convention and that of "the entire territory is landscape" of the ELC, which is not privy of consequences on strategies, also in terms of allocation of resources and commitment in the management and enhancement of the territory) is held to be outdated and even negative.

Environmental evaluations initially influenced those on landscape. In evaluative frameworks, the landscape component was a critical point, without any sure, quantifiable, shareable and generalizable values, like on the other hand certain scientifically established and shared "thresholds" on water, air or land. In practice we have two attitudes: the reduction of the complexity of landscape to just one aspect, ecological for example, on which widely accepted internationally indexes are based, or the use of the qualitative and synthetic judgement of experts, in the form of "landscape quality", "perceptive value" and similar, which are obviously subjective values, difficult to justify and monitor.

Another field of activity that greatly inspired research into landscape indicators is that of agricultural policies of the latest generation, which establish the multifunctionality of agriculture as a primary objective, therefore attributing also importance to the ecological, scenic and recreative value of the rural landscape and appreciation of said landscape by the population. Nevertheless, in the frameworks of assessment (cf. the Common Monitoring Evaluation Framework, CMEF, of the European Commission, Directorate General for Agriculture and Rural Development, EC DG AGR 2006) little space is dedicated to landscape.

1.2 Fields of Application

Although landscape has been considered a simple "component" of the environment that can be measured with synthetic indexes like "landscape quality" in environmental evaluations, today however we must consider it as the specific object of assessment, to meet the requirements of the ELC. This volume does just that, with the conviction that the results can have a positive impact also on many other fields, such as Unesco site management plans ("cultural landscapes" category), or protected areas (in particular in IUCN category V "protected landscapes"), for example.

It is only in recent years that the international scientific community has been doing specific studies on the theme of landscape indicators, also with the aim of introducing assessment in the monitoring systems of policies and plans drawn up specifically for landscape. European literature in particular, contains some examples of studies that tend to collect and compare rather than propose[4]. The major studies provide a collection of indicators for the assessment of rural landscapes, for monitoring agricultural policies (Piorr 2003): this is certainly a strategic sector, but with a limited field of attention. In the case of territorial plans and policies, we must in fact assess all types of landscape, including urban landscapes, and agricultural landscape indicators are inappropriate for this purpose. At the same time, indicators developed in relation to the urban environment (cf. for example the European Common Indicators on the state of the urban environment, which are used in the environmental reports of Agenda 21) refer to a limited context.

One of the most extensive studies on the theme, "Proposal on Agri-Environmental Indicators" (Landsis et al. 2002), states: "In spite of the scarcity of operational landscape monitoring systems, a wide range of different indicators could be identified. Almost 340 indicators, partly overlapping or with similar meaning have been collected, covering a wide range of different thematic aspects of landscapes." The indicators analysed are classified in three groups: landscape features, human perception, landscape management, conservation and protection. This and other studies (cf. Chap. 3), which constitute precious information, in our opinion have the limit of presenting long lists in which each indicator is extrapolated from its context of use and the group of indicators of which it is part, creating the impression (also beyond the authors' intentions) that one can choose any indicator in the list, or rather, that any indicator can be universally valid.

1.3 The Approach of the Work

The volume provides a state of the art framework, comparing the indicators in scientific publications, but also proposing other indicators. As will be seen, one of the fundamental differences between environmental indicators and landscape indicators lies in the fact that the latter cannot necessarily be generalized and applied to any context, for they lose their specific characteristics, which is one of the values of landscape. In fact, the characteristics of the different landscapes and the values related to the appreciation of the same by the population are both variables.

For this reason, the study finally illustrates the construction of a set of indicators with reference to a certain territory: Piemonte, a region in the north of Italy. As landscape indicators are particularly sensitive to the scale factor, the study deals with two levels, the regional and the local scale, which correspond to two processing levels of plans and policies.

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[4] In particular, the recent volume from the Landscape Observatory of Catalunya: Nogué et al. (2009). Comments on the principal international studies on the subject (for example ELCAI, ELISA, PAIS) can be found in Chap. 3.

Although landscape is appreciated in a holistic way, due to the intersection of its many dimensions, analysis must break it down, so it can be processed with the scientific methods of the various disciplines to obtain non-generic indicators. Five principal landscape dimensions have been selected: environmental, historic-cultural, perceptive aesthetic, territorial, economic. These are corroborated by The Dobris Assessment indications mentioned above, by the ELC definition of landscape and by the indications of CoE Recommendation CM/Rec (2008)3: "Action should be taken to: - promote integration of the different knowledge-production approaches to observation of the territory (economic, social, environmental, historic/cultural, perceptive/visual, etc.) (…)"[5].

As we have said, existing studies do not develop every aspect in the same way, and this is why it is all the more important to attempt to consider also the less consolidated aspects, knowing full well that the results are still merely interim. For example, the theme of social perception, often referred to in the ELC, and the economic dimension, strategic for the role that landscape may have in the local economy (a role which is not only passive but active, in the creation of value: a developing field of study, strategic for policies and actions).

The analyses and assessment of the various aspects of landscape have been dealt with by specialists from different disciplines. In the literature examined there are frequent cases of studies done by landscape specialists or specialists in estimative disciplines; in both cases, there is a limit due to the insufficiently interdisciplinary and reductive approach, and a certain dissatisfaction in relation to the results when considered from the perspective of the single disciplines.

Studying the landscape for the purpose of assessment through indicators therefore entails notable interdisciplinary effort and reciprocal contamination.

The formulation and selection of indicators depends on the aims of the assessment, the territorial context, the scale and on many other factors. Assessing landscapes and their transformations, the effects of landscape policies and plans, and the relationship between a work and its landscape context, are three distinct activities with separate objectives and fields of focus, which can require different indicators. The authors have focused on monitoring landscape in the ambit of territorial programming and planning, with particular attention on the relevant processes of Strategic Environmental Assessment (SEA), a promising sector for the application of these indicators.

Another particularly important factor when drawing up landscape indicators is the territorial scale of reference. We must remember that, for ecological disciplines, landscape represents a particular level of scale in the organisation of life on earth; while for scenic analysis, reference to the field that can be perceived by the human senses is vital. This work refers to two territorial levels: the local level and the

[5] "Action should be taken to: - promote integration of the different knowledge-production approaches to observation of the territory (economic, social, environmental, historic/cultural, perceptive/visual, etc.); (…) – encourage the establishment and availability of landscape databases; these should concern the condition of places, their past and present dynamics, pressures and risks (…)" (CM/Rec (2008)3, II.2.1 knowledge of landscapes: identification, analysis, assessment).

vast area level, which can correspond to administrative action at regional and local levels.

The work is therefore organized in the following way: the next chapter considers systems of assessment and the modelling of indicators; the second comments on the state of the art of types and sets of indicators, followed by a series of theme chapters on profiles of interpretation, each of which presents: a definition of the field of focus, a review of published indicators, a selection and proposal of indicators, illustrated in detailed tables. Finally, in the second part of the study we include an example of the composition of two sets, at a regional and local scale, with reference to the Italian region of Piemonte.

The result is the identification of numerous indicators for each profile of interpretation, establishing appropriate sets for the context and in particular for the aim of the assessment; and also a model of presentation for the same indicators, to recommend the applicability. The indicators are therefore considered in a systematic and comparable way.

We referred to the DPSIR model (cf. Chap. 2) for the classification of the indicators, which, while open to debate, appears to be the most widely accepted model at an international level, used by numerous international bodies. Other studies on landscape indicators have already adopted the same line (Wascher 2005 for example).

1.4 The Problem of Synthetic Assessment

This study concentrated on indicators, rather than on models of assessment—a subject which would require another volume entirely. The indicators can be included in different models, such as the DPSIR model for example.

This and other models do however leave a significant problem unsolved: the integration of evaluations on the various profiles of interpretation mentioned above, to attain one holistic indicator to use in extensive assessment frameworks (in particular in environmental evaluations, where, instead of considering the landscape as a system, it is considered as a single component). The problem is not simply one of calculation, in other words it is not a question of finding a solution formula, because no such thing exists. Assessment in fact, is not a neutral instrument: at every turn, starting with the choice of indicators, and ending with the weighting of each of these in relation to the others, political decisions must be taken. These choices establish the goals and priorities. As the weighting of each indicator varies, so does the result, and a different significance can be attributed on the basis of points of view and values attributed in different contexts and for different goals. The weighting of indicators is therefore not an operation for which a technician is competent, but something that must be done by the subjects responsible for assessment.

The integration of different indicators is therefore a line of research that must be developed, working on the basis of matrixes and ponderal methods, which may make it possible to allow for and appreciate the known diversity between the points of view of the various subjects[6], intersecting studies on the social values of landscape. With this in mind, the system of assessment based on indicators is in any case a technical instrument that can help us make a comparison of the various aspects of the problems, with different situations and, in particular, show the transformation of the situations observed in time.

If we allow for the role of the actors involved in the assessment, we must also take the same into consideration, as they are also the subjects for which this study was intended.

1.5 Subjects for Which the Study is Intended

The main subjects for which this study is intended are bodies involved in land transformation and management, in other words the administrations which, at various levels, are responsible for procedures of environmental assessment, the assessment of landscape compatibility in interventions, management plans for protected areas or UNESCO sites, but also the officials and technicians responsible for drawing up town planning, territorial or landscape policies, plans and programmes.

The public authorities are usually the same subjects that draw up the plans, outline the evaluations and monitoring, gather, process and store the information and environmental and territorial data[7]. Sometimes this generates a negative short-circuit, both in the choice of the indicators (which may be chosen to obtain the envisaged results), and in the transparency of the process. Recommendation CM/Rec (2008)3 of the Committee of Ministers of the Council of Europe on the guidelines for the implementation of the European Landscape Convention (CoE 2008), which suggests setting up the relevant Landscape Observatories, Centres or Institutes to study and monitor the dynamics of the landscapes (Appendix 1, 10), is observed in very few cases. The Convention and the Recommendation emphasise the importance of involving the population in the assessment: the idea of mixing expert knowledge with that of non experts is certainly a research frontier which remains to be explored, also in relation to the theme of indicators. The Observatories could therefore be one of the principal subjects for which this study is intended.

Are there Landscape Centres and Observatories in Europe? We did one modest study in collaboration with the European Network of Local and Regional Authorities for the implementation of the European Landscape Convention (ENELC) considering just a few situations in 2009, some of which were long-standing research centres, while others were established in specific relation to the implementation

[6] Cf. for example the system called Analytic Network Process. Examples of application with respect to policies associated with spatial/land use in Bottero et al. (2009).

[7] In Italy, the law for the application of the SEA Directive distinguishes between the subject doing the assessment and the subject drawing up the plan/programme, in other words between "authority responsible for the SEA" and "authority responsible for the plan or programme". Nevertheless, in reality, these subjects are often the same, two offices of the same administration for example.

of the ELC: this is the case of the Spanish Landscape Observatories, including the Landscape Observatory of Catalunya (Observatori del Paisatge de Catalunya), which draws up catalogues of the landscape, programmes to promote education and public awareness, holding international meetings on the theme of indicators. In Italy the establishment of national and regional Landscape Observatories was envisaged in 2008 by a national law[8], but only a few observatories were actually set up, too few and recent to be taken into consideration (Peano and Cassatella 2009). There are however many local landscape observatories, which started spontaneously as associations (some in the Civilscape network—NGO for the Landscape European Convention): of a less institutional nature and closer to the citizens, they are obviously unable to conduct organized and continuous monitoring activities, also in consideration of the difficulties associated with accessing and managing territorial databases.

International treaties attempt to make information as transparent and readily available as possible, in particular for the environment (The Aarhus Convention and Directive 2003/4/EC, EC 2003), and as landscape is also a public good, one line of work is the creation of specific databases for the monitoring activity. The situation in Europe is not very homogeneous: the Corine Land Cover protocol seems to be the only common reference (although it is not used by all regions), and for this reason, as we will see, literature favours landscape indicators that refer to land use.

Only some countries (Great Britain, Germany, The Netherlands first and foremost) have systematic knowledge of the landscape characters of their own territory, with uniform and stable databases on the national territory, to make the formulation of indicators and the monitoring of the same an easier task. In many other countries, the first step to take is the description (or characterisation) of the landscape, and this field of activity is also in a phase of growth and experimentation. It is obvious that the presence of evaluative processes can influence the construction of knowledge, which must be traceable and receptive to dynamics and processes.

1.6 A Concrete Example: The Italian Landscape

One last consideration concerns the country we are writing from, Italy. We all know how important the Italian landscape is for our country: it is a part of our identity, an immediately recognizable element of Italy for people visiting from abroad, and an important economic resource. Therefore, we believe it is only right to maintain that Italian character in some conceptual, operative and bibliographic references, which is perhaps a new outlook in a framework of scientific literature which comes mainly from Northern Europe.

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[8] In Italy since 2008 a national law envisages the existence of a national Observatory for the quality of landscape and regional Observatories to carry out studies, analyses and make proposals for landscape policies (Italian Republic 2004).

Our country has an age-old tradition of studies on geography and on the theory of landscape, and also on the protection of heritage (passing some of the first European laws on the subject), but it is without doubt less consolidated in the praxis of landscape planning. Let us digress and consider the Italian situation, to clarify the context of the work and the situation of this land so loved by many.

The Italian landscape planning system has been innovated to a great extent by recent European stimulus: from the almost exclusive focus on situations of excellence (landscape heritage and areas protected by law) we are now in fact considering the territory as a whole, from a traditional division of the environmental dimension and the cultural, historical and aesthetic dimension we now have a definition of landscape which acknowledges the possible intersection of these values, from a principally restrictionist approach we are now attempting to establish goals and actions, also for transformation.

The innovative nature of this approach, in accordance with the Cultural Heritage and Landscape Code of 2004 (modified in 2006 and 2008) was welcomed in the scientific community and by administrations, despite the fact that the application requires notable commitment to the renewal of existing methods and instruments. What does however appear to be more difficult to accept and apply is the culture of assessment and monitoring, which in other European contexts is part and parcel of making policies and plans. Italy, with a little initial resistance, therefore introduced some assessment and monitoring procedures such as EIA and SEA, required by EU legislation[9].

There have been many landscape plans or plans with reference to landscape (envisaged also in Law n. 1497 dating back to 1939). Nevertheless, no effort has been made until today to verify the effects (in a scientific way) of the plans or the transformations of the landscape caused by ordinary dynamics. Without processes of assessment to put the state of the landscape in relation to the implementation of policies and the dynamics in act in relation to the consequent opportunities and threats, every new planning act "starts again from scratch" or from the previous plan, instead of following a process of progressive parallelism and retroaction. The same cognitive frameworks of the plans often only describe the state of things, without attempting to make evaluative considerations or comments on the dynamics.

The Strategic Environmental Assessment of new landscape plans (drawn up in accordance with the new Code) is therefore an extremely promising field of work.

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[9] In Italy the growth of the activity of assessment relevant to landscape is notable and structured. The ELC attempts to identify and assess (or characterize, according to other interpretations) landscapes; the Cultural Heritage and Landscape Code gives landscape plans the task of conserving and re-establishing landscape values and indicating lines of development in town planning and building compatible with the same (Art. 135 c. 4); furthermore, the effects of the same plans (subject to Strategic Environment Assessment) on the landscape are assessed and monitored. The interventions on protected assets and areas are subject to the assessment of landscape compatibility (Art. IV), on the basis of which the Ministry of Cultural Heritage and Activities issued a Prime Ministerial Decree (12/12/2005) and guidelines. There are obviously three different aims and types of assessment: the first focused on landscapes, the second on the effects of the planning, the third on the relationships between an intervention and its landscape context.

We must however underline how the application of both the Code, and the SEA Directive, is the competence of single regions[10], so the panorama is highly differentiated and a framework of knowledge and methods is not configured on a national level.

The case study in the last part of the volume considers a region, Piemonte, which is exemplary for many reasons: an area rich in waters (with the source of the River Po), Alps, hills, old town centres, woods and highly characterised agricultural landscapes (the rice fields, and vineyards of the Langhe); over half the surface area is subject to protection, a regional law acknowledging environmental and cultural heritage dates back to the 1970s, the first Regional Territorial Plan (1997) with little reference to landscape and the second Plan drawn up in 2008 specifically with landscape in mind in accordance with both the ELC and the SEA.

The proposed indicators refer to this situation, also allowing for the state of knowledge, administrative data evaluation and management structures. An in-depth study was done on the feasibility of the application of the proposed indicators in collaboration with the *Consorzio per il Sistema Informativo del Piemonte* (CSI-Piemonte), which manages the regional territorial databases. The specific elements of the case may make the application of the study seem too local, but on the contrary, the intention was to diverge from studies which, in the name of apparent universality, conceal the generic character of their proposals with little verification in applications. The table of indicators constitutes one of the methodological proposals of the volume.

The concrete reference to the Piemonte region also appears in the first part of the volume, where we have used as many examples as possible from applications in this territory to illustrate the use of the indicators. Our intention was to make the text more homogeneous and simplify the comparison of the methods proposed, also on the basis of the original works of the Authors.

1.7 Limits and Prospects for Research on Landscape Indicators

Research is based on experiments that appears partial, never finished. This is a limit that can be found in most SEA studies, which, hampered also by the time taken to adopt the same in national systems and for processing the plans and programmes to which they apply, can count on very few complete applications, from the ex ante to the ex post phase, required also to assess the effectiveness of the indicators used. One of the first applications of the SEA Directive in Europe was in Piemonte, for the programme of the XX Winter Olympics held at Turin in 2006: only ecological indicators have been used for landscape, while the attention of the public, as can be

[10] Italy has 20 regions, 8091 municipalities; over 50% of the national territory is subject to special restrictions for landscape conservation. Protection in these areas is in any case the competence of the state, while the Regional authorities can enhance their landscape.

expected, has been focused on the visual impact of transformation associated with major sports facilities in particular.

The landscape indicators introduced in the CMEF of agricultural policies for the period 2001–2006 were reserved the same sort of fate: in the following period, 2007–2013, they disappeared, probably due to the difficulties in monitoring them. There does however appear to be light at the end of the tunnel, and we cannot turn back now: experimentation appears to be the only way forward.

Particular diligence will be necessary in the in-itinere and especially ex-post phases, which are indispensable if we are to learn from experience, but on which politicians appear to be less interested and where resources are sometimes unavailable. The definition of a reasonable period of time for the monitoring is another delicate and important aspect. What conclusions can be drawn, for example, in the ex post assessment of the Turin Winter Olympics just one year after they finished, when the major works have not been reconverted to stable uses yet, when the relevant works of mitigation and compensation must still be finished? But in the case of Turin 2006, the technical structures of the programme have been wound up, and with these also the monitoring. Only some studies by universities have attempted to bridge this gap[11].

We should have stable structures, such as the Observatories, centres or institutes mentioned in the European Council of Ministers Recommendation, able to carry out studies with continuity, as third parties, without any ties to the single plans or programmes, but useful for providing a framework to decision makers, also to avoid these situations.

As well as their function of acknowledgement, indicators can also provide another very different function. When considering the effectiveness of the indicators, attention should be placed on a role which is not rightly considered, that of measuring not only the processes, but also providing an orientation for the same: to some extent, they represent the goals of the policies, plans or programmes, for which they indicate the sensitive factors[12]. They can be interpreted as guide criteria, indicating the themes the policy makers are focused on, and in any case they could act as guidelines for the actors involved. A concrete example: in the SEA of a local plan, the decision to use an indicator relevant to the protection instead of the enhancement of the cultural heritage, constitutes a signal and stimulus, as well as a kind of programmatic commitment for the administration, with a vested interest in obtaining a positive performance.

Therefore a perspective for research is to study and use the indicators as a guide criterion. Let's consider the success of slogans such as "Plant One Million

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[11] Part of the group of Authors (Peano, Cassatella, Bottero) participated also in this process, which constituted the first SEA case in Italy, and carried out a "territorial" monitoring parallel to the environmental monitoring done by the authorities responsible for the SEA (2001–2007): Cf. Peano and Brunetta (2009); Bottero (2007).

[12] In same extent, the relationship between an indicator and a policy target is taken into account by assessment methods which use benchmarking as a technique weighting of indicators (cf. Parachini et al. 2008).

Trees", which range from global initiatives, such as those of the UNEP, to local initiatives, such as those of the administration of the City of New York and thousands of others. Approximately 315,000 trees were planted in New York (February 2010). Not by chance, "Tree canopy coverage" is one of the most common indicators used in Environmental Reports on the implementation of the Rio Convention and Agenda 21!

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Chapter 2
Indicators Assessment Systems

Marta Bottero

Abstract This chapter deals with the theme of environmental indicators in general, the principles and the fundamental definitions that regulate the use of the same. On the basis of experience gained with environmental indicators in the international field, we will consider the main models used for assessment in detail (first and foremost the DPSIR, Driving forces-Pressures-State-Impact-Responses), indicating the prerequisites and various fields of application. The paper studies various environmental indicator systems in depth, with the aggregation of the same in concise indexes to convey the information in an effective way for a specific target. The last part of the chapter contains a proposal for a table presenting the landscape indicators covered in the following chapters of the book.

Keywords Environmental indicators • DPSIR framework • Environmental assessment • Weighting and aggregation • Indicators presentation

2.1 The Use of Indicators: Environment and Landscape

2.1.1 Definition and Requirements of an Environmental Indicator

Landscape indicators have only recently been used in the field of analysis and for the assessment of territorial transformation. These indicators derive from more consolidated and structured models, referring to environmental indicators in general (DEFRA 2009; Eurostat 1999, 2009; International Institute for Sustainable Development 1999; UNCSD 2001, 2007; World Bank 2008).

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The indicator is a parameter associated with an environmental phenomenon, which can provide information on the characteristics of the event in its global form (OECD 2003).

Its purpose is to indicate the state, or the variation in the state, of a phenomenon which cannot be measured directly. In fact the data, even if suitably presented, does not constitute an indicator, and can only be used as such when linked to a phenomenon other than that measured.

By using indicators we can obtain targeted information, in order to concisely represent the problems studied while maintaining the informative content of the analysis intact (Schmidt 1986).

Many experts agree that a good indicator must meet some fundamental requirements.

These requirements can be summed up as follows:

- *Representativeness:* the indicator must be clearly correlated with a certain phenomenon or certain characteristic we wish to measure or control; it must be highly correlated with the above-mentioned effect, with a minimum statistical dispersion; it must not be easily hidden by surrounding factors; it must be sufficiently valid in many similar situations, even if not identical;
- *Accessibility:* it must be easy to measure and if possible to monitor automatically; it must be easy to sample; it must have a analytic measuring threshold accessible with standard techniques;
- *Reliability:* it must have minimum systematic error values;
- *Effectiveness:* it must be directly and easily usable to quantify interventions, costs and benefits.

The informative content of an indicator depends greatly on:

- the *relevance*, in other words the importance of the characteristic measured for the knowledge of the phenomenon in question;
- the *specificity*, in other words the capacity to identify only the characteristics associated with the phenomenon in question;
- the *precision* of the measuring parameter, in other words the capacity to measure the state and variations of the characteristics at the in-depth level required.

In particular, several of the bodies that promoted the diffusion of environmental indicators have established criteria for specific selection and validation. The three main requirements established by the OECD (2003) are shown in Table 2.1.

In particular, the definition provided by the Landscape Observatory of Catalonia should be referred to for the analysis and assessment of landscape using environmental indicators. The landscape indicator is defined as a quantitative or qualitative element, which can be used to assess and monitor the evolution and state, public satisfaction, and the effectiveness of public and private initiatives for the improvement of the same.

Furthermore, Vallega (2008) emphasises that a landscape indicator is not merely an act of acknowledgment, but must also be an instrument of assessment. In other words it must assess the terms in which aspects, processes, and behaviour are coherent with the pursuit of landscape quality in accordance with sustainable development.

Table 2.1 Requirements of an environmental indicator at a common international level. (Source: OECD 2003)

Relevance
An environmental indicator must:
1. provide a representative image of environmental conditions, the pressure on the environment and the social response;
2. be simple, easy to interpret and able to show trends in time;
3. be sensitive to changes in the environment and interrelated human activities;
4. provide a basis for international comparison;
5. be useable at both a national level and in issues of regional interest;
6. be associated with a threshold or value of reference so the user can rapidly assess the determined level.
Analytical soundness
An environmental indicator must:
1. be well defined from a theoretical point of view and in technical terms;
2. be based on international standards and be validated at an international level;
3. be ready for interfacing with economic models and territorial IT systems.
Measurability
The data necessary for the construction of the indicator must be:
1. already available or obtainable at a reasonable cost/benefit;
2. suitably documented and of a certifiable quality;
3. revised at regular intervals in accordance with validation procedures.

2.1.2 Environmental Indicator Systems

2.1.2.1 The DPSIR Model

Alone, an indicator provides little information unless it is associated with a system of indicators, able to provide systematic information for the purpose of assessment.

A system of indicators consists of several indicators correlated from a logical and functional point of view, able to describe and provide information on several phenomena associated with each other, or which need to be interpreted in a coordinated way.

One consolidated instrument for the integrated analysis of the social-economic and environmental aspects in the field of sustainability assessment is the system of environmental indicators known as the DPSIR model (Driving forces, Pressures, State, Impacts and Responses), established by the Organisation for Economic Co-operation and Development in the early 1990s (OECD 1993), and acknowledged by the European Environment Agency (EEA 1995).

In the DPSIR model, the basic idea is that the *driving forces* of the economy generate pressure on the territory in terms of consumption of resources and pollution. If this pressure exceeds the capacity of the territory in question, it is considered unsustainable and the direct effect will be a deterioration in the state of the environment in question. The impacts, which are associated with the state of the territory, concern the ultimate effects of the pressures on the environment; and are therefore related

Table 2.2 Categories of environmental indicators in the DPSIR model

Category	Description
Driving forces (D)	These constitute the basic factors that influence a range of variables pertinent to the same (for example: the number of cars per inhabitant, total industrial production)
Pressures (P)	Describes the variables that directly cause environmental problems (for example: toxic CO_2 and noise emissions from traffic; the quantity of waste produced by demolishing vehicles per year)
State (S)	The current condition of the environment (for example: the concentration of lead in urban areas; noise levels near main roads)
Impact (I)	Describes the ultimate effects of the changes in state (for example: the percentage of children who suffer from lead-induced health problems; the number of people who die of hunger due to crop loss caused by climate change)
Responses (R)	The efforts of the social system to solve the problems (for example: the percentage of cars with catalytic exhausts; the maximum levels of noise emissions allowed for cars)

to a deterioration in human health, a drop in biodiversity, and a deterioration of the landscape. These impacts are countered by the response of society and institutions administering the territory (Boeris et al. 2002).

Therefore, to be effective for territorial planning, the DPSIR model must be supported by a system of indicators that can quantify the various components to establish the specific cause/effect of environmental deterioration. These indicators are divided into the five categories shown in Table 2.2.

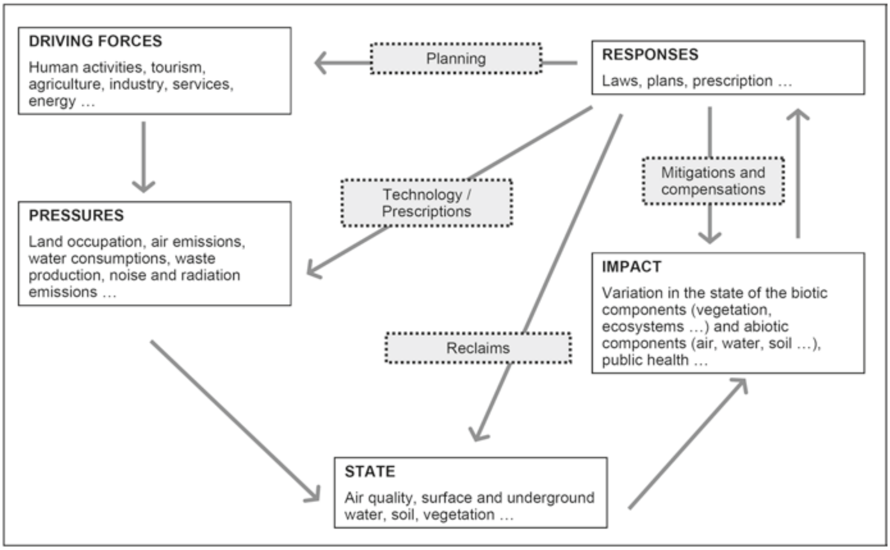

Fig. 2.1 The DPSIR model

Figure 2.1 describes the causal sequence between: anthropic actions (Driving forces and Pressures), conditions of state/environmental quality (State and Impacts) and actions taken to solve any critical situations (Responses).

Another organisation dealing with environmental indicators refers to the different functions that these can have. In particular, different types of indicators are established (EEA 2003) to answer the following questions:

- What is happening? (Type A)
- Is it relevant? (Type B)
- Are we witnessing changes? (Type C)
- Are the responses effective? (Type D)
- Does it contribute to the level of global wellbeing? (Type E)

In other words, the following five classes of environmental indicators are identified:

(a) *Descriptive indicators:* usually presented as linear diagrams that represent the trend of an environmental variable in time; normally used as indicators of state, pressure or impact;
(b) *Performance indicators:* associated with certain objective values (target), measuring the distance between the current environmental situation and the desired environmental situation; they may be indicators of state, pressure or impact;
(c) *Efficiency indicators:* these measure the efficiency of products or processes from a point of view of the consumption of resources, emissions and waste per output unit;
(d) *Policy-effectiveness indicators:* used to provide information on the relationship between the change in environmental variables and environmental policies; mainly indicators of response;
(e) *Total Welfare indicators:* specific indicators that provide information for policy decision makers on environmental, economic and social issues.

2.1.2.2 The CMEF Model

The CMEF (*Common Monitoring Evaluation Framework*) model refers to a system of assessment created by the European Union to monitor Rural Development Plans (European Commission 2006).

In particular, this system defines five categories of indicators for the assessment of the plans on the basis of the scheme shown in Fig. 2.2.

The assessment system is developed in a series of phases.

Starting with the development of a SWOT analysis to establish the strengths and weaknesses, opportunities and risks of the system, on the basis of some context indicators, we can establish the goals we wish to reach with the implementation of the plan and strategies to use. Subsequently, with reference to the measures of the action indicated in the plan, we will have to monitor the implementation through input, output, result and impact indicators. Table 2.3 shows a summary of the indicators in the CMEF model.

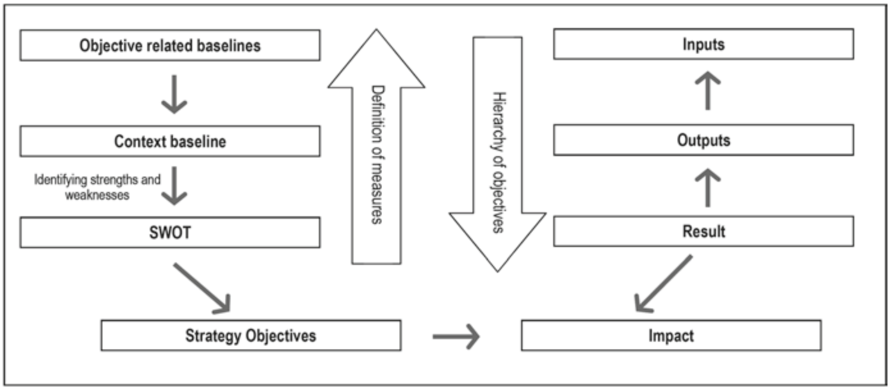

Fig. 2.2 The CMEF model. (Source: our elaboration from European Commission 2006)

Table 2.3 Categories of indicators in the CMEF model

Category	Description
Input indicators	These indicators refer to the budget and the allocation of the resources used (Ex. declared cost of each measure identified)
Output indicators	These indicators are used to measure the actions carried out directly as part of the plan. These activities are the first step towards the implementation of strategies for reaching the envisaged goals, and are measured in physical or monetary units (Ex. number of training courses held, number of companies that received incentives …)
Result indicators	These indicators measure the immediate effects of the planned interventions and provide information on the changes implemented (Ex. number of jobs created)
Indicators of impact	The indicators of impact refer to the benefits of the programme. They do not only consider the direct beneficiaries, but include the entire area affected by the plan (Ex. increase in employment in rural areas, growth of productivity in the farming sector)
Basic indicators	These indicators are useful for the preliminary analysis of the plan and are divided into the following categories: • objective indicators (used as a reference to assess the impact of the plan) • context indicators (provide information on the general state of the system for which the plan was drawn up)

2.1.3 Indicators and Indexes

One indicator alone cannot express the complexity of the system being observed, but it is just as true to say that a system of partial and extremely incoherent indicators can be an obstacle in the assessment procedure.

Therefore, synthetic indexes can be defined, based on a combination of the information with reference to a multitude of indicators, able to express a value which represents the phenomenon being studied.

The importance of defining synthetic indexes through the aggregation of several different indicators (even with the loss of information as a result of said aggregation), is clearly expressed by all experts in strategic assessment who must, due to the nature of these procedures, be able to make judgements on compatibility very quickly (Jesinghaus 2000).

The correct procedure for establishing synthetic indexes that refer to a determined situation subject to study is based on the following steps:

- Identification of the goals we wish to reach with the project being assessed;
- Definition of the alternatives and future scenarios the assessment must refer to;
- Definition of the useful and available partial indicators the aggregation should be based on;
- Definition of the operational mathematical procedure for the partial data combination;
- Definition of the methods of representation for transferring and applying the results.

The main methodological reference for the aggregation of a system of partial indicators in an overall index is the approach based on the *performance index*. Particularly, the Policy Performance Index was drawn up by Jochen Jesinghaus in 1999 during research for the JRC (Joint Research Centre of the European Commission) to integrate classic social-economic indicators (GNP, inflation rate, employment) with new elements (in particular concerning environmental policies) in the assessment of the success or failure of certain policies (JRC 2009).

Let's look at the pie chart in Fig. 2.3. As we can see, there are several indicators that can be used as a starting point for the analysis, divided into three main categories:

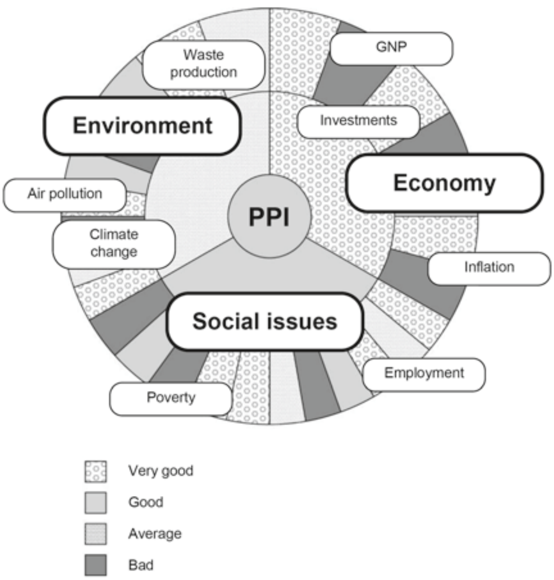

Fig. 2.3 Example of representation of the *Policy Performance Index*. (Source: Jesinghaus 1999, reworking)

- an *Environmental index*, consisting of many indicators in the environmental field (waste produced, atmospheric emissions, etc.);
- a *Social index*, consisting of indicators on social matters (the quality of medical healthcare services, distribution of wealth, poverty, etc.);
- an *Economic index*, which consists of typical economic indicators (GNP, inflation, investments, etc.).

The three partial indexes are combined in one single Policy Performance Index (PPI) and shown in a pie chart with three concentric circles. The three circles contain:

1. the global PPI in the centre;
2. the three sub-indexes for Environment, Society and Economy in middle circle;
3. the simple indicators in the outer circle, where the size of each segment indicates the effect on the overall assessment.

When considering indicators and synthetic indexes, it is fundamental to reflect on the basic data on which the assessment is developed. One very useful concept consist of the "information pyramid" (or "iceberg information") (Fig. 2.4) which highlights the essentiality of so-called "invisible work", in other words the technical and methodological approach of research and statistics institutes, without which assessment would be impossible (Jesinghaus 1999).

We must emphasise the importance of a synthetic index when developing the assessment. This requirement can be attributed to various reasons. First and fore-

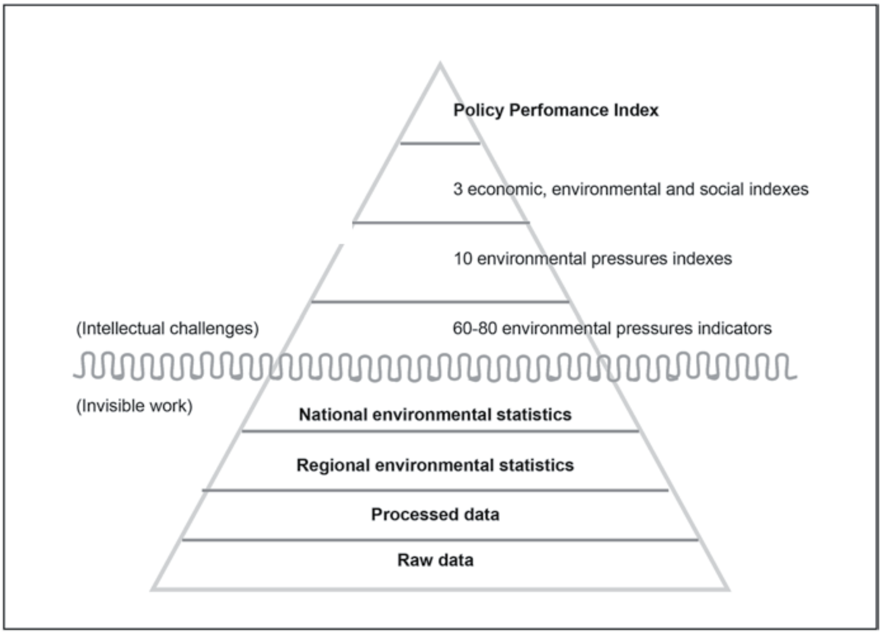

Fig. 2.4 The information pyramid. (Source: our elaboration of Jesinghaus 1999)

most policy decision makers require a further summary of environmental information, for fast and immediate interpretation, to base their decisions on (Giovanelli et al. 2000). In fact, it is a lot better for policy decision makers to have, for example, an index on the quality of water, rather than a series of indicators on the specific physical-chemical characteristics of water resources. Furthermore, with particular reference to landscape assessment, the use of a synthetic index able to provide information on the state of a certain landscape system is of primary importance in more extensive assessment contexts, in which the landscape is one of the components of sustainability. The landscape index can therefore be integrated and combined with the indexes of other components of the system to create an index of overall sustainability.

The last important element in the construction of a system of indicators and indexes that represent the real situation of the territory in question is the weighting of indicators. In fact, various indicators can contribute with varying importance to the definition of a single quality, or have a different affect in the goals-criteria system of a decision-making process. With this in mind, we should remember the role that derived statistics techniques such as multiple regression analysis and multivariation analysis, or methods such as the *Delphy* method have played in defining the importance of criteria or indicators in an assessment procedure.

2.1.4 Fields of Application

The need for integrated use of the indicators stems from a considerable growth of interest in the field of government instruments on environmental quality, and economic and social instruments in general.

The context of the theme is related to decision-making system and its various aspects pursuant to the existing situation (in particular decisions concerning administrative aspects of the organisations involved) and those of the future (decisions on plans, programmes and projects).

We must also consider the progressive organization and the complexity of the references, which include consolidated tools (system of standards and controls), others being defined (environmental reporting for example), other tools recently adopted as a result of legislation within which there is ample room for improvement (such as those for Strategic Environmental Assessment or for the assessment of environmental damage).

Some tools apply to future forecasts for the purpose of prevention, others to the current situation again for the purpose of prevention, some favour the support of decisions, others put the emphasis on evaluation.

Figure 2.5 shows the overall picture on the use of indicators, while Table 2.4 provides a description of the main existing fields of application.

The last entry on environmental indicators refers to the problem of the scale of reference. The theme of the scale concerns both the time coordinates and the geographical coordinates of the indicator.

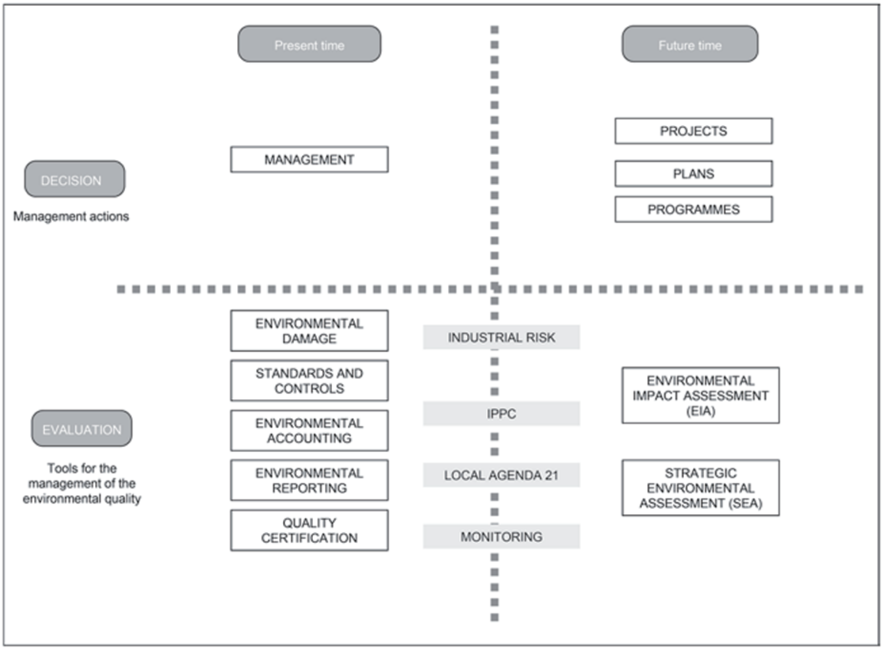

Fig. 2.5 Chart showing the main government instruments that envisage the use of environmental indicators. (Source: Malcevschi 2004, reworking)

As for the time scale, the indicators may be *synchronous* if they refer to an instant in time, or *diachronic* if they refer to variations in conditions and behaviour. The second type is mostly used in relation to landscape, as we are referring to a process in which elements and structures change along a time line.

The theme of the territorial scale of reference is more interesting however. The problem of scale is particularly important for analyses such as those considered from the time that affects the successful outcome of the assessment. The choice of the territorial scale of reference in fact, is closely associated with the problem of the availability of basic data for indicator calculation (assessment done using an analysis scale at a regional level, for example, cannot be based on national data as the transformations in question would be illegible).

Most of the indicators used by international organisations on sustainable development take the national scale as a reference. However, for landscape, as established by the European Convention, the indicators can refer to both the national scale and subnational scales (regional and local).

In the case of the present study, we will adopt an inter-scale approach as far as possible, without using one specific scale and using the regional level as reference. This level in fact is the one used as reference for landscape and territorial policies in general.

Table 2.4 Use of environmental indicators in various fields of application. (Source: Malcevschi 2004, reworking)

Decision-making instrument	Use of environmental indicators
Command & Control	• To assess the level of environmental quality • To establish legislative standards by acknowledging thresholds beyond which the value of an indicator becomes a potential risk
Environmental Impact Assessment (EIA)	• To describe the persistent environmental situation at the sources of impact generated by the project • To forecast and estimate impacts • To control the evolution of efficiency and stability of the work and the situation of the environmental system in question
Strategic Environmental Assessment (SEA)	• To emphasize the environmental and territorial characteristics of the area affected by the plan • To make the specific goals of the plan measurable • To assess the major effects deriving from the actions of the plan • To monitor the degree of implementation of the plan and the situation of the environment in question
Environmental reporting	• To describe the state of the environmental system • To report on the conditions of quality and criticality of the environment to help in decision-making processes
Corporate environmental communication	• To describe the level of interaction between the company and the environment • To measure the level of response in the field of the company to improve environmental performance
Sustainable development	• To provide a solid base for decision-making processes on all levels • To obtain a diagnostic outline of the territory in question • To monitor and verify the goals of sustainability are reached
Environmental certification	• To assess the environmental performance of the certified organisation
Management Plans	• To monitor systematically the results of the plan in time

2.2 The Presentation of Indicators

2.2.1 Types of Existing Tables

The use of indicators and systems of indicators for a specific assessment requires that the same are presented in a clear and effective way. The documentation on indicators contains various types of models for the presentation of the single indicators.

A first, very simple type, refers to the presentation of the fundamental indicator information, such as the definition, the formula for calculation, and some other essential data.

Examples of this type are provided in the list of indicators drawn up by the Association of Environmental Analysts (AAA 1999) or other international reports (Esty et al. 2005, 2006).

A second, slightly more complex type, involves presenting a table, which is concise and easy to consult, containing the definition, formula and description of the process. This type is used in the Mediterranean Action Plan (Plan Bleu 2006) or OECD (2004).

A third type, more complete and structured, refers to models in which the tables for the presentation of the indicators contain the definition, the standards of references and an indication of the thresholds of reference for the assessment, the method of calculation, the data specifications, any uncertainty associated with the indicator, future work and other general data (including, among other things, the category of the DPSIR model).

An example of this kind of table is used for the indicators monitored by EEA (2009); in Italy we can also refer to the indicators used by Piedmont Regional Agency for the Protection of the Environment (2008) (APAT 2006; Nappi et al. 2007). Furthermore, the system of landscape indicators proposed by Vallega (2008) also refers to this type of presentation.

Finally, a useful and complete form of presentation, in line with the above but specifically drawn up for landscape assessment, is proposed by Malcevschi and Poli (2008). The presentation contains the description of the indicator, the landscape aims, the type of indicator (simple or complex, qualitative or quantitative), the variables in the same, the indications relevant to the work in which the indicator was used, the unit of measure, the time and territorial scale, the characteristics of use of the indicator, the availability of initial data and the method to use for presenting the results.

The last model is the one used to draw up most of the tables for the presentation of the indicators in the study.

2.2.2 Proposed Table for Landscape Indicators System

The proposed table (Table 2.5) is the result of a summary done on the basis of the study, and the comparison and analysis of existing documentation at a national and international level. In fact, in order to establish a common model for the presentation of the indicators in this study, we initially referred to various tables in existing documentation.

Once the most suitable type was found, we proceeded by testing the operative capacity, verifying the applicability of the elements of the table and proposing some others.

The result of these operations resulted in the table for the presentation of the indicators shown below.

- *Indicator:* name of the indicator;
- *Definition:* a short definition of the indicator;
- *Description:* describes the indicator and presents the methods and formulas for calculating the same;

- *Category:* the indicator category of those identified in the present study (ecology, perception, soil uses, cultural heritage, economy);
- *Aims pursuant to landscape:* the aims of the indicator in landscape study; the indicator can be used to establish elements and processes of interest for landscape, identify or assess the same;
- *Status/Process:* the theme concerns the time and geographical coordinates of reference for the indicator; the indicator can in fact refer to an instant in time (State) or temporal variations in conditions and behaviour (Process);
- *DPSIR category:* the category in the DPSIR model (Driving forces-Pressures-State-Impact-Responses);
- *Typology:* indicates whether the indicator is a simple indicator or a complex index, that is the result of the aggregation of several indicators; in this case the variables of the index and the aggregation procedure used must be specified;
- *Unit of measure:* the unit of measure that describes the indicator;
- *Territorial scale:* the geographical scale of reference; as the framework of indicators proposed refers to the European Landscape Convention, the geographical scale encompasses the local and regional scales;
- *Time scale:* the most suitable period of time the indicator should refer to;
- *Characteristics of use:* specified in fields of application in which the indicator can be used (technical-scientific analysis, monitoring, plans, …);
- *Availability of data source:* the sources of the data on which the indicator calculation is based;
- *Method of representation:* the ways in which the processes associated with the indicator can be represented (theme maps, temporal diagrams, …);
- *Fields/work in which it was used:* the fields of application in which the indicator was used; whenever possible, indicate the bibliographic reference of the work in which the indicator was used and/or applied.

Table 2.5 Indicators table

Indicator
Definition
Description
Category
Aims pursuant to landscape
Status/Process
DPSIR category
Typology
Component variables (if index)
Unit of measure
Territorial scale of reference
Time scale of reference
Characteristics of use
Availability of data source
Method of representation
Other explanatory notes
Fields/work in which it was used

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ARPA Piemonte Agenzia Regionale per la Protezione dell'Ambiente. http://www.arpapiemonte.it

EEA European Environmental Agency. http://www.eea.europa.eu/

ESL European Statistical Laboratory. http://esl.jrc.it/

European Commission. http://ec.europa.eu/index_en.htm

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IUCN International Union for Conservation of Nature. http://www.iucn.org/about/index.cfm

Observatori del Paisatge de Catalunya. http://www.catpaisatge.net/cat/index.php

OECD Organization for Economic Co-operation and Development. http://www.oecd.org/

SINAnet Sistema Informativo Nazionale Ambientale. http://www.sinanet.anpa.it

UN United Nations Department of Economic and Social Affairs Division for Sustainable Development. http://www.un.org/esa/sustdev

World Bank. http://www.worldbank.org

Chapter 3
Indicators Used for Landscape

Claudia Cassatella and Angioletta Voghera

Abstract Each landscape assessment model selects some aspects, component and profiles of interpretation. The chapter provides a state of the art framework, comparing the proposed systems of assessment and the indicators in scientific publications and in international bodies documents. The attention is focused on the categories of indicators: historic, ecological, perceptual, land use and economic are the landscape dimensions which are chosen for the subsequent chapters and proposals.

Keywords Categories and types of indicators • Functions of indicators • European studies on indicators • Landscape model

3.1 Categories of Indicators Traditionally Used in Different Operative Conditions and Studies

Landscape study is an interdisciplinary activity to such an extent that, in consideration of the many disciplines dealing with the same, we can consider the theme of "sectorial landscapes": landscape as a system of ecosystems, a system of signs, a palimpsest of traces of history, a "scene" or view… After years of discussion in which, each time, one or the other concept prevailed, today the most widespread conviction is that the "sense" of landscape can be found in the intersection of different dimensions. For this reason, assessments concerning the various aspects and, in particular their relations are required.

C. Cassatella wrote Sects. 3.1, 3.3, and A. Voghera wrote Sect. 3.2.

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The following chapter deals with the aspects to be considered, and those covered by this study. We will review the analytical categories used in the main European studies on the question, favouring those of an international and comparative character (cf. Sect. 2.2). In this panorama we can draw some general conclusions on the categories used, the landscape model in relation to the cultural context, the validity of indicators in relation to geographical context, and on the scale and aims of the use.

With reference to scientific literature and the sets of indicators used by national or regional bodies, it is easy to see that in each country the landscape characters most present in local cultural and scientific traditions, or most pertinent to the characteristics of the area are favoured or emphasized: for example, in Northern Europe the natural and environmental aspects are of great importance, while in Mediterranean Europe there is more emphasis on historical-cultural aspects. This is not the place to ponder the difference between the concepts of "*landscape/landshaft/landschap*" and "*paysage/paesaggio/paisaje*", but it is important to mention that, currently, the majority of literature and most experiences concerning landscape assessment using indicators pertains to the first area, with the historical-cultural aspects lacking or unsatisfactory (cf. Chap. 5).

Also in methodological proposals which strive for general validity, we can find indicators associated with the specific nature of the territories in question: for example, the indicator "presence (or maintenance) of hedges and linear systems", which is a characteristic of bocage in Central and Northern Europe, or "presence (or maintenance) of terraces", pertaining to Mediterranean Europe. These indicators are therefore not universal, but they do have one particular quality: they are extremely sensitive to the value attributed to certain landscapes by the population. Other examples of indicators with a local reference are indicators relevant to perception (cf. Chap. 6): *visual openness* and *perceptual naturalness* are judgement parameters commonly proposed and considered positive for the purpose of assessment; but they reveal the existence of a "beautiful landscape" cultural model based on broad horizons, meadows or fields with rich vegetation, a model which is certainly not universal, and most probably improper with respect to cultural mediators of populations inhabiting territories with a rough morphology where the anthropical signs have a significant connotative value.

The impression left by a review of published indicators is that each of these contains an implicit model of landscape quality, in other words an "implicit project". It is probably impossible to avoid this model; instead, we can infer that it is legitimate to hope that the indicators are drawn up ad hoc, for each single landscape, with reference to the values expressed by the population and experts. Obviously, this does not exclude the international comparability of the approaches, but makes it obligatory to verify the applicability to the case in question and leads to misgivings about "lists of indicators", today widely available on the web, from which the unskilled (but sometimes also public decision-makers) feel they can choose freely. In this respect, landscape indicators differ greatly from environmental indicators, which have a higher level of transferability[1].

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[1] However, also environmental indicators are not universal: for example, local habits which reflect on legislation, show variations with respect to the tolerance of pollution thresholds and other

This problem can be dealt with in two ways. Firstly, the categories and type of indicators can be identified at a general level, while the indicator can be defined and measured, at a local level, favouring different and specific factors. For example, the preservation of traditional elements of farmland landscape can be measured in one case with reference to the length of the hedges, and in another with reference to the length of dry stone walls, but it can also merge these in one single indicator, for example called "*Length of green linear landscape features maintained and/or restored by farmers: hedges, grass margins in arable fields, stone walls, terraces (...)*", as proposed by the PAIS project (Landsis et al. 2002). The assessments of a regional or national landscape observatory could function in this way. Secondly, the choice to use just some categories of indicators can be justified by putting them in relation to the landscape values held to be relevant in said context.

Let us now look at some *frameworks* in which landscape indicators are presented. Vallega (2008) first establishes the functions of the indicators:

- *recognition function* (monitoring and measuring conditions and processes);
- *evaluation function* (judgement of the value on the condition, on the process and on the human action in relation to these);
- *orientation function* (supplying indications on the ways in which human action should be implemented).

Also according to the aims of the assessment we have the indicators relevant to "*structure, management, function, value*" (Wascher 2004; Haines-Young and Potschin 2005), *state and change*, or *characterization, transformation and enhancement* (for example "*understanding the assets, caring and sharing, using and benefiting*", English Heritage 2009). Others prefer to use a division based on the values and functions of the landscape (instead of the indicators) and on the values associated with these: ecological function, social function, economic function (Wascher 2000), *natural value, cultural, use* and *perception* (Farjon et al. 2009). Or the indicators are divided into indicators that refer to "*landscape as an object*" or "*landscape and perception*" (Wascher 2005). There are many mixed sets, for example the PAIS project (Landsis et al. 2002) lists the following *landscape dimensions*: *landscape features, human perception, landscape management, landscape conservation and protection*. The Landscape Observatory of Catalunya proposes ten indicators that measure the physical transformation of the landscape, the social perception, and the implementation of landscape policies (Sala 2009). Other sets,

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precise aspects. Of landscape indicators, only ecological indicators seem transferable and admit generalizations: the indexes recur (although with many variations) in international literature, and are applied in a wide variety of countries. In reality, it is the interpretation of these indexes that incorporates the "local" point of view, through the knowledge of the expert. Let's consider the theme of diversity: as a result of its fragmentation, a periurban area may have a high degree of diversity, which depends on the variety of land uses and the length of the perimeters of the patches, but the expert "corrects" the results by applying a landscape quality model, in which the variety is considered good when it consists of patches of a certain type. Methods for estimating the economic value of the landscape also use apparently universal concepts (willingness to pay for a good, attractiveness and recreational value …): it is easy to see that their declination (and measurement) must allow for models of social behaviour and the locally differentiated use of the space.

while extensive, deal however with one aspect only, for example the ELCAI project (Wascher 2005) concentrates on "*character indicators*", and the Countryside Quality Counts project on "*indicators of change*" (Baker 2009).

In general, indicators that describe the state of the landscape, and therefore relevant to the characterisation, are more developed in Europe but not homogeneously with respect to all the analytical dimensions and all types of landscape. As mentioned in Chap. 1, landscape indicators were developed for the rural landscape in particular, with the aim of measuring the effects of agricultural policies: this leads to the relevant deformations, whenever one attempts to apply "agri-environmental" indicators to landscape in a broader sense. These in fact favour the ecological aspects and the use of land, disregarding urban landscapes completely. In some of these models, antropization is definitely considered a negative factor (consider, for example, the land consumption indicator or the index of naturalness)[2], so the assessment of historical-cultural aspects is based only on the persistence of traditional farmland landscape, or comes into play as a factor of appreciation, in the scenic-perceptual aspects.

The aspects associated with land use (from which the ecological aspects derive also) have the advantage in that they can be analysed using cartographic bases and data present homogeneously on the European territory (Corine Land Cover), in other words on each national and regional territory[3]. For this reason, some studies concentrate on the possibility of measuring also other landscape dimensions, starting with land use, establishing correlations between elements (for example, between the diversity of use, ecological diversity, visual diversity). Certainly the most common and universally accepted indicators are those relevant to landscape ecology, which also have the advantage of being applicable in every geographical context.

In countries where there is a characterisation of landscapes at a national level (such as Great Britain and The Netherlands), in other words with a complete and homogeneous description of different aspects, it is easier to find structured and differentiated sets of indicators. Obviously, if a description of also the historical-cultural and perceptual aspects is available, it is easier to propose indicators that assess the state and transformations[4]. In other countries, like Italy, the elaboration of indicators must involve the construction of ad hoc databases, or be hampered by considerable restrictions, reducing the complexity of the aspects to those known (see, for example, the recurrence of almost tautological indicators, such as "Designated land areas") (Malcevschi and Poli 2008).

Not many studies clearly express the scale at which the indicators can be used, although this can be deduced from the context: local, regional, or vaster (national or continental). It is clear that this is an extremely important factor however, to such

[2] For example, in the Andalusia map of landscapes, the urban landscapes are included in the indicator "urban and unaltered landscapes", the presence and growth of which is obviously evaluated negatively (Rodríguez and Villar 2009).

[3] Cf., the identification of European landscapes in particular, by Alterra: Mücher et al. (2010).

[4] Studies on the theme of "tranquillity" in England for example: the indicator is made up of numerous indexes, with a broad-ranging cognitive base, associated with national Countryside policies (Haggett et al. 2009).

an extent it influences the type of elements observed. Moving through the scales, are all the aspects into which we break down the landscape analysis equally relevant? Let's consider, in particular, the theme of visual perception: there can be no visual perception of a territory at a regional scale, except with the sum of elements obtained on a detailed scale or as a "mental image", an overall impression, which no longer considers the scenic aspects but rather the theme of social perception and the cultural and identity values associated with the same: as a consequence, the landscape dimension and the methods of analysis must change. Extending the scale weakens the reference to concrete objects and we will observe indirect phenomena; for example, instead of measuring the quality of the landscapes, the "percentage of designated landscapes" is taken as an indicator, a theme which considers the landscape not only as an object, but also in relation to policies. Thanks also to the availability of homogeneous data, the aspects associated with land use and landscape ecology are commonly taken into consideration on a large scale. On this scale, furthermore, the assessments are concentrated on the policies of international bodies, so there are often indicators of response used to measure landscape policies. The differences that can be attributed to the concept of landscape, observed on various scales, are in any case worthy of in-depth study, as yet to be developed.

Another important question concerning landscape indicators is the quantitative or qualitative nature of the measurement. As we will see, there are a considerable variety of approaches, indicators and therefore measurement methods. It is, however, indubitable that establishing thresholds can often represent a problem, every time we have to deal with intangible aspects and symbolic values rather than tangible aspects. In this case, well illustrated by Vallega (2008), despite that fact that there is specific reference to attaining certain goals (such as the ELC goals for example), the thresholds are not necessarily established by the researcher, and can be interpreted by the decision maker: "in other words, it is reasonable to believe that establishing thresholds is methodologically complicated and sometimes even impossible and, when it is possible, a deterministic function cannot be attributed to them as regards to the action".

One last general consideration concerns the level of application of published indicators: in many cases, when we are not dealing with theoretical formulations and proposals, the indicator was applied once only. Obviously this represents a very real limit in the assessment of the effectiveness and in particular the sensitivity to the transformations of the landscape. There are a few exceptions, in other words studies where the researchers deliberately tested a method that had matured in the same places in which it was developed years earlier (for example the methods of analysis on visual preferences in the USA), or studies carried out by institutions and bodies involved in constant research activity and able to plan the research in the long-term (Natural England, English Heritage, Alterra for example)[5]. The continuous evolution

[5] The Countryside Quality Counts programme (Natural England et al. 2009), which assessed the changes in English landscape over the periods 1990–1998, 1998–2003; or the AAAMPB studies on landscape perception in The Netherlands, carried out on a representative sample of the national population, to be repeated in the future (Farjon et al. 2009).

of landscape research seems to make it impossible to study the same place with the same method twice, although there is often the intention (or proposal) to do so in the future. This is implicit in the Strategic Environmental Assessment (SEA) of plans and programmes that envisage monitoring and several phases of assessment. Therefore we can expect growth in the applicative experiences on all European territories, which should (at least in theory) concern the indicators of transformation and enhancement.

3.2 Indicators in Europe

The construction of a set of indicators that can be used to identify and assess European landscapes in implementation of the European Landscape Convention (CoE 2000) is a subject of debate in the international scientific community. The types of indicators used in key international studies have been listed below, emphasizing how landscape is identified and assessed mainly on an ecological, perceptual and land use scale (Table 3.1); limited attempts have been made to assess the economic value of landscapes, while there is an evident absence of methods for the analysis of historical-cultural values.

The types of indicators used to interpret the landscape are affected by the cultural matrix of landscape policies in north European countries (United Kingdom, The Netherlands, Germany, etc.), the coordinators and/or partners in these studies, who in general focus on the protection of the ecological-perceptual aspects of the countryside for public use (Voghera 2006).

The recent work "Indicadors de paisatge. Reptes i perspectives" of the Landscape Observatory of Catalunya (Nogué et al. 2009) provides some interesting examples on landscape assessment and systems of social, economic and ecological indicators developed in various areas such as Catalunya, Andalusia, The Netherlands, Italy and Great Britain.

Table 3.1 Types of indicators used in studies

Studies	Indicator types				
	Historic	Ecological	Perceptual	Land use	Economic
ENRISK		X	X	X	
OPC		X	X	X	X
ELCAI		X	X	X	
CTN-NEB		X			
IRENA		X	X	X	
SPESP				X	X
DG AGR		X		X	X
EUROSTAT		X	X	X	
EEA 2001		X		X	X
PAIS	X	X	X	X	
MTT		X		X	
APAT		X		X	
Vallega	X	X	X	X	

Of the studies that focus in a systematic way, starting with the collection of methods and applications, on the identification of indicators with a degree of sensitivity to the goals and contents of the ELC, we should mention: the European project ELCAI (Wascher 2005) and the Italian study *Indicatori per il paesaggio* by Vallega (2008).

The ELCAI project (The European Landscape Character Initiative) coordinated by Dirk Wascher, examines landscape assessment techniques in 14 countries, analysing the role of landscape policies at various territorial government levels; it provides a description of the European landscapes as a basis and a common language for the definition of policies at a European level. The study propose a spatial revision of the LANMAP2[6] (European Landscape Map), a model for the identification and assessment of landscapes that can be used to classify them in "character areas", through the integration of two consolidated methods of assessment:

- ENRISK (Environmental Risk Assessment of Agriculture in Europe, a study coordinated by the European Centre for Nature Conservation; Delbaere 2005; UNEP 2004) which interprets the state of landscapes and identifies areas at risk and sensitive areas using the following indicators: openness, closeness, coherence and diversity; the approach aims to interpret the vulnerability of the landscapes, above all on an *ecological* scale, by interpreting land use (with Corine Land Cover types[7]) and by using the Shannon index;
- IRENA (based on the DPSIR model and developed by the European Environment Agency to interpret the impact of Agricultural changes on landscape) which uses *ecological, perceptual and land use* indicators such as: diversity, state of the spatial and linear characteristics of the landscapes and types of cultivations, on the basis of LANDMAP2 data (EEA 2003).

In this context the work finally proposes groups of indicators to study (Fig. 3.1):

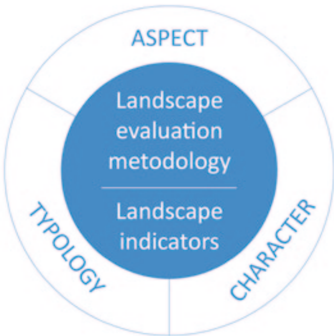


Fig. 3.1 Method developed by ELCAI (Wascher 2005). (Author's layout)

[6] LANDMAP2 is a model for the analysis of developed landscapes at a European scale on the basis of four parameters focusing on the biophysical characteristics of the landscape: climate, topography, physical characteristics and land use.

[7] This is based on the indications of the Pan-European Biological and Landscape Diversity Strategy (CoE, Sofia 1995) and the European Landscape Convention (CoE, Florence 2000).

- landscape diversity;
- landscape coherence (on the basis of the prevalence of a type of land use);
- openness and closeness of landscapes.

The study *Indicatori per il paesaggio* (Vallega 2008), with an analysis of conceptual settings—found in international scientific publications—on the characteristics and role of landscape indicators, makes a functional proposal for the assessment of landscape on a subnational scale according to the following themes associated with the ELC:

- biological quality (biodiversity, species at risk, protected species);
- environmental quality (relevant to air, water and land factors);
- urban quality (historic and public green spaces);
- "tangible" culture (historical-cultural heritage);
- "intangible" culture (panoramic views, places of interest, events,…);
- aesthetic quality (perceptual value of the skyline, of damaged landscapes and landscapes under pressure);
- institutional action (effectiveness of steps taken to protect, plan and manage landscape);
- didactics (efficiency of landscape education, information and training);
- social communication (efficiency of landscape communication; landscape in the media).

ELISA (Wascher 2000) is another important international study which identifies agri-environmental indicators useful for interpreting landscape processes also on a European scale, in response to OECD indications. ELISA identifies the following types of indicators:

- environmental and ecological such as the biophysical adequateness of land use, with the need to define a representative territorial system of reference, on various levels (regional/national/European) of landscape analysis;
- perception—openness or closeness, the scenic value of landscape;
- historical-cultural which refers to the presence of goods and/or elements of a historical-cultural value.

The studies of the Statistical Office of the European Communities on Landscape Indicators are of international interest. These, using the IRENA project and with reference to the CEP, propose a landscape classification on the basis of three levels of indicators:

- Level 1, which includes indicators based on the data pursuant to *land use* (for example land occupied by agriculture, silviculture, in conditions of semi-naturalness, or urbanized);
- Level 2, consists of indicators of *landscape coherence* based on the assessment of the degree of fragmentation and ecological diversity, the importance of the characters such as patterns, lines and points, assessing their evolution in time;
- Level 3, which includes the indicators used to attempt to assess *landscape quality and its perception*, through the legibility, diversity and visual variety of the different landscape elements, the specific importance of the cultural identity which can be traced in elements or single characters of the landscape.

The SPESP study (Nordregio 2000) which assessed the effects and impact of the implementation of ESDP—European Spatial Development Perspective (EC 1999), identified *land use and economic* indicators with reference to policies for the protection and enhancement of cultural landscapes, acknowledged as a factor of European identity and diversity. In particular the study focused on:

- identifying indicators relevant to rural cultural landscapes useful for interpreting the quality of the landscapes, identifying areas requiring policies for the management of tourist flows;
- the construction of a method of data analysis and collection, data obtained mainly on a regional and local scale.

In this context, the following indicators, available on a European scale (first and foremost in the EUROSTAT "Regio Database" and "CORINE Land Cover Database") were identified:

- land use: AP (Agricultural production) which interprets the UAA (Utilised Agricultural Area) percentage;
- economic: Share of farms with a UAA less than 20 ha.

The two indicators provide data on the intensification of production and the concentration of small farms, which can be used to assess rural territories, characterised by non-industrialized production methods and a greater landscape and ecological diversification. Through the integration of the results deriving from AP and UAA with the yearly tourist stays indicator we indirectly obtain indications on the quality of landscapes and their attractiveness.

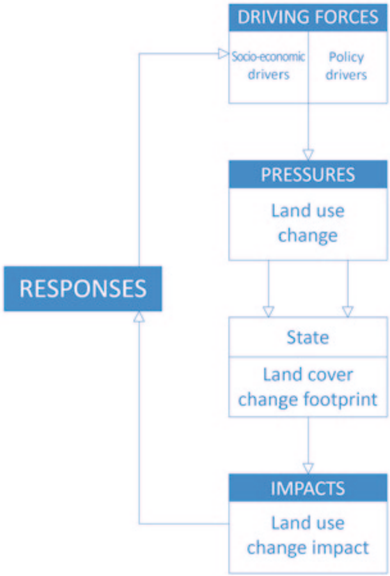
The European Environment Agency (EEA 2001) recently drew up a method for assessing the effects of territorial policies on the environment and landscape, which uses some indicators of performance, useful for putting the pressures and the state of environmental and landscape values in relation (Fig. 3.2); the result is indications for specific regulatory actions on a European (directives and regulations), or national (laws, regulations, restrictions for protection) scale; the method uses:

- *environmental* indicators, useful for interpreting environmental and landscape values with reference to the "past" state;
- indicators of risk, which highlight short-term criticality/sensitivity on a local scale;
- "sector" indicators for assessing the effects of European sector policies with impact on the territory (transportation, agriculture, tourism, etc.);
- indicators of *sustainability*, the expression of an integrated long-term vision of *socio-economic, environmental and landscape* values.

The European PAIS[8] project (Landsis et al. 2002) identified some agri-environmental indicators (Proposal on Agri-Environmental Indicators) useful for interpreting the landscape dimension of rural territories, divided into the following types:

[8] The general aim of the PAIS project is to help identify agro-environmental indicators that can be used by the European Commission for the assessment of policies, as indicated in the documents

Fig. 3.2 Type of indicators proposed by the European Environment Agency with reference to the DPSIR model. (Author's layout)



(a) Landscape features, to interpret the state and changes in the structure of the landscape, in its ecological function, and in current and historic cultural values (Landscape composition, Landscape configuration, Natural landscape features, Historical-cultural landscape features, Present—cultural landscape features (State and Change);
(b) Human perception, which describes the social perception (visual and aesthetic) of the landscapes;
(c) Landscape management, with reference to the action taken to protect cultural values (Cultural landscape protection/conservation) and natural values (Nature conservation/protection).

To provide guidelines for rural policies in the period 2007–2013, the Directorate-General for Agriculture and Rural Development (2006) developed some indicators to assess the effects of Rural development plans on the environment and landscape, in accordance with the new Council Regulation (EC) No 1698/2005 of 20th September 2005 on support for rural development; in fact *the regulation* establishes the need to adopt a strategic approach to rural development, based on goals rather than measures[9], by defining three such goals (Art. 4):

COM(2000)201 and COM(2001)1442. In this context PAIS develops three sets of indicators relevant to: Landscapes, Agricultural policies and Rural development.

[9] In fact it intends to promote a radical simplification of the implementation of policies, through the introduction of a single financing system and by modifying the programming framework, financial management and control for rural development programmes.

- increasing the competitiveness of the agricultural and forestry sector through renovation, development and innovation;
- enhancement of the environment and natural landscape through territorial management;
- improving the quality of life in rural areas and promoting the diversification of economic activities.

With reference to these goals, the following *ecological and land use* indicators have been identified for the assessment of environmental and landscape inclusion: Land cover, Less Favoured Areas, Areas of extensive agriculture, Natura 2000 area, Biodiversity: Protected forest, Development of forest area, Forest ecosystem health, Water quality, Water use, Protective forests concerning primarily soil and water.

The studies of the Finnish MTT (2002) and the Italian APAT (2003) identify sets of indicators that interpret the landscape from a point of view of biodiversity. MTT Agrifood Research Finland and the University of Helsinki (2002), to assess the possible ecological and territorial effects associated with the reform of the Common Agricultural Policy, identifies four indicators of biodiversity relevant to the rural landscape: the quantity of semi-natural pastureland, the number of endangered species, the endangered species in the rural habitat and the butterfly population. These indicators, applied in the study of the Finnish rural territory, make it possible to monitor the state, pressures and the evolution of biodiversity in the rural landscape on a vast (national) scale, to define strategies and draw up guidelines to stem the reduction of biodiversity in the rural territory (Kuussaari et al. 2004).

In Italy the APAT, through the National Nature and Biodiversity Thematic Centre (CTN-NEB)[10], developed a method for collecting the data for *elaborating indicators of biodiversity* (2003). Landscape is considered part of the group of *Nature and Biodiversity (NaB) indicators:* trends and changes; the effects of climate changes on the environment; protected zones, bogs; forests; landscape; ecosustainable agriculture, genetically modified organisms. A report was drawn up for each indicator to describe the main characteristics (thematic area, denomination, description, Institution of reference, sampling unit, timing, instrumentation, aims of the collection, associated indicators, collection network, users, etc.). This method, while it still fails to consider the elaboration of landscape indicators, interprets the landscape "both as a system of ecomosaics and as a perceptive and identity ambit".

[10] The National Nature and Biodiversity Thematic Centre (CTN-NEB) is one of the thematic centres set up as part of the Environmental Information and Control System (SINAnet), on the basis of indications from the APAT with the contribution of the Regional environmental agencies, the regional authorities and the authorities of the autonomous provinces. The CTN was established on the legacy of the previous National Nature Conservation Thematic Centre (CTN-CON) updating the information gathered by the same and developing the knowledge.

3.3 The Indicators Categories Proposed by the Study

As can be seen in the previous paragraphs, each landscape assessment model selects some aspects, components and profiles of interpretation. In general, there are three core themes: nature, culture, and perception.

In short, which aspects of the landscape must or can be assessed, and with which indicators? On the one hand, our proposal derives from theoretical acquisitions on the nature of the landscape, while on the other it derives from the need to provide a response to the European and national legislative and administrative framework.

The first reference is the European Landscape Convention and the subsequent Recommendation CM/Rec (2008)3 of the Committee of Ministers on its application, which establishes the following principle:

> B. Recognize the fundamental role of knowledge. The identification, description and assessment of landscapes constitute the preliminary phase of any landscape policy. This involves an analysis of morphological, archaeological, historical, cultural and natural characteristics and their interrelations, as well as an analysis of changes. The perception of landscape by the public should be analysed from the viewpoint of both its historical development and its recent significance (Part I.1).

Further indications in Part II.2.1 *Knowledge of the landscapes: identification, analysis, assessment*:

> Action should be taken to: - promote integration of the different knowledge-production approaches to observation of the territory (economic, social, environmental, historic/cultural, perceptual/visual, etc.) (…).

In Italy, which is our case study, the Cultural Heritage and Landscape Code of 2004 (Italian Republic 2004) (modified in 2006 and 2008) indicates the aspects which must be considered to declare a landscape of "notable public interest" (a procedure necessary for the application of national protection): "The proposal is motivated with reference to historical, cultural, natural, morphological and aesthetic values expressed by the distinctive aspects and characters of the buildings or areas considered and by their identity value and quality in relation to the area they are in, which are perceived as such by the populations" (Art. 138).

On the basis of these indications and the international review on the subject, in the following chapters we intend to consider and analyse the landscape indicators on the basis of these profiles of interpretation:

- landscape ecology;
- historical-cultural heritage;
- visual and social perception;
- land use;
- territorial economy.

These aspects include the three main core themes, nature, culture and perception, with the most dynamic aspects (useful for the purpose of monitoring). Indicators have already been developed for some of these categories, while others represent a new research frontier, in particular inspired by the European Landscape Convention (as is the case for social perception and the economic value of the landscape).

In particular, as for the natural aspects, we feel it is of little use to include morphological aspects, which are most certainly instrumental in the characterisation of a landscape but with a lower probability for change, and specifically naturalistic aspects, more pertinent to other types of environmental assessment, while the ecology of the landscape offers a common interpretative paradigm at an international level.

Historical-cultural heritage is understood first and foremost as material manifestations, evidence of the history, and characterizing the identity of a landscape, and secondly as an intangible dimension concerning the aspects of acknowledgement, conservation, and use of resources.

The perception of landscape also concerns two aspects. The first is the scenic-perceptual aspect (in particular visual), associated with aesthetic appreciation but with reference to the material structure of the landscape (for example the relation between morphology and visibility). The second, the intangible dimension, is represented by the type of value society attributes to landscape, with many different values for different social groups. This attribution of value is associated with the social justification of public policies, and is therefore quite relevant.

The study of this last aspect intersects methods of economic analysis: the estimated value that can be attributed to the landscape, in monetary terms (a field of research that have been developed with the specific aim of including the landscape in the economic evaluation of natural resources and environmental goods). Therefore, the economy of the territory in this work includes two aspects: on the one hand the economic value of the landscape, and on the other the contribution of the landscape to the economic system, for example through tourism, or the externality in real estate values, et cetera. The study of the economic aspects is therefore useful both to establish social appreciation and to consolidate political action for landscape, emphasizing the benefits for populations.

Furthermore, the use of the territory includes a series of phenomena associated with land use, which in many cases constitute decisive elements or put pressure on the landscape (for example, soil sealing or certain categories of use, predictive of landscape quality or criticality). The aspects of landscape planning, such as protection or actions of enhancement are considered, which, on the one hand affect the landscape, and on the other can be taken as indicators of social sensitivity or be subject to monitoring.

In the following chapters the indicators relevant to each of these profiles of interpretation will be considered in depth by specialists in the various disciplines, while in the last chapter we will deal with the problem of considering the different aspects in relation to each other (Fig. 3.3).

Each chapter is structured in the following way:

- principles and definitions, presentation of the concepts, traditional studies and approaches, and thematic organization;
- review of published indicators, full list;
- Critical selection and proposal: list of published indicators selected, some of which have been re-elaborated, and new proposals;
- Description of the proposed indicators;
- Boxes illustrating applicative cases.

Fig. 3.3 Categories of indicators proposed by the study. (Author's elaboration)

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Chapter 4
Landscape Assessment: The Ecological Profile

Francesca Finotto

Abstract In recent decades, Landscape Ecology has consolidated a broad set of indicators to analyse and quantify the significant correlations between the morphological structure of a landscape mosaic and its ecosystem functions. These correlations define the principles of landscape organization on different scales space-time. This contribution proposes a review of some of these indicators, identifying those that the empirical evidence proved to be most effective in an ecologically oriented planning. The review concludes with the selection of two indexes, that for the high information content and for the wealth of experiments conducted on a national and international level, are particularly significant: *Evenness* and *Biological territorial capacity* (Btc). The technical requirements and the reliability at different scales of these indexes are detailed, with particular regard to the Piemonte territory.

Keywords Diversity • Connectivity • Patch • Richness • Scale

4.1 Principles and Definitions

When considering Landscape ecology indicators and indexes, first and foremost we must take a look at the theories and principles these instruments are based on, which condition the method of application and the interpretation of results.

Landscape ecology defines a landscape as a system of ecologically different interrelated spatial units, in other words as a system of ecosystems, or meta-ecosystem (Forman and Godron 1986; Ingegnoli 1993). This is characterised by many space-time scale hierarchical domains and represents a specific level of biological organisation, immediately above the ecosystem.

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This definition embodies the entire innovative character of the discipline: it reveals the fundamental principles that govern the field of action, and the notable theoretical and applicative implications.

Firstly, the definition of landscape as a system means we must adopt a paradigm of analysis in which both the relations between the elements of the system, and its principles of organisation can emerge. From their interaction, in fact, we can obtain the global properties of the system, different to those of the single elements (principle of emergent properties). A landscape, and its environmental system, is always more complex than the sum of its parts, and each part has different characteristics on the basis of how it interacts with its surroundings.

This, in operative terms, means we have to emphasize the reciprocal correlations between the *structure* and *functions* of the environmental systems which, as intrinsic aspects of the same phenomenon, define the configuration of a landscape on the basis of various space-time scales (O'Neill et al. 1986, 1989; Turner 1990).

Secondly, when defining landscape as a biological system we must implicitly refer to a hierarchical organisation model, where the interactions between components of the lower level are controlled by slower interactions at higher levels.

Landscape ecology emphasizes the influence of scale on ecological phenomena (Turner et al. 1989), an influence with significant implications also on the application of control indexes, as we shall see.

In operative terms, using a hierarchical type organisation means acknowledging that the properties of a landscape mosaic can only be comprehended in a more all-encompassing context. While the ecology of ecosystems was based on the *vertical* study of homogeneous and all but autonomous spatial units, Landscape ecology on the other hand leans towards a *chorological* study, which analyses the horizontal relations between separate and non-homogeneous spatial units. The heterogeneity of the environment is no longer merely background noise of secondary importance (Blondel 1986).

Finally, it must be said that Landscape ecology has made it possible to go beyond the man/environment opposition which traditionally characterizes most biological and natural disciplines, creating a new integration between natural and human domains. Landscape is, in fact, an expression of both natural and anthropic dynamism, the expression of a continuous superimposition and interpenetration of the two domains (Ingegnoli 1993).

Therefore, anthropic ecosystems, their disturbances and their influence on the environment, are an integral part of landscape and subject to more intense study in order to harmonize human requirements with those of nature and the environment.

4.2 Landscape Ecology Indicators

The notable progress in the theoretical Landscape ecology models, and the numerous experiments in the field, have established and consolidated several types of different indicators which we can divide, from a merely instrumental point of view, into two main macrocategories:

- structural control or pattern indexes;
- functional control or process indexes.

This group of indexes is measured on the basis of the different kinds of land use in the territory in question. The above information is integrated, using methods that vary for each single index, with data on the morphological structure of the different patches in the landscape mosaic (surfaces, perimeters, longitudinal and transversal axes, …) and with data on their reciprocal relations (distances between neighbouring patches, distances between patches of the same type, …).

Therefore the characteristics of the geographical context define the matrix with which the ecological processes are analysed and compared. Landscape ecology operates within this context, defining the meeting point of ecosystemic functions and chorological patterns (Farina 2001).

This structure derives from the theoretical and cultural paradigms that have contributed to establishing the discipline. The first experimentations in Landscape ecology were done in Central-Northern Europe (Germany, Holland, Denmark) and in Eastern Europe (Czechoslovakia, Poland, the Baltic countries), and while establishing the common ground for epistemological theories, models and approaches, they were in fact related to human landscapes (natural landscapes long since modified by anthropic activities) and were solidly based on both geographical and geomorphological disciplines.

In the 1980s, the main movers of the European school took their ideas overseas with the resulting development in American ecological schools, where large-scale ecosystems, found only in this continent, became the main focus of attention. This new approach concentrated in particular on the problems associated with the correct management of vast natural areas and their relations with neighbouring agro-ecosystems, where the complexity of the places is almost always synonymous of diversity and richness.

The influence of the European approach (focused on the human component of landscape mosaics and its geographical dimension) and the American approach (more focused on the complexity of large natural and seminatural areas) and vice versa, consolidated and enriched the Landscape ecology disciplinary body, favouring also the creation of useful operative tools, including a rich set of indicators and indexes.

The widespread diffusion of these indexes made it necessary to review them, selecting the more reliable, and this review referred not only to the various and diversified applications, sometimes uncontrolled and incorrect, but also to the authors who first proposed the experimentation for ecological planning (Tables 4.1 and 4.2). Furthermore, an attempt was made to emphasize the theoretical references that consolidated content and applicative methods.

4.2.1 Structural Control Indexes

Structural control indexes measure in quantitative terms some salient characteristics of the structure of an ecomosaic or, in some cases, of its organisational cell:

Table 4.1 List of indicators

		Indicator	DPSIR	Source
Structural indexes		*Spatial indexes*		
	1.	*Elongation index* Measures the elongation of a patch considered as a suitable topological condition for favouring the exchange of organisms, biological energy and matter in a landscape mosaic	S	Davis 1986; Forman 1995
	2.	*Circularity ratio* Measures the distance of a patch shape from the isodiametric, evaluating the greater or lesser articulation of its surfaces and therefore the greater or lesser tendency to exchange organisms, biological energy and matter with the surrounding context, through more or less defined edges	S	Stoddart 1965; Unwin 1981; Forman 1995
	3.	*Shape factor* Measures the distance of a patch shape from the isodiametric, assessing the greater or lesser articulation of its surfaces and therefore the greater or lesser tendency to exchange organisms, biological energy and matter with the surrounding context, through more or less defined edges	S	Davis 1986; Forman 1995
	4.	*Grain index* Measures patches size in a landscape mosaic in relation to the density of the same	S	Forman 1995
	5.	*Isolation of patches* Considering a landscape mosaic represented on a cartesian plane of coordinates x and y, this index measures the isolation level of the patches in the same as a sum of the patches variation in relation to axes x and y of said plane	S	Lowe and Moryadas 1975; Forman and Godron 1986; Forman 1995
	6.	*Dispersion of patches* Measures the dispersion level of the single landscape element types in a particular environmental system, differentiating between compact groups and discrete distributions of elements of the same type with no connection between each other	S	Pielou 1977; Forman and Godron 1986; O'Neill et al. 1988
		Numeric indexes		
	7.	*Relative richness* Measures the richness of a landscape mosaic as a percentage based on a ratio of the number of patch types measured and the maximum possible	S	Romme 1982; Turner 1989; Forman 1995
	8.	*Margalef richness* Measures the richness of a landscape mosaic relating the number of landscape element types to the logarithm of the overall number of patches	S	Margalef 1958; Farina 2001, 2004

Table 4.1 (continued)

		Indicator	DPSIR	Source
Structural indexes (*cont.*)		*Numeric indexes* (*cont.*)		
	9.	*Menhinick richness* Measures the richness of a landscape mosaic relating the number of landscape element types to the square root of the overall number of patches	S	Menhinick 1964; Rossaro 1998
	10.	*McIntosh diversity* Measures the ratio between the different element types of a landscape, assessing the position of the same in a space of n-dimensions, where n is the number of landscape element types. The position of any kind of element is determined by its entity and it is measured as the distance from the origin along its axis. The distance average is equal to the diversity of the landscape pattern analysed	S	McIntosh 1967
	11.	*Hill diversity* Measures the dominance of a precise number of landscape element types in a landscape mosaic. The index varies from 0 to the total number of types considered	S	Hill 1973; Farina 2004
	12.	*Shannon diversity* Measures the diversity of a landscape mosaic on the basis of both the number of patch types present, and their relative abundance in the mosaic	S	O'Neill et al. 1988; Turner 1989; Forman 1995
	13.	*Evenness* (Pielou) Assesses the ecological diversity, in other words the richness of the landscape element types (biotopes) that characterise a landscape mosaic. Ratio between the real diversity of a landscape mosaic obtained with the Shannon formula (H) and the maximum possible (H_{max})	S	Pielou 1977; Romme 1982; Turner 1989; Forman 1995
	14.	*Simpson dominance* Measures the prevalence of a few patch types in an environmental system, based on the application of the Simpson formula (1949)	S	Simpson 1949; Farina 2001, 2004
	15.	*O'Neill and Turner dominance* Measures the prevalence of a few patch types in an environmental system, based on the application of the Shannon formula (1949)	S	O'Neill et al. 1988; Turner 1989; Forman 1995
	16.	*Contagion index* Assesses both the composition, and the configuration of a landscape mosaic, measuring the level of aggregation of each single patch category	S	O'Neill et al. 1988; Turner 1989; Li and Reynolds 1993; Forman 1995
Functional Indexes	17.	*Gamma index of network connectivity* Indicates the connection level of a landscape system represented schematically in a planar graph, consisting of nodes and connections along which the flows of organisms, matter and energy move. It is measured by comparing the number of existing connections with the maximum number of possible connections	S	Forman and Godron 1986

Table 4.1 (continued)

		Indicator	DPSIR	Source
Functional Indexes (*cont.*)	18.	*Alpha index of network circuitry* Indicates the efficiency level of the connections in a landscape system represented schematically in a planar graph. It is measured by comparing the number of existing independent circuits to the maximum possible	S	Forman and Godron 1986
	19.	*Percolation index* Analyses the possibility of movement of a species or of an organism in a territory, through the application of percolation theory. In general, it describes the connection level of an environmental system	S	Gardner et al. 1987a, b, 1989; Turner and Gardner 1990; Farina 1993
	20.	*Biological Territorial Capacity* (Btc) Magnitude of the metabolism of the ecosystems in a territory and of its homeostatic and homeoretic capacity (for self/re-equilibrium), which measures the equilibrium level of an environmental system. It is defined by the sum of the products of surfaces with land use types, and the relevant unit biological territorial capacity value, and by the subsequent weighed average of this sum in relation to the total surfaces being studied	S	Ingegnoli 1980, 1993, 1997, 2002; Ingegnoli and Giglio 2005

Table 4.2 Formulas for the application of indicators

Elongation	
$E = \frac{\omega}{l}$	w = width of patch perpendicular to long axis l = length of the longest axis of a patch
Circularity ratio	
$C = \frac{A}{A_c}$	A = area of patch A_c = area of smallest circle enclosing a patch
Shape factor	
$SF = \frac{p_c}{p}$	p_c = perimeter of circle having same area as patch p = perimeter of patch
Grain index	
$G = \frac{A}{n}$	A = area of the landscape mosaic n = number of patches in the landscape mosaic
Isolation of patches	
$D = \sum (\sigma_x^2 + \sigma_y^2)$	σ_x^2 = variance on the x-axis of the patches in a landscape mosaic, represented as a graph on the cartesian plane of coordinates x and y σ_y^2 = variance on the y-axis of the patches in a landscape mosaic, represented as a graph on the cartesian plane of coordinates x and y
Dispersion of patches	
$R_c = 2d_c \left(\frac{\lambda}{\pi}\right)$	d_c = average distance from a patch (its centre or centroid) to its nearest neighbouring patch λ = average density of patches
Relative richness	
$R = \frac{s}{s_{\max}} \times 100$	s = number of landscape element types $s_{\max}$ = maximum possible number of landscape element types
Margalef richness	
$R = \frac{s}{\ln(n)}$	s = number of landscape element types n = total number of landscape elements
Menhinick richness	
$R = \frac{s}{\sqrt{n}}$	s = number of landscape element types n = total number of landscape elements
Shannon diversity	
$H = -\sum_{K=1}^{s} (p_k) \ln (p_k)$	p_k = percentage presence of a K type element in the ecomosaic (percentage in terms of surfaces) s = number of landscape element types
Evenness (Pielou)	
$E = \frac{H}{H_{\max}} = \frac{H}{\ln(s)}$	H = Shannon diversity $H_{\max}$ = ln (s) = maximum possible diversity s = number of landscape element types
Simpson dominance	
$D = \sum_{i=1}^{s} \left(\frac{n_i}{N}\right)^2$	n_i = number of landscape elements in the i-esima category N = total number of landscape elements s = number of landscape element types
O'Neill and Turner dominance	
$D = H_{\max} + \sum_{K=1}^{s} (p_k) \ln (p_k)$	$H_{\max}$ = ln (s) = maximum possible diversity p_k = percentage presence of a K type element in the ecomosaic s = number of landscape element types

Table 4.2 (continued)

Contagion	
$C = 2s \log s + \sum_{i=1}^{s} \sum_{j=1}^{s} q_{i,j} \log q_{i,j}$	s = number of landscape element types $q_{i,j}$ = probability of landscape element i being adjacent to landscape element j
Gamma index of network connectivity	
$\gamma = \frac{L}{L_{\max}} = \frac{L}{3\,(V-2)}$	L = number of connections in a planar graph V = number of nodes in a planar graph L_{max} = maximum possible number of connections in a planar graph
Alpha index of network circuitry	
$\alpha = \frac{(L-V+1)}{C_{\max}} = \frac{(L-V+1)}{(2V-5)}$	L = number of connections in a planar graph V = number of nodes in a planar graph $C_{\max}$ = maximum possible number of circuits in a planar graph
Biological Territorial Capacity – (Btc) [Mcal/m²/year]	
$Btc_i = \frac{1}{2}(a_i + b_i) \times R$	$a_i = (R/PG)_i/(R/PG)_{\max}$ $b_i = (ds/S)_{\min}/(ds/S)_i$ R = respiration PG = gross primary production ds/S = R/B = structure maintenance ratio B = biomass i = principal ecosystems of the biosphere

the landscape patch (Forman and Godron 1981). As the morphological structure of a certain landscape influences the ecological function, conditioning the relations between the single components of the system, obviously the analysis of the same discloses and supports the assessment of the ecological processes in act.

To get a better idea of the peculiarities and purposes, it may be useful to make a further distinction between spatial indexes and numeric indexes. Spatial indexes describe the characteristics of the components of a landscape mosaic on the basis of both a topological approach (shape and size), and a chorological approach (position of a component in relation to other components or of a different type). Numeric indexes, which derive from the Ecology of ecosystems, are mathematical expressions that can be used to measure the information implicit in the complexity of a landscape mosaic.

4.2.1.1 Spatial Indexes

Spatial indexes include both indexes that focus on a single patch, and indexes that assess the structural characteristics of a mosaic of patches as a whole.

Of the former, Forman (1995) indicates the *elongation index* (Davis 1986), the *circularity ratio* (Stoddart 1965; Unwin 1981) and the *shape factor* (Davis 1986), which measure the distance of the shape of a patch from the isodiametric, using different criteria. In other words, these indexes assess the greater or lesser articulation of the surfaces considered and therefore the greater or lesser disposition to exchange organisms, biological energy and matter with the surrounding context, through more or less developed edges. The *shape factor* in particular is built so the range of its values is always between 0 and 1. Values near 0 indicate a high convolution of the margins; values near 1 indicate an increasing compactness of the area in question.

Of the indexes that assess the characters of a complex system of patches, the same author (1995) indicates the *grain index*, the *isolation of patches* (Lowe and Moryadas 1975; Forman and Godron 1986) and the *dispersion of patches* (Pielou 1977; Forman and Godron 1986; O'Neill et al. 1988).

The *grain index* measures the size of the patches in a landscape mosaic in relation to their density, and can therefore be used to size new patches correctly.

The *isolation of patches* measures the reciprocal position of the patches in a landscape pattern, therefore their degree of isolation, or vice versa clustering, in an ecologically non-neutral matrix, which is resistant to the movement of species. Considering a landscape mosaic represented on a cartesian plane by coordinates x and y, the degree of isolation of patches is determined by the sum of the patch variance in relation to axes x and y of said plane.

The *dispersion of patches* establishes the degree of dispersion of the single landscape element types in the environment, differentiating between compact groups (for example a compact portion of woodland) and discrete distributions of unrelated elements of the same type (groups of trees). This index measures the relationship between the number of interruptions in landscape elements of the same or type, or functionally homogeneous, and the overall surfaces of the same elements. For want of an internal connection between natural and seminatural patches, it can represent a good stepping stone indicator.

4.2.1.2 Numeric Indexes

There is a rich set of indexes to use in the Ecology of ecosystems and communities which, by sampling the presence of animal or vegetable species, measure the degree of heterogeneity in a biological community. Landscape ecology, instead of sampling species, samples landscape element types (ecotopes, biotopes, patches, …), making some of these indexes ideal for measuring the heterogeneity and complexity in an environmental system of a particular landscape (Bernini and Padoa-Schioppa 2002).

Some of the most commonly used and consolidated indexes include richness, diversity, dominance and evenness, applied at an ecomosaic level.

Romme (1982) and Turner (1989) were the first to measure the heterogeneity of a landscape mosaic using the *relative richness index*, which calculates the percentage ratio between the number of patch types (habitats) in a landscape system, and the maximum possible.

The *Margalef index* (Margalef 1958; Farina 2001) and the *Menhinick index* (Menhinick 1964; Rossaro 1998) are two more sophisticated variations of the relative richness index. These indexes compare the number of element types with the effective number of patches in a landscape mosaic, in consideration of the fact that the first term increases as the area in question increases.

The richness of a landscape mosaic, as can be imagined, is significantly influenced by the dimensions of the sample analysed. Therefore, we must use corrective factors to increase the margin of variation in the results induced by the weight of the dimensional factor.

For this purpose, the number of element types in the landscape is compared to the logarithm of the overall number of patches in the landscape mosaic in the Margalef richness index, and to the square root in the Menhinick index.

Diversity is a complex figure. It is influenced by the dimensions of the sample in question, and therefore by the number of landscape element types, as well as by their quantitative distribution. Therefore, results are more reliable and exhaustive when measuring diversity using indexes of ecosystemic diversity which consider, not only the richness of the element types in the landscape mosaic, but also the quantitative distribution (the relative weight) of the single types in the mosaic. In other words these indexes, along with the number of types present, also consider their relative abundance, without indicating a value for the single types. Each single element is only considered in relation to its presence and abundance.

A complete review of diversity indexes can be found in the Environmental Impact Assessment Manual published by the Association of Environmental Analysts (Colombo and Malcevschi 1999; Malcevschi and Poli 2008) in the "Indicators of terrestrial ecosystems". These include the *McIntosh index* (1967), the *Hill index* (1973) and the *Shannon index* (1949).

Shannon diversity is based on information theory (Shannon and Weaver 1949) and was first applied to Landscape ecology by O'Neill et al. (1988) and Turner (1989).

The Shannon formula measures the mean degree of uncertainty in the prediction that an object, chosen at random from a group, will belong to a certain category. This uncertainty increases with the number of categories and the equal distribution of the same. Applying this type of calculation to Landscape ecology means that the greater the value of the index—adimensional index which varies from 0 and infinite—the greater the landscape diversity.

Furthermore, in terms of diversity, note that a conspicuous number of landscape element types is a necessary condition, but insufficient on its own to guarantee a high level of ecological diversity in a certain geographical context. For this to be the case, these types must all tend to be equally represented. Diversity depends not only on the overall number of landscape element types, but also on their reciprocal balance ratio.

In operative terms it can be very useful to compare the real diversity of a landscape mosaic with the maximum possible, which represents the equitability or equal distribution, seen as the possibility that the different elements of the landscape are found in the same quantity.

Evenness or *equitability* (Pielou 1975, 1977)—equal to the ratio between the value of the real diversity and the maximum possible (H_{max})—measures the distribution of the relative abundances of landscape element types in a landscape mosaic. If this ratio tends towards 1 then the real diversity tends to coincide with the maximum possible, and the ecomosaic being examined will be characterised by many elements of a similar relative weight. On the other hand, when this ratio tends towards 0, the landscape mosaic will be dominated by one single, widespread and interlinked element, which acts as a matrix. In other words, comparing H and H_{max} lets we calculate how far the real value of ecological diversity departs from the maximum possible value which represents the optimal situation in terms of ecological functionality.

Shannon diversity and evenness, as mentioned in Sect. 2.2 are included in a group of indicators proposed in recent European documents for landscape assessment and monitoring.

The EnRisk project (*Environmental Risk Assessment for European Agriculture*) of the European Centre for Nature Conservation (Delbaere 2003), with the aim of identifying indicators to monitor European agro-environmental policies and the landscape dimension of rural territories, includes these indexes in the tools suitable to establish the status and vulnerability of European landscapes, in relation to processes of transformation dictated by the use of farmland (identification of sensitive zones with environmental risks). With similar aims, the PAIS project (*Proposal on Agri-Environmental Indicators*) (Landsis et al. 2002) indicates Shannon diversity as one of the indicators on "formal landscape features", and lists it with the "landscape configuration" indexes, used to assess the properties in the structural pattern of a landscape (*structural arrangement of landscape elements*).

The ELCAI project (*European Landscape Character Assessment Initiative*) (Wascher 2005), part of the 5th Framework Programme for the Environment, with the aim of selecting suitable indicators for highlighting the distinctive character of a landscape (*Landscape Character Assessment*), proposes Shannon diversity as the ideal instrument for estimating both landscape diversity (*Spatial structure landscape*), and habitat diversity (*Biodiversity*).

Dominance indexes have an opposite trend to evenness and measure the prevalence of a few elements in an environmental system. A high value in these indexes means that in the territory in question, a few landscape types have a monopoly on resources.

Several authors have proposed the *Simpson index* (1949) to calculate dominance, the first index used for this purpose in the Ecology of ecosystems. The value obtained with the Simpson formula, which varies from 0 to 1, measures the probability that two objects chosen at random in a group, belong to the same category. If a category is abundant, the probability that this condition occurs is high, and therefore the global diversity of the system will be quite low.

O'Neill et al. (1988) and Turner (1989) however, calculate dominance as the difference between the maximum possible diversity (H_{max}) and Shannon diversity. The higher the difference between the two terms, the greater the dominance, in this case seen as the complementary of diversity.

Of the indicators derived from the Ecology of ecosystems, the *contagion index* (O'Neill et al. 1988; Turner 1989, revised by Li and Reynolds 1993; Hunsaker et al. 1994; Riitters et al. 1996) is widely used, simultaneously indicating the composition and the configuration of a landscape mosaic, measuring the level of aggregation of each single patch category.

When the contagion value is low, all the patches are equally adjacent to each other, and the landscape system will consist of many small patches; vice versa, if the value is high, we will have the maximum possible aggregation of patches and the system will be characterized by a few large patches.

Forman (1995) includes this index, along with dispersion of patches and isolation of patches, in the tools used to measure the overall pattern of the landscape mosaic (*All-patch pattern measures*), differentiating it from indexes focused on the assessment of single patches (*Patch-centred measures*) such as isolation of patch or accessibility of a patch. Farina, in a similar way, classifies the index in "indexes of spatial organisation", in other words indexes that measure the relationship between the single patches of an ecomosaic on the basis of their reciprocal position.

4.2.2 Functional Control Indexes

Functional control indexes assess the resistance of the fundamental processes that the stability of the landscape environmental system is based on, analysing the functional relations between its components. These indexes also measure the interference of anthropic disturbance for these processes, establishing the ranges within the variables, the processes are based on, can oscillate without causing breakage or degeneration.

The most widely used functional control indexes (process indexes) both in planning and environmental assessment, are the gamma index of network connectivity, the alpha index of network circuitry, the percolation index and the biological territorial capacity.

The stability of an environmental system—in other words its capacity to maintain a constant structure and function—depends on the efficiency of the flows of organisms, biological energy and matter which, by traversing the landscape help to conserve it intact (Forman and Godron 1986), and therefore the stability of an environmental system also depends on the availability of functional paths for said flows. These paths, in our current landscape situation, are becoming more and more compromised and reduced by the progressive fragmentation and insularization of the territory, in particular due to the indiscriminate and often auto-referential growth of anthropic settlements.

Therefore, in order to calculate the ecological function of an environmental system, we must identify the connections between the single components of the landscape structure, along which organisms, matter and energy flow, and the barriers that obstruct and interrupt these flows.

Gamma index of network connectivity and alpha index of network circuitry (Forman and Godron 1986) meet these requirements. Based on graph theory, these have been widely used for some time, both in the study of Landscape ecology, and in the specific study of ecological networks.

Their use involves the construction of a planar graph that indicates the connections between the different patches of the landscape mosaic analysed, and the connections to re-establish or reconstruct. Therefore, the application of these graphs implies simplification of landscape elements into nodes and superimposed connections for areas without connective functions.

The *gamma index* shows the level of connection between the nodes of a graph and provides an indication of the number of existing connections in relation to the maximum possible number of connections. The *alpha index* measures the level of efficiency and is expressed by the relationship between the number of independent circuits in a graph and the maximum possible. Globally, these indexes define the level of complexity of a network.

The *percolation index* (Gardner et al. 1987a, b, 1989; Turner and Gardner 1990; Farina 1993) has similar aims to gamma and alpha indexes and lets us analyse and quantify the possibility of movement of a species or of an organism in the territory, and in general describes its level of connection.

In physics, the percolation theory (Stauffer 1985) studies the dynamics of fluids in an aggregated medium; in Landscape ecology this doctrine is used as a theoretical base for creating neutral models to describe and explain different patterns which can be observed, on different scales, in an environmental mosaic, and to provide approximate forecasts of its suitability to support focal species.

Considering a matrix m×m, the probability that a fluid, and in the same way a species, expands and crosses the entire matrix is established by the critical probability (*cp*), calculated experimentally, as equal to 0.59275.

If the cells of the matrix, which in a landscape mosaic coincide with patches suitable for supporting the movement of a particular species, reach the critical threshold[1], in other words a coverage of 59%, we have percolation. It is highly probable that the species in question can transit throughout the entire mosaic, occupying the majority of the cells. The landscape mosaic, in relation to the requirements of said species, is linked.

Near the critical value (*cp*), the behaviour of the system is very unpredictable, and even the smallest change in the abundance of a certain object, whether land use or vegetation, can result in significant modifications in system organisation and also in the behaviour of the species that inhabit it.

Biological territorial capacity (Btc) (Ingegnoli 1980, 1993, 1997, 2002; Ingegnoli and Giglio 2005) is a status function that measures the latent auto-equilibrium capacity of a landscape system.

Landscape, being a living system, is a complex adaptable structure, in continuous evolution, characterised by a dynamic metastable equilibrium, in other words by a specific condition of precarious stationariness, liable to evolve into a more organised status, or vice versa deteriorate.

The levels of landscape system organisation and order depend on its capacity to incorporate disturbances (events that produce significant modifications in the structure and function of the system) and always represent the point of equilibrium between the forces that encourage change and those that oppose it.

Within a range of ordinary disturbances a landscape mosaic, using and optimising the energy flows that cross the same, fluctuates with subtle variations, remaining within its own field of metastability. If the disturbance exceeds the limit of this range, the system recalibrates its functions to meet the new conditions. This means reach-

[1] The threshold value *pc* is a theoretical value which must be increased or decreased in relation to the species in question. Each species, in fact, has a specific perception of the contiguity of a specific environment.

ing a threshold of metastability, beyond which the landscape type in question will change, and tends to be replaced by a new one. If the metamorphosis is incompatible with a landscape on a greater scale, or it is unable to incorporate the local regime of disturbance, the entire system will deteriorate and reclamation will be necessary.

Large-scale transformations are usually hard to measure, and in many cases it is impossible to assess, a priori, what effect the changes will have on the ecological stability of the landscape system.

With this in mind, it can be useful to measure the metastability of the system analysed, in other words the tendency to maintain the functional processes and its own structure constant, while modifying, due to the disturbances, its point of equilibrium (homeoretic type mechanisms), or vice versa its tendency to recover its original functional level (homeostatic mechanisms) after a disturbance.

Biological territorial capacity (Btc) was established to provide a synthetic parameter to assess the metastability threshold of a landscape system: to assess, in the case of environmental stress, the limit beyond which it is impossible for the ecosystems to maintain the conditions necessary for survival. This index estimates[2] the energy flow that a landscape system must reintegrate to maintain its level of order and metastability, and it is a magnitude related to the degree of organisation of the same system and to the metabolic capacity of its main ecosystems. The Btc of a landscape system is therefore closely related to the presence of vegetable biomass and its capacity to assimilate and transform solar energy[3].

Btc associates high values with ecosystems that have a high resistance to disturbances, but a slow capacity for recovery (high metastability), and low values with ecosystems that have scarce resistance to disturbances, but a fast capacity for recovery (low metastability).

4.2.3 Scale of Application: Characteristic

The indexes considered in the previous paragraph can, in general, be applied on a large, medium or small scale, and produce reliable results at various scale resolutions[4].

It must be said however that the biological spectrum, of which landscape is a specific organisational level, is characterised by an evident principle of integration, corollary of the more important principle of emergent properties (Lorenz 1980; Kirk 1980). On the basis of this principle, the properties that characterise a certain level of biological organisation are essential in order to comprehend processes at higher

[2] Btc represents a magnitude which can be precisely measured but, as the result requires considerable expenditure in terms of time and instrumentation, an estimate is often more practical.

[3] The processes that enable a landscape to self-perpetuate, in other words to renew its fundamental components, are closely associated with the presence of vegetation, an element which plays a crucial role in the ecological functionality of the landscape system. In reality, the useful energy for the entire biosphere depends on photosynthesis and is subject to the action of autotrophic organisms.

[4] The information content of the index/indicator depends on the detail of the base data used for the calculation. The vaster the area in question, the more probable it becomes that the information acquired with the indicator will be of a general nature, as it is harder to obtain uniform in-depth data.

levels, but never enough to explain them in exhaustive terms. This means that no landscape mosaic can be fully studied at one single scale or organisational level.

Therefore, the correct use of ecological control indexes dictates that these instruments are applied at least to three different levels of analysis—interest level, higher level and lower level—which define the same number of spatial scales.

The interest level, which reflects the level of organisation of the landscape system analysed, defines the most suitable spatial size for the analysis, which will produce the most information with the greatest efficiency, in other words with the lowest margin of error. The higher level lets us comprehend the actual role of the mosaic in question in a vaster territorial structure, providing information on the limits to which it is subject. The lower scale level explains the processes that develop as emergent properties at the level of interest, and at the same time lets us highlight phenomena that can be hidden at a higher level by compensatory processes, using more detailed and disaggregated information.

On a timescale, the more complete and correct applications adopt a process type approach, applying these indexes to several historical frames, to show evolutive dynamics, and clarify and verify possible scenarios of intervention.

4.3 Proposal for Landscape Ecology Indicators

Of the above indicators, the indexes of evenness and biological territorial capacity (Btc), for the information content, the wide range of experiments and the reliable and standardized methods of application, are particularly significant (Tables 4.3 and 4.4).

Evenness—calculated with the Shannon formula—is currently the most suitable instrument for measuring the ecological diversity of a territory, in other words the variety of the patterns that distinguish an ecomosaic and control its evolution. This is extremely useful, as ecological diversity is essential for the existence of specific and intraspecific or genetic diversity and, in a hierarchically organised system like landscape, it represents the super-ordinate level. Each habitat in fact, with its own physical-chemical conditions, supports a particular variety of life forms, and the range of species in each area depends on the size, shape, variety and dynamics of said habitat.

With the greater differentiation of the natural and seminatural elements in a territory, statistically, there will also be a greater variety of species inhabiting said territory. In other words, diversified environmental characteristics will correspond to a high number of biotopes, and therefore a high number of species will find the ideal conditions for development (ecological niches)[5].

[5] The richness of different species in the community determines an increase in the number of rings in the food chain, greater probable biocenosis stability, a more efficient energy flow and matter cycle, corresponding to, in short, higher stability of the structure and in the function of the ecosystems. Furthermore, the control of any disturbances which could arise in a territory is closely related to ecological diversity. A disturbance of a certain size in a landscape with a low index of diversity, with just a few elements or just one, can cause changes of such a magnitude they cause the landscape to collapse. The same disturbance in a landscape with a high index of diversity, may be irrelevant. In fact, not all its elements react in the same way to the same disturbance, so the risk

Table 4.3 Evenness

Indicator	Evenness (E)
Definition	Assesses ecological diversity, as the richness of the landscape element types (biotopes) that characterise a landscape mosaic
Description	Ratio between the real diversity of a landscape mosaic obtained with the Shannon formula (H) and the maximum possible (H_{max})
Category	Ecology
Aims pursuant to landscape	Acknowledgement, assessment
Status/Process	Status
DPSIR category	Status
Typology	Index
Component variables (if index)	Total number of different landscape element types Relative percentage of the surfaces for each landscape element type
Unit of measure	Adimensional index
Territorial scale of reference	Municipal/provincial/regional
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, environmental assessment
Availability of data source	Cartographic layers on land use
Method of representation	Theme maps Diagrams if applied to time grid
Other explanatory notes	The range of the index varies from 0 to 1 Values near 0 indicate landscape mosaics dominated by one single, widespread and interlinked element, which acts as a matrix Values near 1 indicate landscape mosaics characterized by many elements with a similar relative weight The index can be used to compare the values of different landscape units, highlighting the different conditions of equilibrium and the role in the environmental system
Fields/works in which it was used	EIA, SEA, Plans and projects on various scales, monitoring

The analysis and assessment of ecological diversity are therefore absolute priorities in ecologically-oriented planning with the fundamental goal of maintaining and improving the environmental stability of a landscape mosaic.

In short, evenness solves the problem of assessing biodiversity at a cognitive level which is more pertinent to the planning scale. The planned strategies establish the morphological pattern of a territory, and therefore condition the level of biodiversity with direct and immediate repercussions. In other words, evenness lets us assess the impact of anthropic transformation processes in the landscape on the ecological diversity and, indirectly, on the overall biodiversity of the environmental system.

Biological territorial capacity (Btc) provides a high information content. Unlike other functional indexes, which merely assess specific phenomena (connec-

of collapse is almost equal to zero, and the probability that the environmental system as a whole will survive is high. Protecting and guaranteeing a higher level of ecological diversity therefore means increasing the environmental stability of a landscape.

Table 4.4 Biological territorial capacity (Btc)

Indicator	Biological territorial capacity (Btc)
Definition	Magnitude of the metabolism of the ecosystems in a territory and of its homeostatic and homeoretic capacity (for self/re-equilibrium), which measures the level of equilibrium of an environmental system
Description	It is defined by the sum of the products of surfaces with different land use types, and the relevant unit biological territorial capacity value, and by the subsequent weighed average of this sum in relation to the total surfaces being studied
Category	Ecology
Aims pursuant to landscape	Acknowledgement, assessment
Status/Process	Status
DPSIR category	Status
Typology	Index
Component variables (if index)	Metabolic data of the ecosystems in a territory: R = respiration PG = gross primary production B = stable biomass Metabolic data of the main types of ecosystems in the biosphere
Unit of measure	Mcal/m^2/year
Territorial scale of reference	Municipal/provincial/regional
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, environmental assessment
Availability of data source	Cartographic layers on land use, phytosociological and physiognomic-structural analysis of the vegetation Table estimating the values of unit biological territorial capacity for land use categories (Ingegnoli 1993)
Method of representation	Theme maps Diagrams if applied to time grid
Other explanatory notes	The range of the index in temperate and boreal environment ecosystems is from 0 to 13.2 [Mcal/m^2/year] It is structured in standard classes of magnitude, corresponding to a precise ecological meaning The index can be used to compare the values of different landscape units, highlighting the different conditions of equilibrium and the role in the environmental system
Fields/works in which it was used	EIA, SEA, plans and projects on various scales, monitoring

tion, fragmentation, carrying capacity, …), Btc is an important synthetic index as it indirectly assesses the environmental quality of a landscape. This index provides a synthesis of the equilibrium configurations in a landscape system, and therefore its tendency for environmental stability, incorporating and recapitulating the status of a territory, determined by the reciprocal interaction of diversified processes.

When planning vast areas, Btc lets us assess the degree of stability in a landscape system and its evolutional trend, when applied to subsequent time thresholds (Gibelli 1999).

For monitoring, both indexes give us evolutive projections, to qualitatively and quantitatively evaluate the scenarios planned in landscape-territorial policies, measuring the impact of the transformations envisaged, both on the preservation/destruction of habitats essential for maintaining high levels of biodiversity, and on the functional and structural stability of the landscape system.

Further confirmation of the chosen proposal comes from the fact that both the indexes in question are characterised by threshold values with which we can compare the results of the applications.

The range of biological territorial capacity, which in ecosystems in a temperate and boreal environment varies from 0 to 13.2 [Mcal/m^2/year], was listed by Ingegnoli and Giglio (2005) in 7 standard non-homogeneous classes of magnitude, corresponding to a precise ecological meaning. Evenness, as mentioned above, is always standardized between 0 and 1.

In short, the existence of reference values—as well as there being numerous and consolidated applications for the validation of the results obtained by comparing similar territorial or temporal situations—make these indexes trustworthy and reliable tools.

Box 4.1 Application of *Evenness* and *Biological Territorial Capacity* in the Piemonte Context: Technical Supports, Past Experiences and Future Prospects The application of evenness and biological territorial capacity (Btc) is based on suitable knowledge of the different land use types in the territory in question, defining the matrix within which we can analyse and compare the ecological processes.

The various land use forms are, from an ecological point of view, seen as patches of an ecomosaic or biotopes, where the presence or vice versa the absence of natural, seminatural or anthropic elements indirectly indicates the level of disturbance induced by man on the stable component of the environmental system. The ecomosaic, which can be considered as the projection on the territory of a certain system of functional and structural relations, represents the most significant configuration of juxtaposed landscape elements, to use as a basic reference in the ecological study of a landscape. The ecomosaic map of a specific territory therefore, represents the essential propaedeutic tool for the application of the above indexes: a tool used to reveal how much and in what ways man has had an impact on the environmental system, and to what extent we have altered its structure and function. In other words, the elaboration of the indexes considered envisages an evolution from the cartographic distribution of the various biotopes to obtain a synthetic mean value for the overall area being studied or the defined sub-fields of the same.

In Piemonte, *Regional Land Cover* provides a suitable source of data for said purpose: an "information layer on land use and coverage[6]" which paints an

[6] Land coverage concerns the physical characteristics of earth surface such as the distribution of vegetation, water, glaciers, … and the physical characteristics induced by human activities. Land use however refers to the utilization and strategies for the management of certain land coverage by man.

in-depth cognitive picture of the territory status and provides detailed information which can easily be used to meet these ecological analysis requirements.

The *Land Cover Piemonte* (LCP) project, implemented in 2002 by the Piemonte Regional Authority (Strategic Planning, Territorial and Building Policies Department, formerly Territorial and Town Planning Department), in collaboration with the Institute for Wood Producing Plants and the Environment (IPLA S.p.A.) and Piemonte CSI (Information Systems Consortium), has the fundamental goal of creating a homogeneous geographical database, for total regional coverage, establishing a wealth of territorial information which is easily accessible and constantly updated, for the Public Administration and for other subjects[7].

The greater part of this geographical layer derives from the standardization and integration of different information levels[8] set up by various Public Administration subjects, completed and verified by traditional photo-interpretation.

The sources considered make it possible to distinguish 33 exhaustive land use/coverage entries, for three primary classes: territories modelled artificially, farmland territories, woodland territories and seminatural environments[9].

In particular, the entries relevant to woodland territories, established by the Territorial Forestry Plans (TFP), are very high definite: this guarantees the objective adherence of the selected index value to the phenomena analysed. In other words, it is possible to reduce the margin of uncertainty in the estimate, improving reliability, significance and the information content of the same indexes.

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[7] With the implementation of the INSPIRE Directive (Directive 2007/2/EC) which establishes the Territorial Information Infrastructure (TII) of the European Union, the diffusion and the transversal shared use of territorial data by the public administration bodies has assumed a more and more fundamental role in the field of Geographical Information.

[8] The following data was used to draw up the LCP:

- *Register of Farms:* containing information on regional farmland use acquired at a cadastral parcel level, updated annually and geo-referenced with AGEA cadastral source data;
- *Forestry paper* of the Territorial Forestry Plans (TFP): containing detailed information on woodland surfaces and seminatural environments (grazing land, open grassland, stabile meadows, grazing meadows, …) in Piemonte, which refers to period 2001–2005;
- *Report on the Status of the Territory* (RST) and *Numeric Regional Technical Paper* (NRTP) with the limits of the urban surfaces updated at 2001–2005;
- *Plurimodal regional transportation graph:* with continuous integrations and updates, reproduces the road network (motorways, A-road, regional roads, provincial roads and urban roads), the railway network (lines in use or disuse) and service footpaths of the previous types, summarizing them on the basis of the specifications of European standard GDF2 (Geographic Data Files) for the construction of topographical databases.

[9] The LCP classification, in the same way as for the CORINE Land Cover Project, is organized in hierarchical levels. The first three levels have currently been defined and organized. The third, the one with the highest definition, identifies 33 land use/coverage classes.

The woodland system is organized into 21 forestry categories[10] which, especially in the mountain territories, characterised by a high degree of naturalness and the general absence of significant anthropic activities, let us determine the effective value of evenness and biological territorial capacity, established on the basis of the simultaneous presence of different forestry categories rather than the variety of land use types.

Furthermore, one of the fundamental aims of the *Land Cover Piemonte* project is to create an information layer which is constantly updated: not a rigid cartography fossilized in time, but rather a dynamic instrument for the systematic acquisition of territorial transformations. The Piemonte Regional Authority is therefore striving to establish a method for updating the information levels relevant to land use/coverage "in real time"; using both data from ordinary activities in various sectors, entered in the regional geographical databases on a regular basis, and the information gathered in projects for the analysis and assessment of the transformations in act (Diegoli et al. 2007).

The continuously updated knowledge of the territory and its transformations, will therefore be the ideal support for monitoring the proposed indexes.

As mentioned above, both evenness and biological territorial capacity are status indexes, in other words functional interpretative models which simply provide a picture of the condition of a territory at a certain time. To establish the evolutionary trend of an environmental system, or to verify the scenarios programmed by landscape-territorial planning policies, these indexes must be applied on the basis of a process type approach, with subsequent elaborations corresponding to different time frames.

The frequency with which the proposed indexes are updated must vary in relation to the entity of the actual transformations and the size of the territory in question. While on a large scale an update every ten years may be sufficient, on a local scale more frequent revisions of the indexes must be envisaged. The same source of impact will usually have a more or less marked effect on the environmental system in relation to the size of the territory analysed. On a large scale, the variation in the synthesis value of the indexes will be diminished by the compensation processes between the more natural and stable ecosystems and the more artificial ecosystems; processes which are unlikely to be found on a local scale, where the same source will produce a more intense impact, with faster and more significant transformations.

[10] The forestry categories correspond to physiognomical units defined on the basis of the dominance of one or more developing arboreal species.

Box 4.2 Application on a Regional Scale: The Strategic Environmental Assessment of the Piemonte Regional Landscape Plan In the framework of new territorial government process implemented by the Piemonte Regional Authority in 2005, the first Landscape Plan, drawn up in accordance with the Cultural Heritage and Landscape Code (Legislative Decree 42/2004 and subsequent modifications and integrations) and the European Landscape Convention (Council of Europe Treaty Series no. 176, Florence, 20.10.2000), is a fundamental instrument for establishing the sustainable development of the entire regional territory based on the quality of landscape and the environment.

As can be inferred from the system of strategies and the general and specific goals that characterize the same, the principal aims of the Plan are the protection and development of the Piemonte landscape and environmental system. It considers various levels of focus ranging from themes specifically dedicated to the protection and development of the historical-cultural heritage and of its identity, to themes more closely associated with the protection of the environmental system (conservation, development of the ecological range, protection of fragile ecosystems, reduction of the risks associated with abandoning the protection of the territory or vice versa with the banalization and homologation that derive from its intensive exploitation).

On these themes the Strategic Environmental Assessment (SEA) (Directive 2001/42/CE of the European Parliament and Council), which has supported and integrated the planning process, identifies a set of indexes, firstly to synthesize the level of quality/criticality of the Piemonte environmental and landscape system within which the Plan operates, and secondly to monitor the effectiveness of the lines of intervention envisaged by the Plan, measuring the transformation dynamics involved. Overall, these indexes focus on the functionality of the environmental component in the Piemonte territory, emphasizing the actual status in relation to the principal pressures on the more natural contexts, and those which are highly anthropic. Evenness (ecological diversity) and biological territorial capacity (Btc) are two of these indexes (Figs. 4.1, 4.2, and 4.3).

In operative terms both indexes have been applied in the 76 Landscape territorial ambits into which the regional territory is divided, in accordance with Art. 135 of the Cultural Heritage and Landscape Code. The value of the same was estimated using the map of the regional ecomosaic drawn up with Land Cover Piemonte data.

Therefore, it was possible to assess both the different conditions of ecological diversity, and the richness in terms of habitat for each territorial ambit, as well as the different degrees of ecological equilibrium, in other words their role in relation to the ecological stability of the Piemonte territory, identifying

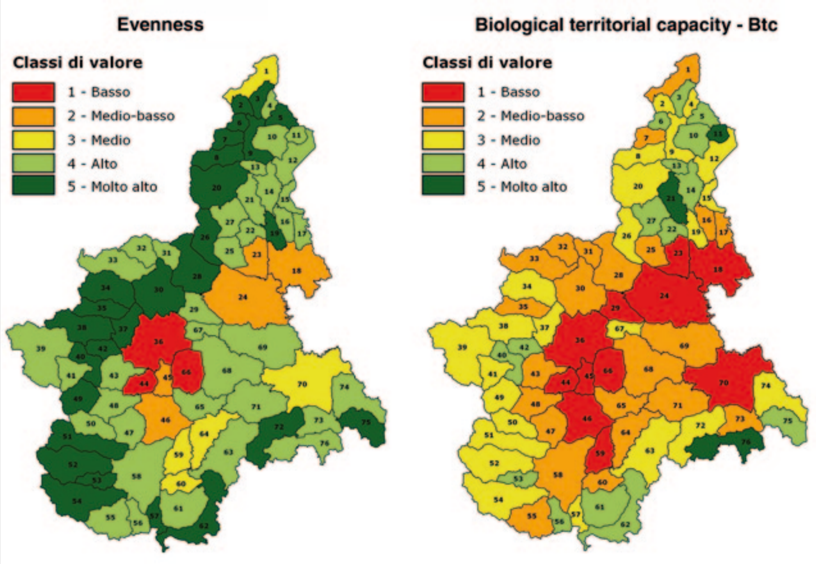

Fig. 4.1 Evenness and biological territorial capacity (Btc). The cartograms illustrate the results of the applications of the two indexes in the Landscape territorial ambits defined by the first Piemonte Regional Landscape Plan. (Piemonte Regional Authority, Strategic Planning, Territorial and Building Policies Department, *Regional Landscape Plan. Environmental report and non-technical synthesis*, July 2009) (Regional Council Resolution n. 53-11975—4/8/2009)

the territorial ambits which may still have a strategic role for the functionality of the regional landscape-environmental system.

The integration of this information with that of the application of the other indexes, envisaged in the SEA process, made it possible to measure the environmental and landscape status of each single territorial ambit, and to establish the status of the entire regional territory on the basis of the summary of the results. In the Landscape territorial ambits, where the indexes showed high critical thresholds, the plans for implementing the indications of the Regional Landscape Plan must envisage specific actions for requalification based on the Regulations for the Implementation of the Plan.

The Environmental report (Directive 2001/42/CE, Art. 5, Enclosure I) of the SEA contains a paper with in-depth information on the ontological and methodological content of each index and with illustrations of the results of their application. This paper includes: a detailed description of the index, the reason for which the index was used in the SEA process, an explanation of the method of construction and calculation and of any units of measure used, a brief description of the classes in which its range can be developed, a table

Fig. 4.2 Map of the Piemonte ecomosaic. (Piemonte Regional Authority, Strategic Planning, Territorial and Building Policies Department, Regional Landscape Plan, *Report*, July 2009) (Regional Council Resolution n. 53-11975—4/8/2009). The creation of the ecomosaic map and the quantification of the surfaces relevant to its landscape element types represent the propaedeutic tools for the application of evenness and biological territorial capacity. The various patches of the landscape mosaic, established by the Land Cover Piemonte project, were organized into four main types (natural, seminatural, anthropical agricultural and anthropical urbanized components) in relation to the level of naturalness, and the origin and type of energy supporting the ecosystemic function (solar energy or substitutive energy)

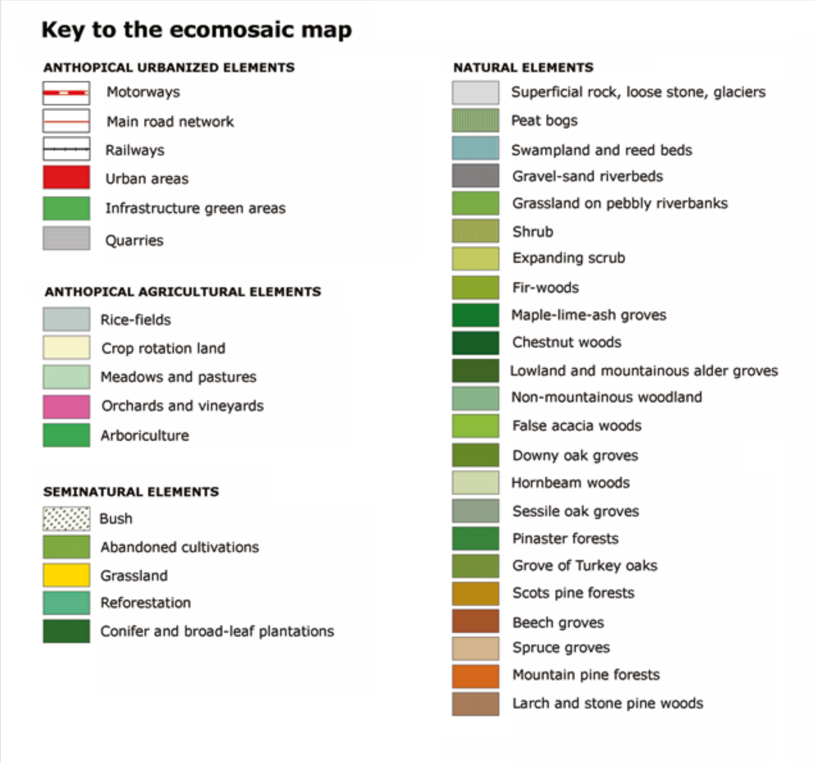

Fig. 4.3 Key to the ecomosaic map. (Piemonte Regional Authority Strategic Planning, Territorial and Building Policies Department, Regional Landscape Plan, *Report*, July 2009) (Regional Council Resolution n. 53-11975—4/8/2009)

with the results obtained at a Landscape territorial ambit level, also with an explanatory cartogram and, finally, a short summary of the conditions that can be found at regional level.

The index set used by the SEA (including evenness and biological territorial capacity) is not only the tool for monitoring and assessing landscape-territorial policies and the consequent environmental repercussions of the Plan, but it is also a reference for the assessment of the plans and programmes regulated by the Regional Landscape Plan.

Box 4.3 Application on a Local Scale: The Pinerolo District in the Research "Constructed Environment and Natural Environment in the History, the Rural Tradition and the Future of Turin and Its Province (Figs. 4.4 and 4.5)"

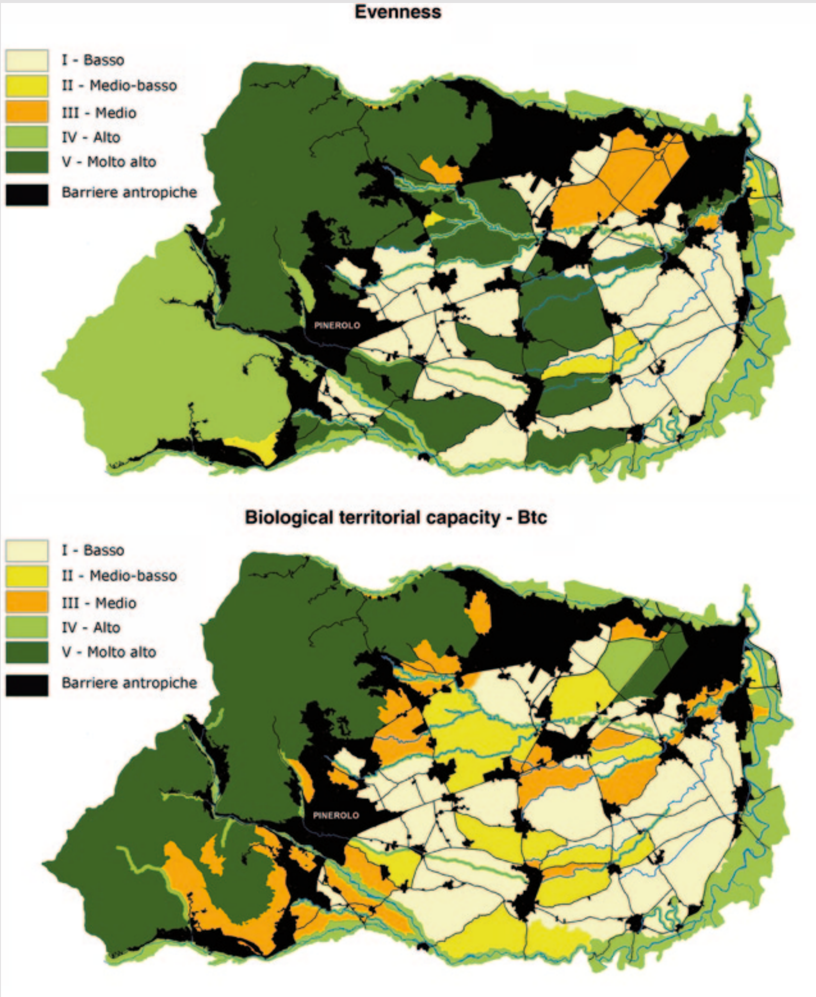

Fig. 4.4 Evenness and biological territorial capacity (Btc). The cartograms show the results of the application of the two indexes to the Pinerolo district territory in the research "Constructed environment and natural environment in the history, the rural tradition and the future of Turin and its Province", by the Inter-University Department of Territorial Studies (Polytechnic and University of Turin (Diter) in 2004 under contract to Diter—Provincial federation of direct cultivators of Turin (Coldiretti) with the contribution of the CRT Foundation—Scientific coordinator: A. Peano. This study, using an interpretative matrix of the provincial landscapes consisting of four inter-related approaches (geographical and social-economic, historical, ecological, town planning-building), establishes guidelines for rural development based on the development of the landscape. The author's cartographic elaboration

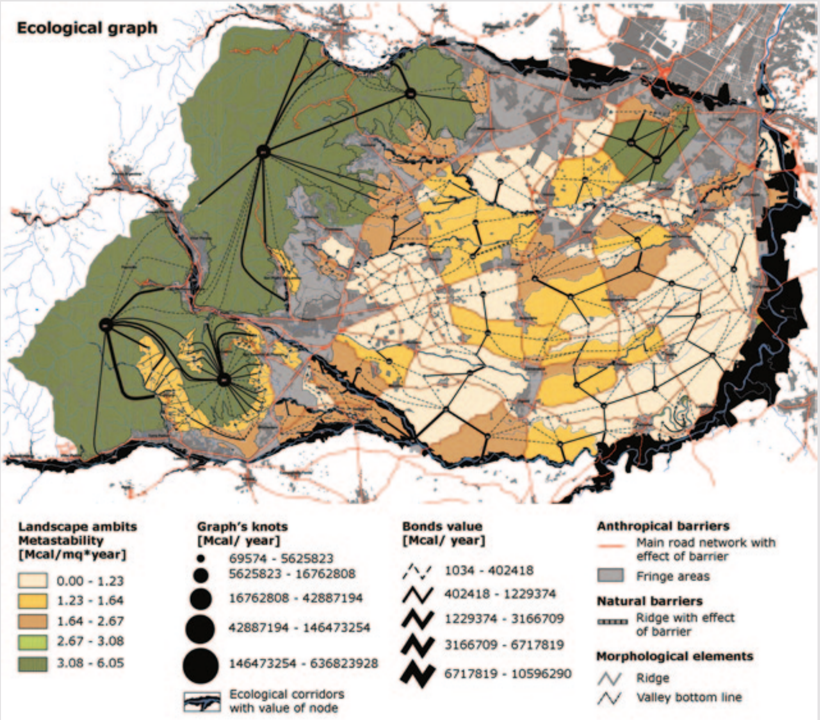

Fig. 4.5 Pinerolo district ecological graph

In the field of research, evenness and biological territorial capacity have been used to draw up the *ecological graph* (Cantwell and Forman 1993; Fabbri 2003, 2007; Fabbri and Finotto 2007), to assess the level of fragmentation in an environmental system. This model is based on the premise that an environmental system can be organized into different *ecological sectors* separated by natural or anthropic barriers, which can have different degrees of permeability, or be impermeable to the passage of biological energy and matter. The stability of the environmental system, in other words its capacity to maintain a constant structure and function, depends on the efficiency of these flows and therefore on the availability of functional paths for said flows.

The ecological graph model, quantifying and relating the values of biological territorial capacity of the various ecological sectors of an environmental system to their structural characteristics (in this case with reference to evenness) and to the permeability of their barriers, lets us analyze and assess rural and natural areas as interacting components of a single system or *virtual ecological network*. The graph considers both the intrinsic value of each single element of the environmental system, and the value of said element in relation to the other components of the same system in terms of potential exchange in the flows of biological energy and matter. Therefore, the ecological graph establishes a synthetic functional model which lets us reproduce, with an excellent degree of clarity, the network of energy flows that support the landscape organisation, also highlighting the level of ecological effectiveness of all its elements (Finotto 2006)

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Chapter 5
Indicators for the Assessment of Historic Landscape Features

Mauro Volpiano

Abstract Although connected to a relevant topic—the management of cultural heritage in the framework of planning and conservation policies—until now this specific category of landscape indicators has not been identified with a convincing set of operational standards at an international level. Cultural features are therefore one of the most interesting aspects for establishing landscape quality indicators, which may prove effective and easy to use. A review of international and Italian case studies is discussed, followed by a proposal of indicators for the protection and assessment of cultural landscape components, based both on a comparison with the proposals in scientific international literature and experience "in the field" in some Italian territorial contexts characterized by a greater presence of historical architecture and valuable cultural heritage.

Keywords Cultural heritage • Cultural landscape • Historical-cultural indicators • World heritage sites

5.1 Principles and Definitions

As can be seen in the quoted scientific publications, historical-cultural heritage indicators may have many different interpretations, something which is firstly due to the fact that indicators refer to a highly diversified concept of historical landscape. In short, there is a concise interpretation that coincides with the concept of built heritage: indicators concerning mainly buildings, monuments and architectural complexes fall into this category. There is also a more extensive idea that considers heritage also from the point of view of territory, culture and historical stratification, not necessarily focusing on architecture alone (cultural heritage or *patrimoine* in French-speaking countries); this is the interpretation which seems to

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be more suitable to the field of landscape analysis. In this case, the overall number of permanent elements and territorial transformations stratified in time can be part of the more extensive concept of *cultural landscape*, by now well consolidated at an international level (UNESCO 1996; Rössler 2005; Leask and Fyall 2006), which also takes immaterial aspects into consideration.

In the first case, published indicators are mainly used for the direct verification of the state of built heritage, providing a wealth of information which, to be of use for the purpose of landscape analysis, must be correlated with other databases—environmental and perceptive for example—to assess the multidimensionality of the landscape and territory in a satisfactory way. In the second case, less used, integrated sets of indicators on the historical-cultural components are instruments to try and interpret dynamics and related phenomena, introducing, for example, elements of a relational type to describe the historical-territorial heritage from a systemic point of view.

To get our bearings in the extensive publications and applicative case records, it is essential to refer to the scale of study, which can change the logic of the indicators completely, and also establish a notable differentiation of the subjects, almost always public, using or promoting the use of these instruments. The greater the scale in fact, the more the indicators appear to assume the form of *policy-oriented indicators* which can be compared with economic and social macrocategories; the more the scale is reduced—and the interest of the institutions involved is restricted to a limited territory—the more suitable the indicators are for directly monitoring the physical transformations of the territory (morphologies, state of preservation of the assets and so on).

International proposals, such as those from Pearson (Pearson et al. 2001), normally have a qualitative character which aims to contextualize historical-cultural themes in the framework of economic and social dynamics, for high profile strategic and political decision-making actions, taken mainly by national and international bodies. At the other end of the spectrum however we have extremely technical indicators, intended to detect the morphological transformations of the territory on a local scale, using photointerpretation techniques, for example, or comparing historical and modern cartography, to establish the transformation dynamics of the landscape, the integrity or loss of historical value (Socco 2005): these indicators are obviously mostly used by local bodies operating in a limited area.

It must be said that the theme of indicators, consolidated in scientific publications, is somewhat alien to the traditional studies in the field of the history of architecture and territory. In the strictest sense the subject has not been dealt with using historical methods, as far as this study has been able to ascertain, if not by scholars from other technical-scientific sectors, mainly in environmental or economic assessment. The same applications are in many cases relevant to agro-environmental policies for which the historical-cultural component is marginal. In the field of economic assessment, where historical-cultural aspects are present, what is important is to find indicators to establish “non-market values” which can be associated with a landscape, such as the willingness to spend to use a certain cultural asset, for example (Nijkamp 1989).

The indicator is however an applicative instrument, with an implicit planning function—although it is possible to conceive also indicators purely "of acknowledgment" (Vallega 2008)—sometimes at the risk of some form of deterministic reductionism which is not always compatible with the interpretative aims of historians studying the territory. Nevertheless, historians have long since created instruments to describe historical-territorial phenomena, both in basic studies and in relation to tools for planning on different scales. Furthermore, indicators monitor a reality which often has not been accurately described beforehand: currently, heritage indicators are mostly used by those involved in the management of sites or the monitoring of plans and projects, and not by those providing the basic historical-landscape and historical-territorial information. Also in the UNESCO proposals for establishing management plans for the areas in the World Heritage List, indicators are proposed (with reference to DPSIR methods) for *in itinere* monitoring. Nevertheless, it is clear that the use of state indicators which cannot be compared with coherent fact-finding campaigns, before actions are taken, can represent an element of weakness not only in historical-cultural heritage landscape monitoring systems: "Obtaining a record of the landscape character should hence be considered the necessary prerequisite for identifying state or quality indicators for landscape, and for identifying the most relevant pressure indicators that affect this state" (Wascher 2005).

In short, the indicator requires the precise preliminary *characterization* of the landscape, to verify the variability and the quality of the phenomena "intercepted" and measured. One problem to bear in mind is therefore the possibility of implementing suitable preliminary fact-finding in the construction of indicators: there is still much work to be done in this sense. What does appear clear though, is that we must go beyond quantitative schematization—often disarming for "professional historians"—which attempts to interpret historical-cultural phenomena in relation to landscape using elementary numeric indexes and sometimes banal cartographic output distorted by the logic of software applications.

Finally, also historical studies on territory (and the culture of conservation) should claim new fields of action and, especially in order to be useful for the purpose of assessment, must once and for all go beyond a static view, overcoming the traditional goal of inventorying the listed cultural assets, to approach historical dynamics as a continuous and ever changing process, which determines the transformations of the territory in time, thus getting aware of the logics of change, and the evolution of the landscape. A landscape which is always contemporary landscape, and could not be otherwise (Roggero and Volpiano 2007).

5.2 A Critical Review of Historical-Cultural Heritage Indicators

The theme of historical-cultural heritage indicators became topical in the late 1990s, as in the case of the United Nations documents on sustainability. The document drawn up by the Global Urban Observatory of the United Nations, *Monitoring* *human settlements with urban indicators* (UNCHS 1997) indicates that "The purpose of the Urban Indicators Programme is to build national and local capacity to collect and use policy-oriented indicators as part of a strategy for the development of sustainable human settlements. Human settlements may be defined in the simplest terms as places where human activities take place. It is, however, in our urban areas—our cities—that we face the main challenge for the future. Increasingly, the world's problems are urban problems. How we anticipate, recognize, measure and interpret urban problems and how we respond to them in policy will determine the overall sustainability of human development".

In this context there are some references to heritage indicators: the indicator "land use in km^2" requires the percentage of *conservation areas*, and the "conservation area includes all surfaces which are protected for environmental or agricultural purposes or which are classified as protected historical zones, monuments or heritage areas". In the section of the same UNCHS document on *Sustainable human settlement development in an urbanizing world* there is reference to actions and the relevant indicators for the preservation and enhancement of historical-cultural heritage, as shown in the Table 5.1.

The list of indicators proposed includes the indicator *monument list* "Number of buildings in city on heritage or monument list"; this, with the *green space* indicator, is used to obtain the indicator of *urban enhancement*.

In the 1990s the Organisation for Economic Co-operation and Development (OECD) developed a set of indicators associated with the DPSIR model. The document makes a brief reference to landscape, mentioning also the historical-cultural aspects[1]. The set of European Common Indicators (EC 2003) also refers to heritage

Table 5.1 Conservation and rehabilitation of the historical and cultural heritage. (Source: UNCHS 1997)

Actions
Promote historical and cultural continuity and encourage broad civic participation in all kinds of cultural activities
Integrate development with conservation and rehabilitation goals
Indicators
Number of buildings in city on heritage or monument lists
Expenditure in rehabilitation and upgrading of buildings in city on heritage or monument lists
Incentives to private owners for rehabilitation and upgrading of buildings in urban areas part of cultural heritage
Qualitative indicators (review of planning practices and policies)

[1] "Specific types of human land use, such as certain agricultural practices, road and house building, hydropower projects, drainage of wetland, forestry and mining may pose a threat to ecosystems, and thus a form of environmental pressure on landscape. In addition, landscape can be seen as a part of environmental quality and as such, important to humans for ethical, aesthetic and cultural reasons. Thus, degradation of landscape entails both a loss of naturalness and historic cultural values. So far, no internationally agreed definition of landscape exists and no attempt has been made to develop landscape indicators in this report" (OECD 1993).

in the indicator *Sustainable land use*[2]*; restoration of urban areas, renovation and conversion of derelict buildings, protected areas.*

While the documents of the United Nations and other international organizations refer quite marginally to heritage, some national bodies have developed cultural heritage indicators in a broader sense. These include the Australian Michael Pearson, who drew up a set of cultural heritage indicators in the 1990s, used in many annual government reports on the state of the environment (Table 5.2).

Other experiments based on the indicators of the DPSIR method go along the same lines, such as those in New Zealand (Table 5.3). In this case, Heritage Indicators are used for the management of the territory with other sets of indicators (Amenity Indicators, Incompatible Activity Indicators, Natural Environment Indicators, Natural Hazard Indicators).

English Heritage (Heritage Counts 2005, 2008) proposes a precise structure for indicators used to monitor heritage policies, although the same organisation indicates several problematic aspects, in particular those relevant to obtaining coherent and complete databases. *Heritage Counts* identifies the indicators on the basis of the policies and relevant goals and lines of action for preserving heritage, with specific reference to landscape in which the same body invests significant resources (in the case of the *Historic Landscape Characterization* programme for example). The indicators are divided into three categories-objective: knowledge, protection and sharing, use (Table 5.4).

Some European projects and, some specific publications in Italy (Colombo and Malcevschi 1999; Malcevschi and Poli 2008; Vallega 2008) have attempted to compare landscape indicators offering a general overview, although never with a focus on heritage components. Below we propose a summary table on this extremely diversified panorama, to provide an initial instrument for general orientation. In the table, the unit of measure used and the source of the information are shown for the type of indicator proposed. The single instruments have been grouped together into *characterization, transformation and enhancement indicators*, an approach which will be considered in greater detail below; in some cases, the instrument in question may belong to more than one of the three groups, depending on the concrete use of the same.

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[2] "Indicator 9 is concerned with a variety of themes that are very different from each other, but all relate to the way the land is used. The main data required for the calculation of the indicator are as follows:

a. urbanised or artificially modelled land: the size of the artificially modelled area as a percentage of the total municipal area;
b. derelict or contaminated land: the size of the derelict or contaminated area (m^2);
c. intensity of use: number of inhabitants per km^2 of the area classified as 'urbanised land';
d. new development: new building on virgin area (greenfield sites) and new building on contaminated or derelict area (brownfield sites) compared to the total area (%);
e. restoration of urban areas: 1. renovation and conversion of derelict buildings (total number);
f. renovation and conversion of derelict buildings (total in m^2 of each floor);
g. redevelopment of derelict areas for new uses, including public open spaces (area in m^2);
h. cleansing of contaminated land (area in m^2);
i. protected areas: size of the protected area as a percentage of the total municipal area;
j. Headline indicator: protected areas as a percentage of the total municipal area." (EC 2003).

Table 5.2 Catalogue of indicators concerning the historical-cultural heritage of landscape

Category	Indicator	Units	Source
Characterization	Historic features. Architectural and urban features	Presence/absence	EEA; Backer 2009
	Presence of cultural and historic/listed buildings and monuments	Presence/absence	ADBPO 2008; Colombo and Malcevschi 1999; Franceschetti and Pagan 2007; Wascher 2000 in Waarts 2005
	Presence of historic human settlements; historic urban features; known and potential archaeological sites	Presence/absence	ADBPO 2008; Colombo and Malcevschi 1999
	Places linked to historical events and people; places of the memory (e.g. locations of battles in wars, places of folkloric traditions, sanctuaries)	Percentage of sites on total in the considered area. Presence/absence	Colombo and Malcevschi 1999; Vallega 2008
	Landscape significance. Obtained considering the listed assets and areas and other connotative elements of the landscape (indicated by the Regional planning tools)	Index value scale	Malcevschi and Poli 2008; Graci et al. 2005
	Historical characteristics that define the rural landscape; Presence of historic/traditional agricultural layouts	Presence/absence	Malcevschi and Poli 2008
	Cultural identity; presence of key-cultural values	Percentage of sites on total in the considered area. Presence/absence	EEA; Wascher 2000
	Historical Land use	Area	Wascher 2005
Transformation	Urban imprint (integrity of the historical values in human settlements in an area)	Presence/absence	DITER 2007
	Loss of cultural landscape elements	Presence/absence	Wascher 2000 in Waarts 2005
	Maintenance of traditional landscape elements (stonewalls, hedgerows, field margins)	Presence/absence	IRENA Project; Waarts 2005
	Stock and change of historical-cultural landscape	Presence/absence (area/linear/point features)	Eiden et al. 2004; Waarts 2005
	Permissions (e.g. to build) in listed area	Presence/absence	Franceschetti and Pagan 2007

Table 5.2 (continued)

Category	Indicator	Units	Source
	Farmland subject to public policies which helps maintain/develop the cultural/historical characteristics of the zone	Area, percentage	Mari 2005
	Buildings at risk; landscapes at risk; monuments at risk; re-use of empty homes	Presence/absence	English Heritage 2005
	Planning trends	Percentage	English Heritage 2005
	Number, type and location of listed heritage buildings or features	Percentage	Matamata-Piako District Council
	Number and location of listed/known/protected culturally significant sites	Percentage	Matamata-Piako District Council
	The number of heritage places assessed (by sampling) as being in (i) good, (ii) average and (iii) poor condition	Evaluation scale	Pearson et al. 2001
	Number of places destroyed or whose value has been severely diminished; number of places reserved for conservation purposes where heritage values have been seriously impaired by visitor use	Percentage	Pearson et al. 2001
	Fragmentation of the rural matrix in cultural landscapes; integrity of hedgerow networks; integrity of rural openness	Percentage	Gulinck and Wagendorp 2002; Van Eetvelde and Antrop 2009
Enhancement	Revitalization of historical urban spaces (urban quality)	Area	Vallega 2008
	Protection of archaeological heritage	Percentage of sites on total	Vallega 2008
	Enhancement of industrial architecture	Area	Vallega 2008
	Creation of cultural routes	Percentage of sites on total	Vallega 2008
	Protection of UNESCO sites (investments on total amounts invested in landscape)	Percentage	Vallega 2008
	Areas of particular environmental and cultural interest subject to protection in accordance with the Italian Cultural Heritage and Landscape Code (CBCP)/Archaeological areas	Area, percentage	ADBPO 2008
	Degraded areas, subject to protection in accordance with the Italian Cultural Heritage and Landscape Code (CBCP), with potential for landscape requalification	Area	ADBPO 2008; UNCHS 1997

Table 5.2 (continued)

Category	Indicator	Units	Source
Enhancement (*cont.*)	Number of sites in the World Heritage List Unesco; number of scheduled monuments; number of listed buildings; number of registered historic parks and gardens; number of conservation areas in England	Percentage	English Heritage 2005
	Extent of area designations in England; extent of area of ancient woodlands; extent of historic landscape characterization; extent of historic environment research	Area	English Heritage 2005
	Number of items recorded on historic environment records	Percentage	English Heritage 2005
	Listed building consent decisions; planning applications affecting registered historic parks and gardens; conservation area consent applications determined annually by local authorities	Presence/absence	English Heritage 2005
	World heritage site management plans; employment nationwide on heritage, museum and conservation services; funding available	Presence/absence	English Heritage 2005
	Number of new apprenticeships in heritage craft skills	Percentage	English Heritage 2005
	New users of the historic environment from priority groups; GCSE level history candidates	Presence/absence	English Heritage 2005
	Students studying courses relating to historic environment; schools visits to historic sites; annual visits to historic visitor attractions	Percentage	English Heritage 2005
	Membership of historic environment organizations	Presence/absence	English Heritage 2005
	Number of historic environment volunteers	Percentage	English Heritage 2005
	Attitude surveys and focus groups	Presence/absence	English Heritage 2005
	Number of resource consents applied for/granted to substantially modify scheduled buildings within the area; number of resource consents granted for the construction of new buildings within the area; number of resource consents applied for/granted to substantially modify listed heritage features; number of resource consent applications submitted/granted involving sites which contain or adjoin a culturally significant site	Percentage	Matamata-Piako District Council
	Public perception of condition/quality of the area	Presence/absence	Matamata-Piako District Council

Table 5.2 (continued)

Category	Indicator	Units	Source
	Number of resource consent applications declined to substantially modify scheduled buildings within the areas; number of resource consent applications declined for the construction of new buildings within the area; number of resource consent applications declined to substantially modify listed heritage features; number of resource consent applications declined involving sites which contain or adjoin a culturally significant site; number and type of consent conditions imposed to protect/enhance heritage resources % of the community that received educational/promotional material regarding heritage resources	Percentage	Matamata-Piako District Council
	Council expenditure ($) on protecting, enhancing and promoting heritage features	$	Matamata-Piako District Council
	Number, type and value of incentives offered for the protection of heritage resources	Percentage	Matamata-Piako District Council
	Proportion of natural heritage places with a condition statement, proportion with a recent condition statement, and age distribution of condition statements	Percentage	Pearson et al. 2001
	Number of objects/collections adequately catalogued; the proportion of collections surveyed for preservation treatment by a trained conservator; the proportion of collections requiring preservation\n subsequently treated; the proportion of collections stored in appropriate environmental conditions	Percentage	Pearson et al. 2001

Table 5.3 An example of historical-cultural indicators: heritage assessment in New Zealand. (Source: www.mpdc.gov.nz)

Pressure
Number of resource consents applied for/granted to substantially modify scheduled buildings within the Te Aroha character area
Number of resource consents granted for the construction of new buildings within the Te Aroha character area
Number of resource consents applied for/granted to substantially modify listed heritage features
Number of resource consent applications submitted/granted involving sites which contain or adjoin a culturally significant site
State
Number, type and location of listed heritage buildings or features
Number and location of listed/known/protected culturally significant sites
Public perception of condition/quality of Te Aroha character area
Response
Number of resource consent applications declined to substantially modify scheduled buildings within the Te Aroha character areas
Number of resource consent applications declined for the construction of new buildings within the Te Aroha character area
Number of resource consent applications declined to substantially modify listed heritage features
Number of resource consent applications declined involving sites which contain or adjoin a culturally significant site
Number and type of consent conditions imposed to protect/enhance heritage resources
% of the community that received educational/promotional material regarding heritage resources
Council expenditure ($) on protecting, enhancing and promoting heritage features
Number, type and value of incentives offered for the protection of heritage resources

Table 5.4 Set of cultural heritage. indicators proposed by English Heritage (2008) in the *Heritage Counts* programme

Indicator	Reference	Measurement
A—Understanding the assets		
A1	*A1.1*	Number of world heritage sites
Designated heritage assets	*A1.2*	Number of scheduled monuments
	A1.3	Number of listed buildings
	A1.4	Number of registered parks and gardens
A2	*A2.1*	Number of conservation areas (2005)
Historic areas and open spaces	*A2.2*	Area of land in England which is a national park or area of outstanding natural beauty (2008)
A3	*A3.1*	Number of on-line historic environment records
Acquiring information	*A3.2*	Extent of historic landscape characterisation
	A3.3	Extent of historic environment research
B—Caring and sharing		
B1	*B1.1*	Percentage of grade I and II buildings at risk; and percentage of those at risk where it makes economic sense to repair (2008)
Historic environment at risk		
	B1.2	Landscapes at high risk (2008)
	B1.3	Monuments at high risk (2007)

Table 5.4 (continued)

Indicator	Reference	Measurement
B2 Managing positively	*B2.1*	Number of planning applications decided 2007/2008
	B2.2	Number of applications for listed building consent decided 2007/2008
	B2.3	Number of scheduled monument consent decisions 2007/2008
	B2.4	Number of planning applications affecting registered parks and gardens 2007/2008
	B2.5	Number of conservation area consent applications determined 2007/2008
	B2.6	Percentage of world heritage sites with management plans in place
B3 Capacity and resources	*B3.1*	Numbers employed in heritage, museums and conservation services (2006)
	B3.2	Amount of public funding available (2007/2008)
B4 Developing training and skills	*B4.1*	Number of new apprenticeships/trainees in heritage crafts skills
B5 Local authority historic environment champions	*B5.1*	Number of local authority heritage champions
C—Using and benefiting		
C1 Education and lifelong learning	*C1.1*	Attendance at designated historic environment sites by priority group 2007/2008 (first six months)
	C1.2	Number of members of historic environment organisation (2007/2008)
	C1.3	Number of historic environment volunteers (2005/2007)
C2 Economic benefits	*C2.1*	Number of visits to historic visitor attractions (2007)
C3 Participation	*C3.1*	Number of gcse/a level history candidates (2007)
	C3.2	Number of higher education students studying courses related to the historic environment (2006/2007)
	C3.3	Number of school visits to historic sites (2007)
C4 Well-being and quality of life	*C4.1*	Number of people agreeing with the statement ‘when trying to improve local places, it’s worth saving their historic features’ (2006/2007)
C5 Environmental sustainability	*C5.1*	Number of empty homes (2007)

5.3 Proposal for Historical-Cultural Heritage Indicators

The complexity of the historical dimension of landscape makes accurate and precise description with single indicators problematic. It would appear to be essential to work on structured instruments, the result of the composition of different indicators, which can partly be obtained from scientific publications, and partly have to be adapted to specific territorial situations. Historical-cultural indicators, in fact, are necessarily strictly linked to the different European cultural identities: we are not analyzing landscape but *landscapes*. This is clear for the Italian case study, where the variety and age-old stratifications of contexts suggest the need for constant verification in relation to the specific local conditions of the territory. A first set of indicators it seems logical to propose to operators interacting with the territorial transformations are therefore those we can call "characterization indicators", in other words instruments used to outline the historical-cultural characteristics of a certain territory. A second possible classification is "transformation indicators", this is instruments used to monitor the transformation of landscape both in relation to territorial dynamics in the broader sense, and in relation to specific projects or plans, for which we wish to verify the effect and compatibility in time, as is the case with the environmental impact assessment. Finally, historical-cultural components can also be monitored from a more extensive point of view taking into consideration the social perception of populations, participation, the effectiveness of programmes and public policies for use and allocation of resources. Numerous indicators used at an international level refer to these aspects, which in general we can call "indicators of enhancement". The following diagram shows some possible applications (Fig. 5.1).

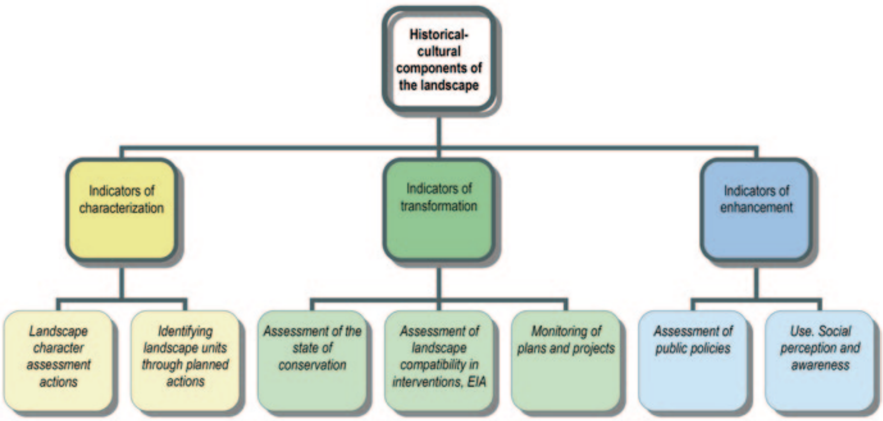


Fig. 5.1 An outline of indicators relevant to the historical-cultural components of landscape in types of application, divided according to "CTE" (characterization, transformation, enhancement)

This block diagram, obtained from a comparison with standards that have become progressively consolidated in recent years at an international level, may provide an outline to begin the process of operational rationalization for the many partial instruments used until today at a local level. Besides the set of specific indicators for single territorial situations, which must necessarily develop analytically in the field, and which have to be differentiated from place to place, the need for more general instruments to provide answers that can be implemented in decision-making processes is all the more evident. For example, in the case of state indicators, which can be associated with characterization, and which constitute the basis of every historical-landscape study, we could consider the development of macroindicators to highlight the:

1. exceptionality/significance of the historical-cultural characteristics of the landscape
2. typicality of the historical-cultural characteristics of the landscape
3. fragility/criticality of the historical-cultural characteristics of the landscape

Obtained through expert analysis, these indicators can be used in general for many concrete experiments, to establish priorities and strategies. Obviously they are not indicators that create a hierarchal structure, as, on the basis of the cases and situations, it may be preferable to favour protection or enhancement of an exceptional landscape, a territory which is particularly at risk, or a particularly significant or characteristic situation, crucial for the identity of the place.

A synthesis could be obtained for monitoring the transformations of historical-territorial structures of value for landscape, with a set of indexes relevant to the:

1. preservation of the assets
2. preservation of the “landscape systems” of historical value

The first concern the material consistency of the assets; the second concern the many systems of relations (functional, symbolic, perceptive) between historical assets, modified by territorial processes in time, which “create landscape”.

Finally, for the third aspect—indicators of enhancement—we can consider compound indexes used to verify the:

1. promotion of actions for the knowledge of historical-cultural heritage
2. economic enhancement of historical-cultural heritage
3. social participation; use and accessibility of historical-cultural heritage

Therefore, these compound indexes can consist of sets of indicators based as far as possible on previously published measurement methods, but associated each time with the specific historical-cultural characteristics of the places. In other words concretely associated with the quality of the cultural heritage and identity of the territory (Table 5.5).

Let’s take a closer look at the system proposed with a case study on Piemonte (see Box 5.1), where the characterization of the historical-territorial structures (Vol-

Table 5.5 Proposed indicators for the historical-cultural heritage of the landscape

Category	Indicator/Index	DIPSIR	Scale	Use
Characterization	1. Exceptionality of the historical-cultural characteristics of the landscape	S	Regional, Local	Applied
	2. Fragility of the historical-cultural characteristics of the landscape	S	Regional, Local	Frequent
	3. Significance/typicality of the historical-cultural characteristics of the landscape	S	Regional, Local	Frequent
Transformation	4. Preservation of the assets 4.1 Protected areas and elements 4.2 Elements protected by local planning instruments/elements protected by regional planning 4.3 Presence/absence of categories of significant assets on territory in relation to historical situation 4.4 State of preservation of built heritage with reference to characterizing elements (see scientific publications in the restoration field)	S	Local	Applied, for monitoring
	5. Preservation of relation systems between assets	S	Local	Proposed for monitoring
Enhancement	6. Promotion of actions for further knowledge of historical-cultural heritage	R	Regional, Local	Applied
	7. Economic enhancement of historical-cultural heritage	R	Regional, Local	Not applied
	8. Use of historical-cultural heritage; networking	S	Regional, Local	Not applied

piano 2008) was part of the studies of the Polytechnic of Turin for the new Regional Landscape Plan. Goal of the research was to highlight the typifying characteristics and the correlation systems with the local context and with the other systems of assets, using parameters of judgment "exceptionality, significance, rank" etc., which we can easily imagine being used for monitoring with indicators. This study refers to regional systems, but the same categories can be found and qualified on a local scale.

In the concrete experience of Piemonte, one among the new generation of Italian regional landscape plans, the scale of measurement was expressed through the qualitative judgment of experts and the characterization indicators were structured as shown in Fig. 5.2.

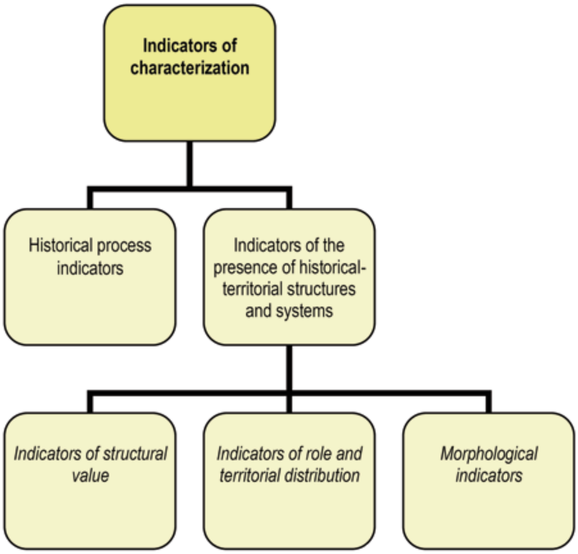


Fig. 5.2 Structure of characterization indicators "C" in the new Piemonte landscape plan

Note the proposal to classify *landscape assessment* indicators in two categories: those relevant to the presence of major historical territorial structures and systems (in Piemonte, for example, the contexts of holiday resorts and *loisir* places of the nineteenth and early twentieth centuries in the area of the lakes at the foothills of the Alps, or the territorial and landscape system of the state residences in the area of Turin, the ancient capital of the house of Savoy) and those relevant to historical-territorial processes, in other words relevant to the driving forces that established the historical structure of the territory (again in Piemonte, for example, the processes of medieval fortification or *urban sprawl* in the late twentieth century (Roggero and Volpiano 2007).

The first phase in a process of characterization of the historical landscape, aiming at the construction of indicators, can therefore consist in establishing the presence or absence of the historical processes which have determined in time the characters of landscape. Then, the second step will be to identify the *indicators of historical-territorial structures and systems*, in other words the concrete historical permanence from the point of view of territorial and landscape assets.

Transformation indicators can vice versa be an instrument used to monitor the evolution of heritage preservation over time, and more (Fig. 5.3). For example, with respect to a given territory, the "asset preservation" index can envisage the following indicators:

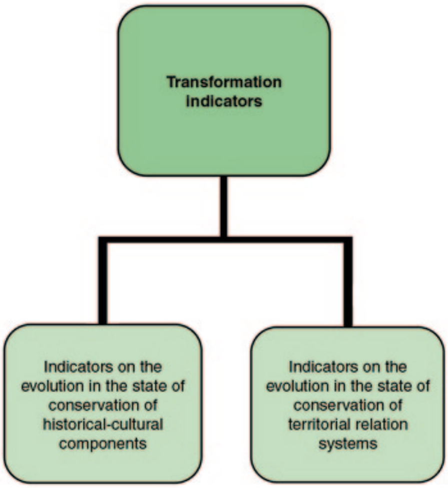


Fig. 5.3 Structure of transformation indicators "T"

1. Protected areas and elements (in Italy, in accordance with the Cultural Heritage and Landscape Code).
2. The relationship between elements acknowledged and protected by local planning instruments and elements protected by regional planning (this can be useful to assess the local preservation policies compared to the general regional frame).
3. Assets existing at the present time in relation to the historical situation (with reference to cartography and other sources).
4. The state of preservation of the built heritage with reference to characterizing elements (see presentation of the indicator in this text for more details).

It is more interesting, but also more complex, to define the state of the systems of relations between objects and place actually pursuant to landscape. Everyone agrees, in fact, that the landscape is more than just that single castle, group of farmhouses, or traditional cultivation system, it is the sum of all these characteristics in a specific context, and the relations—practical, perceptive, symbolic—between the same elements. In the new Piemonte Regional Plan, an attempt was made in this direction to identify the "system unit" (not to define "the farmstead" for example, but the area, in its established historically relationship, occupied by the manor, the chapel, annexed buildings, cottages, paths and roads…): an approach which lets us say something more on the state of the landscape in the places, the integrity of the same, possible regulations and actions to take, as well as simple considerations on the state of preservation of the buildings.

The third category of indicators, of enhancement, can be used to monitor policies on a regional and local scale; in the first case we propose three, relevant to

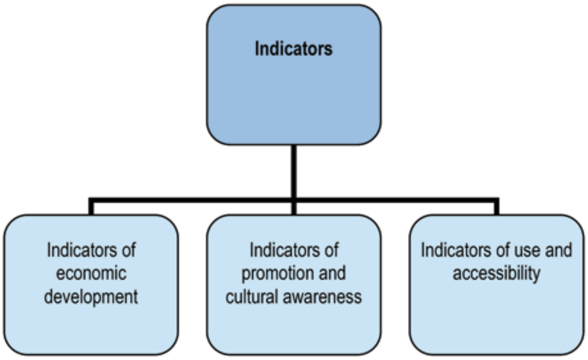


Fig. 5.4 Structure of enhancement indicators "E"

economic development, the cultural promotion of heritage and use of the same, but the logic can be developed further (Fig. 5.4).

Finally, the proposed indicators can be associated with the DPSIR model, although further controls are required: indicators of historical process can be associated with driving forces; characterization indicators with state indicators; indicators of enhancement with those of response (Tables 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12, and 5.13).

Table 5.6 Exceptionality of the historical-cultural characteristics of the landscape

Indicator	Exceptionality of the historical-cultural characteristics of the landscape
Description	The indicator is obtained through expert analysis and it allows the historical-cultural characteristics of a certain territory to be outlined
Category	Historical and Cultural
Aims pursuant to landscape	Acknowledgment/Assessment
Status/Process	Status
DPSIR category	State
Typology	Simple
Component variables (if index)	–
Unit of measure	Qualitative judgment
Territorial scale of reference	Local and Regional
Time scale of reference	Year/period
Characteristics of use	Monitoring, technical-scientific analysis, assessment of territorial plans
Availability of data source	Database or direct research
Method of representation	Databases, thematic maps
Other explanatory notes	–
Fields/work in which it was used	Studies related to the characterization of the historical-cultural landscape (Volpiano 2008)

Table 5.7 Fragility of the historical-cultural characteristics of the landscape

Indicator	Fragility of the historical-cultural characteristics of the landscape
Description	The indicator is obtained through expert analysis and it allows the historical-cultural characteristics of a certain territory to be outlined
Category	Historical and Cultural
Aims pursuant to landscape	Acknowledgment/Assessment
Status/Process	Status
DPSIR	State
Typology	Simple
Component variables (if index)	–
Unit of measure	Qualitative judgment
Territorial scale of reference	Local and Regional
Time scale of reference	Year/period
Characteristics of use	Monitoring, technical-scientific analysis, assessment of territorial plans
Availability of data source	Data-base or direct research
Method of representation	Databases, thematic maps
Other explanatory notes	–
Fields/work in which it was used	Studies related to the characterization of the historical-cultural landscape (Volpiano 2008)

Table 5.8 Significance/typicality of the historical-cultural characteristics of the landscape

Indicator	Significance/typicality of the historical-cultural characteristics of the landscape
Description	The indicator is obtained through expert analysis and it allows the historical-cultural characteristics of a certain territory to be outlined
Category	Historical and Cultural
Aims pursuant to landscape	Acknowledgment/Assessment
Status/Process	Status
DPSIR category	State
Typology	Simple
Component variables (if index)	–
Unit of measure	Qualitative judgment
Territorial scale of reference	Local and Regional
Time scale of reference	Year/period
Characteristics of use	Monitoring, technical-scientific analysis, assessment of territorial plans
Availability of data source	Data-base or direct research
Method of representation	Databases, thematic maps
Other explanatory notes	–
Fields/work in which it was used	Studies related to the characterization of the historical-cultural landscape (Volpiano 2008)

Table 5.9 Preservation of the assets

Indicator	Preservation of the assets
Description	The index allows the preservation dynamics of historical and cultural assets at the regional level to be assessed, through the observation of protected areas and landscape elements according to the Italian Cultural Heritage and Landscape Code and other planning instruments
Category	Historical and Cultural
Aims pursuant to landscape	Assessment
Status/Process	Process
DPSIR category	State
Typology	Index
Component variables (if index)	The index is based on the observation of different elements: 1. Protected areas and elements 2. Elements protected by local planning instruments/elements protected by regional planning 3. Presence/absence of categories of significant assets on territory in relation to historical situation 4. State of preservation of built heritage with reference to characterizing elements
Unit of measure	n.
Territorial scale of reference	Regional
Time scale of reference	The evaluation is developed in the different moments concerning the adoption and the approval of the planning instruments
Characteristics of use	–
Availability of source data	Municipal Plans, Regional Territorial Plans, Landscape Plans, Provincial Territorial Plans
Method of representation	Temporal evolution, thematic maps
Other explanatory notes	–
Fields/work in which it was used	Partially in English Heritage 2005–2008; Pearson et al. 2001; UNCHS 1997

Table 5.10 Preservation of relation systems between assets

Indicator	Preservation of relation systems between assets
Description	The index allows the preservation dynamics of historical and cultural assets at the local level to be assessed through the observation of the principal historical and architectural elements and their relation system
Category	Historical and Cultural
Aims pursuant to landscape	Assessment
Status/Process	Process
DPSIR category	State
Typology	Index
Component variables (if index)	–
Unit of measure	n.
Territorial scale of reference	Local

Table 5.10 (continued)

Indicator	Preservation of relation systems between assets
Time scale of reference	The evaluation is performed according to the needs: in this case, a 10-years period is proposed
Characteristics of use	–
Availability of source data	Municipal Plans, Regional Technical Maps, direct surveys and research, historical sources (maps, images and descriptions)
Method of representation	Temporal evolution, thematic maps, files
Other explanatory notes	–
Fields/work in which it was used	Proposed for monitoring in Piemonte Region 2009

Table 5.11 Promotion of actions for further knowledge of historical-cultural heritage

Indicator	Promotion of actions for further knowledge of historical-cultural heritage
Description	The indicator allows the level of historical and cultural promotion to be evaluated through the observation of the economic resources invested from public authorities (for example, funds for scientific publication on specific goods, researches and studies,…)
Category	Historical and Cultural
Aims pursuant to landscape	Assessment
Status/Process	Process
DPSIR category	Response
Typology	Indicator
Component variables (if index)	–
Unit of measure	Euro/year
Territorial scale of reference	Local and Regional
Time scale of reference	Year
Characteristics of use	–
Availability of source data	Budget plans of regional and municipal cultural divisions
Method of representation	Temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Partially applied in the Management Plans for the Unesco Sites

Table 5.12 Economic enhancement of historical-cultural heritage

Indicator	Economic enhancement of historical-cultural heritage
Description	The indicator refers to the evaluation of the investments born by private entities and the public administration to enhance the historical-cultural heritage in terms of restoration and conservation actions
Category	Historical and Cultural
Aims pursuant to landscape	Assessment
Status/Process	Process
DPSIR category	Response
Typology	Indicator
Component variables (if index)	–
Unit of measure	Euro/year

Table 5.12 (continued)

Indicator	Economic enhancement of historical-cultural heritage
Territorial scale of reference	Local and Regional
Time scale of reference	Year
Characteristics of use	–
Availability of source data	Municipal and regional budget plans, direct surveys
Method of representation	Temporal evolution
Other explanatory notes	–
Fields/work in which it was used	–

Table 5.13 Use of historical-cultural heritage; networking

Indicator	Use of historical-cultural heritage; networking
Description	The indicator gives information about the use of landscape resources (both natural and historical-cultural) made by the population. The analysis is conducted by experts
Category	Historical and Cultural
Aims pursuant to landscape	Assessment
Status/Process	Process
DPSIR category	State
Typology	Indicator
Component variables (if index)	–
Unit of measure	Qualitative judgment
Territorial scale of reference	Local and Regional
Time scale of reference	Year
Characteristics of use	–
Availability of source data	Direct surveys
Method of representation	Temporal evolution
Other explanatory notes	–
Fields/work in which it was used	–

Box 5.1 Assessment of Historical-Territorial Aspects in the New Piemonte Regional Landscape Plan In the context of regulatory revision pursuant to the implementation of the Cultural Heritage and Landscape Code, which today regulates the planning and protection of landscape in Italy, regional government is responsible for the application of legislation. The Piemonte Regional Authority has promoted a plan with a new concept, focused partly on historical-cultural landscape (Fig. 5.5). The plan identifies *historical-cultural systems and structures* (HSS), defined by schemes of historically consolidated relations, with a particular landscape value. The list of structures below indicates the categories of assets the indicators apply to historical-cultural systems and structures of the Piemonte landscape:

1. road system and associated infrastructures;
2. historical settlement structure in centres with a significant morphological identity;

Fig. 5.5 One of the most characteristic landscapes of Piemonte: hills in the region called Monferrato. (Photo by David Vicario)

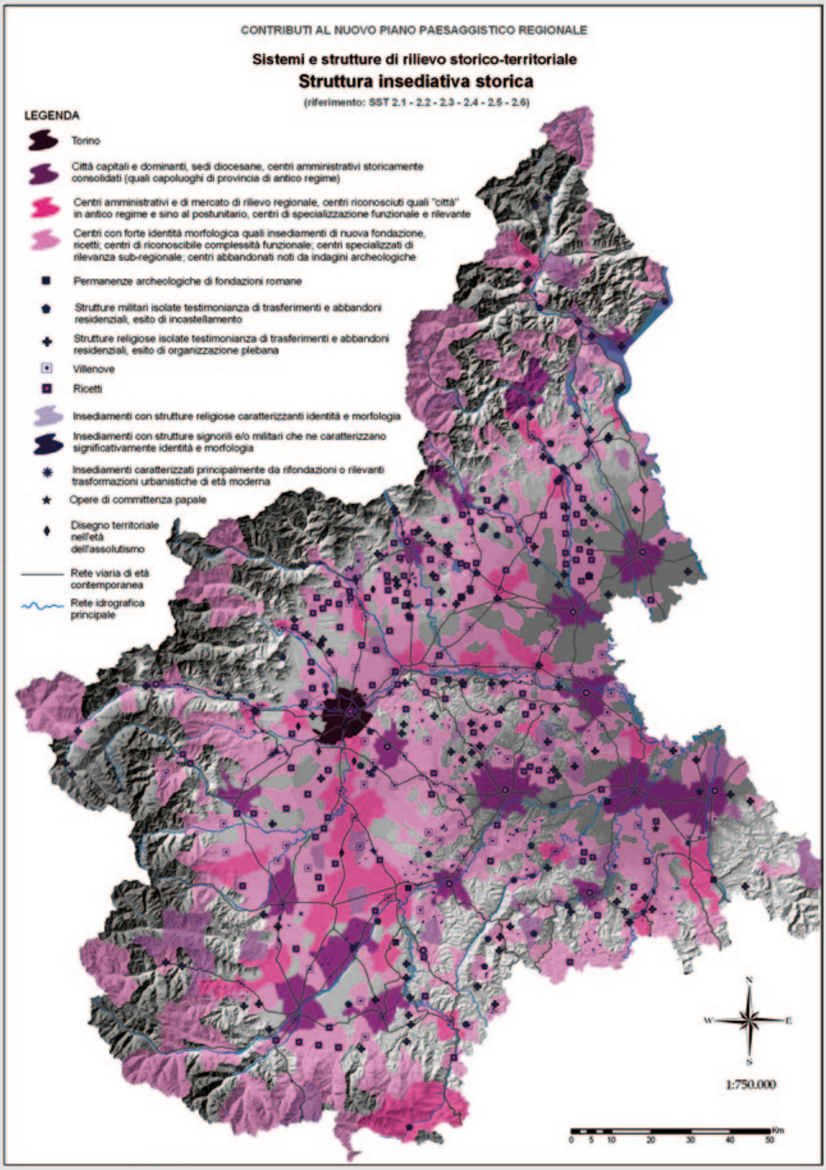
3. systems of historical value for rural territory;
4. systems/places associated with manufacturing and industrial production;
5. religious centres of territorial value;
6. fortification systems;
7. territorial contexts associated with historic holiday resorts.

Figure 5.6 shows the cartographic layout of an HSS, the "Historical settlement structure". A summary table corresponds to each HSS with the most significant elements for the purpose of landscape planning, of value also as indicators for characterization and monitoring (Fig. 5.7). A synthesis matrix, for all HSS, provides the evaluation framework for each indicator (Fig. 5.8).

Fig. 5.6 Systems and structures of historical-territorial importance: historical settlement structure.

The historical-territorial systems of landscape value can be identified using the cartography produced by GIS software. This is one of the tables showing the historical-cultural aspects of the landscape. It is focused on the settlement and historical urban components: settlements and old town centres constitute a fundamental texture for the characterization of contemporary landscape.

Key (in order): Turin. Capital and major cities, dioceses, historically consolidated administrative centres (such as capitals of provinces of *ancien régime*). Centres of commerce and administrative centres of regional importance, centres defined as "cities" in ancien régime and until after the unification of Italy (1861), centres of functional and relevant specialization. Centres with a strong morphological identity; centres of acknowledged functional complexity; specialised centres of sub-regional importance; abandoned centres known through archaeological survey. Archaeological sites and Roman foundations. Isolated military structures that



show relocations and residential abandonments, resulting from *incastellamento*. Isolated religious structures that show relocations and residential abandonments, resulting from the organisation of the parishes. *Villenove* (Middle Age new Settlements). *Ricetti* (collective fortifications). Settlements with religious structures that characterize identity and morphology. Settlements with *seignorial* and/or military structures that characterize significantly identity and morphology. Settlements characterised mainly by refoundation or relevant urban transformations in modern age. Works commissioned by the Pope. Territorial design in the age of absolutism. Contemporary road system. Main hydrographical system

HSS CONNOTATIONS

General value (of the HSS described)

- Structuring (S)
- Characterizing (C)
- Qualifying (Q)

Territorial framework

Localization principles:

- historical-political-institutional
- geomorphological/associated with the presence of resources for said asset
- economic/infrastructure

Distribution:

- major in regional context (MA - ■)
- ample (A - ◘)
- little or not present (N - □)
- major significance (MS - ●)
- significant (S - ◉)
- little or no significance (NS - ○)
- not valuable (NV- ✕)
- singularity (Si - ✱)
- local contexts characterised by marked morphological specificity
- local contexts of morphological homogeneity in relation to regional framework

Effects on historical-landscape of large scale relations Morphologies, concrete permanence and typifying characteristics

System morphology, dynamics of interaction with other HSS on a local scale (settlements and/or road system, hydrography, etc.)

- major significance (MS - ●)
- significant (S - ◉)
- little or no significance (NS - ○)
- not valuable (NV- ✕)
- singularity (Si - ✱)

Specificity of the HSS in relation to the geomorphological framework

- major significance (MS - ●)
- significant (S - ◉)
- little or no significance (NS - ○)
- not valuable (NV- ✕)
- singularity (Si - ✱)

Fig. 5.7 Historical-cultural structures and systems (HSS): significant characteristics for the quality of landscape, which may work as a starting point for establishing assessment indicators, are provided for every class of historical territorial system (symbols and letters refer to the Fig. 5.8)

EVALUATION ASPECTS OF HISTORICAL-CULTURAL CHARACTERISTICS	DYNAMICS OF TRANSFORMATION	**CLASSES OF HISTORIC ASSETS AND SYSTEM UNITS** ○ major significance (MS - ●) ○ significant (S - **O**) ○ little or no significance (NS - ○) ○ not valuable (NV- ✕) ○ singularity (Si - ✱) ○ Exemplification of contexts **CONSTRUCTIONAL KNOWLEDGE AND TECHNIQUES AND OTHER TYPIFYING CHARACTERISTICS OF BUILDINGS** ○ major significance (MS - ●) ○ significant (S - **O**) ○ little or no significance (NS - ○) ○ not valuable (NV- ✕) ○ singularity (Si - ✱) - Exemplification of contexts **OTHER ELEMENTS OF LANDSCAPE VALUE (SKYLINE, LIMITS AND MARGINS, CONSOLIDATED PERCEPTIVE ASPECTS)** ○ major significance (MS - ●) ○ significant (S - **O**) ○ little or no significance (NS - ○) ○ not valuable (NV- ✕) ○ singularity (Si - ✱) **CONSOLIDATED STRUCTURES** ○ major significance (MS - ●) ○ significant (S - **O**) ○ little or no significance (NS - ○) ○ not valuable (NV- ✕) ○ singularity (Si - ✱) **CRITICALITIES:** - physical degradation ✓ - abandonment ✓ - improper use ✓ - abuse of resources ✓ - *deconnotation* of typifying characteristics ✓ - perceptive interference ✓ - alteration of context/decontextualization ✓ - crisis in system of physical or immaterial relations ✓ - loss of identity or memorial value ✓ **POTENTIAL** - landscape value ✓ - documentary value ✓ - identity value ✓ - architectural value ✓ - possibility of reconstructing system or network ✓
	ENHANCEMENT REQUISITES	(…)

Fig. 5.7 (continued)

Historical-cultural structures and systems (HSS)			1.1	1.2	2.1	2.2	[...]	7.1	7.2
			S	S	Q	Q		C	C
Territorial framework	Distribution		□	□	□	■		▣	▣
			●	✱	✱	●		●	●
Morphologies, concrete permanence and typifying characteristics	System morphology, dynamics of interaction with other HSS on a local scale		●	o	●	●		●	●
	Specificity of the HSS in relation to the geomorphological framework		o	o	○	●		●	●
	Classes of historic assets and system units		✱	✱	✱	o		●	●
	Constructional knowledge and techniques and other typifying characteristics of buildings		o	o	o	o		o	o
	Consolidated perceptive aspects		○	o	●	o		●	●
Dynamics of transformation	Criticalities	Physical degradation	✓		✓				
		Abandonment		✓	✓	✓			
		Improper use	✓			✓			
		Abuse of resources						✓	✓
		Deconnotation of typifying characteristics	✓		✓	✓		✓	✓
		Perceptive interference						✓	✓
		Alteration of context/decontextualization	✓	✓	✓			✓	✓
		Crisis in system of physical or immaterial relations			✓	✓		✓	✓
		Loss of identity or memorial value	✓	✓					
	Potential	Documentary value		✓	✓	✓		✓	✓
		Identity value	✓						
		Architectural value						✓	✓
		Possibility of reconstructing system or network			✓	✓		✓	✓

Fig. 5.8 Synthesis matrix of landscape value indicators, applied to the Piemonte territory (extract of the synthesis)

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OECD Organisation for Economic Co-operation and Development. http://www.oecd.org
Piemonte Regional Authority—Ambiente. http://www.regione.piemonte.it/ambiente
UNCHS United Nations Centre for Human Settlements—Habitat. http://www.unhabitat.org/
UNESCO United Nations Educational, Scientific and Cultural Organization. http://www.unesco.org

Chapter 6
Assessing Visual and Social Perceptions of Landscape

Claudia Cassatella

Abstract The perceptual dimension is distinctive of landscape, if compared to the territory. "Measuring perception" is difficult and involves many critical assumptions. Investigating social perception means, first and foremost, establishing the public significance of various landscape values: historicity, naturalness, beauty, recreational usability, and so forth. Secondly, we must associate public preferences with the biophysical structures to which they refer. This study proposes a comprehensive list of references and possible indicators, ranging from scenic assessment to studies on visual preferences to more recently developed studies on landscape values in social perception. The scope of the chapter is to offer a fil-rouge in a developing field of study.

Keywords Scenic assessment • Landscape preferences • Social perception

6.1 Principles and Definitions

The perceptual dimension establishes the difference between the concept of landscape and apparently similar concepts such as territory and environment: for a landscape to exist, there must be a subject to perceive said landscape. The basic definition of the European Landscape Convention (CoE 2000) in fact is as follows, "'landscape' means an area, as perceived by people…" (Art. 1). The following imperative derives from this definition: "to assess the landscapes thus identified, taking into account the particular values assigned to them by the interested parties and the population concerned" (1.b). The Recommendation on the application of the ELC refers to and develops the theme: "The sensory (visual, auditory, olfactory,

Indicator tables drawn up with the collaboration of Luigi La Riccia.

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tactile, taste) and emotional perception which a population has of its environment and recognition of the latter's diversity and special historical and cultural features are essential for this respect and safeguarding of the identity of the population itself and for the enrichment of the individual and of society as a whole" (CoE 2008).

Perception is subjective, but is dependent on cultural codes, in a form of mediation between individual experience and collective values. According to some schools of thought, there are in any case some universally valid parameters, associated with the instinctive and intrinsic aspects of human nature. According to others, cultural coding prevails and the existence of the "landscape view" is not universal, but limited to certain societies and periods (*société paysagiste*, "landscape society", Berque 1995). In any case, for the purpose of landscape assessment it would seem useful to make a distinction between perceptual and aesthetic experience and what the ELC calls the "opinions and expressions" of social stakeholder groups (as suggested also by Potschin and Haines-Young 2005).

Therefore we will define two fields of perceptual landscape study:

(a) studies on *visual and multisensorial perception* and, also *aesthetic values* in the broader sense; studies on *landscape preferences*, in particular *visual preferences* belong to this field;
(b) studies on *social perception*, in other words the *intangible values* of which the landscape is an expression and vehicle for a certain society or social group; we should identify at least two groups of these values: the *cultural value* (for example memorial, identity) and the *fruition value or use* (for example productive, living, recreational and tourist).

Obviously, there are transversal relations between the elements of the layout, for example the aesthetic value is one of cultural values, associated with the fruition value. Nevertheless, this division is instrumental as it corresponds to different research techniques, when the subjects are, on the one hand, material and formal aspects, and intangible aspects on the other. In the first case, landscape *imageability* is analysed, in particular with focus on objective conditions (the "geometry" of vision, the formal characteristics of the scene) generalized and predictive of concrete experience; in the second case, *social acknowledgement*, in other words concrete collective appreciation is considered, the reasons for which can be found in the semiosphere rather than in the ecosphere. The first approach is preferred in the field of landscape management, while the second is limited almost exclusively to a field of pure research.

Calculating the qualitative social acknowledgement of a landscape is a new goal, the application of which is more suitable for policies rather than intervention. However, the most significant field of application for measuring perceptual landscape is in the evaluation of visual impact or, in general, the landscape compatibility of new interventions. Many of the indicators used are therefore contextualized on the basis of the relationship between a (new) element and a context (for example "overall dimension", "contrast"). However, in the field of landscape description and assessment, parameters of a holistic nature are often used (identity, perceptual quality, visual quality, and so on).

Before continuing, we should take a moment to consider the problem of the scale of observation. Visual perception is based on the presumption that a subject is immersed in the landscape, in a certain spatial and temporal position, the visual field of which is the reference to the natural scale; this scale is suitable for measuring a certain (limited) situation, but provides excessive detail for the assessment of extensive territories. For this reason we must use abstract and simplified concepts, but this step, unlike other types of indicators, is not linear and involves the substantial change of the subject and method of measurement. For example, taken as a panoramic value, at a detailed level it is possible to measure the amplitude of a view, but on a vaster scale the best we can do is measure the number of vantage points.

Also with reference to social perception, the question of scale involves substantial changes in the layout of the work: in a limited context, we can identify the representative subjects or groups of subjects in the local situation and if necessary obtain opinions from the same directly (for example using in depth interviews, on the basis of a phenomenological approach, cf. for example Scott et al. 2009), while on a vast scale we must use forms of mediation: it is still possible to use direct research methods (choosing a sample) or indirect methods, such as the analysis of indicative representations of the collective imagination: tourist brochures, web sites, and similar references (cf., for example, Germaine 2008).

The existence of such different situations induces us to consider the aims of the study each time the need arises, to choose appropriate methods and instruments.

6.1.1 The Study of Visual and Multisensorial Perception

Different theoretical models and practical goals result in a wide variety of methods of study for visual perception. Normally, at least two approaches are defined: expert based or public perception based, on the basis of the subjects asked to express an opinion. This may be a holistic opinion, or based on components and features of the landscape scene, or on factors of perception. In fact, there are some approaches that favour “objective” factors (biophysical components) and others that favour “subjective” factors (psychophysical components, preferences) (Daniel 2001). Daniel (2001) establishes the parameters for analysing landscape quality as follows: expert/design parameters, sensory/perceptual parameters, cognitive constructs.

The study of visual landscape perception has an extensive field of application in the assessment of the visual impact of transformations, so techniques for the quantitative measurement of objective factors have been developed, such as the formal characteristics of the scene, the “geometry” of vision (observation points, scope and depth of visual field, lines, colours, texture, etc.). Thanks to the use of Geographical Information Systems, the scale of application of these techniques has recently been developed (Brabyn 2009). Again through expert analysis, we can attribute values (spatially differentiated) of aesthetic quality, on the basis of proven criteria such as scenic beauty or attractiveness (extremely holistic), the imageability, integrity, and variety. The scenic value of a landscape can be "weighed" according to its visibility from populated places and busy routes, and on the basis of the level of public concern.

Numerous empirical studies have shown that the judgement of experts often does not correspond to that of the general public. Research and measurement techniques have therefore been developed based on the visual preference of social groups for landscapes or categories of landscape components, in both positive and negative terms. This is a field of study pursuant to psychology and environmental sociology, and uses methods of study such as interviews and questionnaires. Some researchers have tried to generalize the results of different empirical surveys, to obtain a model of preferences to use in environmental planning, other forms of planning, and for impact assessment: "By knowing what quantitative features in a landscape affect its aesthetic appeal, natural resource planners can make decisions on a factual basis about purchasing, developing, or preserving these features" (Shafer et al. 1969). The use of preference "predictors" means the advantage of avoiding costly and complicated direct surveys on the population. The matrix of environmental preferences drawn up by Kaplan and Kaplan is well known (1989, cf. Sect. 6.2.1 and Table 6.2). Some researchers, such as Appleton (1975) and Bourassa (1990), believe that certain landscape preferences do not depend on cultural differences and have their roots in human nature (the "savannah model", the main characteristics of which are visual openness, the presence of water and vegetation, and variety), while others have done in-depth studies on the variety of cultural codes on the basis of ethnic groups for example. The need to generalize is understandable; nevertheless, regardless of the territorial and social contexts, it would appear to be contrary to the nature of landscape.

For some time now, a few researchers have indicated that the study of landscape perception based on vision is static and limited, and that is would be preferable to study "landscape experience" ("cultural and experiential turn", Scott et al. 2009). This phenomenological approach uses in depth interviews, walks and community visioning exercises to interpret individual feelings.

Landscape perception also involves other sensorial dimensions as well as view. In particular it would seem that the olfactory and auditory senses are of some significance. Nevertheless, there are no widely-used and consolidated methods of study; therefore we will not dwell on the subject. The *soundscape* has been given more attention (in particular in famous works such as the admonition of Rachel Carson, *Silent Spring*, 1962) and therefore we now have methods for measuring noise pollution, but the parameters used are not sufficiently developed for landscape.

Atmospheric effects (fogginess, limpidity) and seasonal effects are certainly significant "colourings" for generating landscape impressions and can constitute identity factors for some landscapes (the "fog in the Po Valley" for example, or snow-covered landscapes, or the colours of autumn; in Vermont, for example, the reddening of maple woods is reported by the relevant tourist service); for this reason there have been some attempts to measure the factors that generate these *impressions*.

6.1.2 The Study of Social Perception

Many values influence landscape perception. Aesthetic judgement can be influenced by the sense of time and memory, use of space and the interests of the observer. It is usual for value to differ on the basis of “points of view”. The study of the “values in play” that influence landscape perception can therefore be strategic in the first phases for studying a specific situation, providing guidelines for policies and the strategic planning, and to define the types of indicators.

The study of social perception uses qualitative methods and constitutes a frontier of research, supported in particular by the indications of the ELC: identify and assess landscapes on the basis of the population concerned. It appears to be immediately clear that it is impossible to generalize and use opinions based only on expert knowledge. For that matter, applicative studies have often shown the difference between the judgement of “common citizens”, who tend to give generalized opinions, and experts who tend to identify the most differentiated parts and structures. Likewise, the first difficulty is to identify and distinguish the social groups of reference, who, as clearly shown by both the explanatory notes of the Convention (CoE 2000) and the subsequent recommendations of the European Council of Ministers (CoE 2008), are not limited to a group of inhabitants but include other different points of view: administrators, tourists, stakeholders. For this reason, one of the phases of assessment consists in the identification of “receptors”.

These groups can be asked to express opinions, on the basis of different participative procedures (discussions, workshops, questionnaires…), but landscape value is not only socially acknowledged through opinions expressed, but also in the practical use of the space and in various forms of representation, in particular figurative or literary representations that prove the fame, or in any case the presence of the same in the collective imagination. Therefore, methods of investigation can use inquiries or the analysis of landscape representations, interpreting the imagery.

Landscape is acknowledged as having different social functions, also in the documents of international bodies, from conserving collective memory to being a source of psychophysical wellbeing, amenity, educational values, etc. These values probably don’t have the same importance in the various different social and geographical contexts. The first studies therefore had the purpose of establishing *the types of value* attributed to landscape by social groups, in other words concerning the categorization of the relevant values. Therefore, landscapes can be classified on the basis of the level of presence/absence of certain selected values, again with reference to social opinion, if necessary highlighting the differences in the attribution of value between the often conflicting groups (for example, the use of some resources can conflict with the value of use and the value of conservation, the tourist value and the value of tranquillity). In literature (for example OECD 1997; NIJOS 2003; Wascher 2004; Palang 2008) the most frequently used categories of landscape values are:

- *historical-cultural value* (and/or traditional value),
- *identity value* (and/or value for the local population),
- *aesthetic value*,
- *amenity*.

Sometimes also the *educational value*, the *scientific value*, the *economic-productive value* (in particular for agricultural landscapes, or for those used in the tourist trade) are mentioned. In general, we can make a distinction between *value in itself* and the *fruition value*; studies in various different territorial contexts show the population has a distinct inclination for attributing a value in itself to landscape (Rogge et al. 2007), which is perhaps the inheritance of a contemplative attitude to landscape in times gone by; nevertheless, one of the preferential criteria in the studies on populations is the *appropriateness* of the landscape with respect to different use (residential, productive, recreational…) (*ibidem*). It is easy to see that most of the conflict which must be solved in the planning phase concerns the social use of landscape, and for this reason we should focus on the utilization or fruitive value, which includes a wide range of possible uses, from recreational to residential. The influence of the above and landscape is the subject of economic studies, covered in the relevant in-depth analysis (Bottero, *infra*, Chap. 8). The choice of the values of reference influences the score attributed to certain parameters; for example, the relationship between aesthetic value and fruitive value, between contemplative fruition and active fruition, and the different values that parameters such as attractiveness, tranquillity, and the presence of facilities can have as a consequence.

Available literature also suggests other general indicators, regarding the social value of landscape in itself. The *identitary value* of landscape is a holistic concept which is often referred to (for example in the documents of the OECD, ECNC, EEA, EC) but for which parameters and indexes have rarely been established; every attempt to define the identity appears to be tautological, or in any case based on implicit assumptions.

We believe it may be useful to propose a category called *ratified value*, with reference to the acknowledgement of the value attributed by institutions acting in name of the community and public interest, for example with administrative acts such as designations or restrictions. The existence of protected landscapes, in fact, is based on the acknowledgement of exceptional value and can therefore be considered a "proxy" indicator of the existence of identitary value.

The theme of social acknowledgement is associated with that of *social sensitivity* for landscape: the goals of the ELC include the "awareness, training and education" on the subject of landscape. Therefore, on one hand there is a measure of this sensitivity (for example the presence of landscape in social communication, the existence of actions for the protection and valorisation of landscape, or opposite phenomena); while on the other hand we have the effectiveness of actions to promote awareness and training that the Convention requires of the Regional Authorities, the effectiveness and efficiency of landscape policies (Vallega 2008).

6.2 Critical Review of Landscape Perception Indicators

6.2.1 The Scenic Value of Landscape and the Relevant Indicators

The aesthetic value of landscape is the most perceived value in terms of public opinion. Along with the identitary value, it is acknowledged by international organizations and included in some sets of indicators (especially with reference to agricultural areas), for example by the EEA, ECNC and OECD. First, let's take a look at the indicators (not many) proposed by these organizations to measure perceptual value, also on the basis of some comparative studies (for example MTT 2002; Wascher 2004; Waarts 2005).

- openness vs. closedness, heterogeneity vs. homogeneity, linear elements (OECD 1997);
- coherence, visual diversity, cultural identity, singular features (EEA 1998);
- openness vs. closedness, presence/adequateness of key cultural features, land recognized for its scenic and scientific value (ECNC, ELISA, Wascher 2000);
- landscape structures (environmental features and land use patterns, cultural features) (OECD 2001);
- number and diversity of memorable elements (EC DG-AGR, cit. in MTT 2002);
- Other indicators, partly used to measure the above, include: land use diversity (Wascher 2000), land use patterns (OECD 2001), land used for recreation (OECD 2003); share of characteristic habitat type (natural or cultural); share of traditional land cover types (Wascher 2000).

Some are parameters, others are cognitive categories, used also in methods based on preferences, which we will cover below. Furthermore, they can be used at different scales, but mainly on a vast scale. Note the focus on the concept of diversity: this is modified by the ecology of the landscape and ratified, for example, by the Pan-European Biological and Landscape Diversity Strategy (CoE 1995). The term *landscape diversity* can be ambiguous, in fact the measure of visual diversity (which should really be called variety) is often associated with land use and ecological parameters. These criteria, and other similar criteria, such as *harmony*, *order*, and *coherence*, can be classified using parameters of greater detail on the characterization of landscapes, such as *pattern, texture, features*.

Once again, we must emphasize the fact that these indicators have been drawn up for rural areas (Reho 2007; EC 2006). Many indicator systems have been studied for specific types of landscape: natural, agricultural, urban, periurban. For this reason, we will refer to some methods for various different landscapes.

One field of application, of longstanding tradition in the USA, is *Scenery Management* (or *Visual Resource Management*) of protected areas and areas of "outstanding beauty" (cf., in particular the manual of the USDA Forest Service—1995, and the USDI Bureau of Land Management), with an almost exclusive focus on natural landscapes. The two fundamental values of reference are *Scenic Attractive-*

ness (measured according to scale: Distinctive, Typical, Indistinctive) and *Scenic Integrity*; the general criteria are variety and harmony, analysed in terms of forms, colours, texture, etc.

In Anglo-Saxon countries there is a great deal of literature and many experiences pursuant to *Scenic View* or *Visual Assessment*, which focus on the local scale and also consider the townscape (with specific methods)[1]. In Great Britain, some authoritative references include the Landscape Institute manual (2002) and the manuals on Landscape Character Assessment (Swanwick 2002). The most commonly used perceptual values are *scenic quality, tranquillity, wildness*, and *representativeness*.

US methods often use scenic value according to the visibility from the most popular places and routes, and on the basis of the level of public concern, attributing a value of *sensitivity*[2] or *significance*, which can also be differentiated for different territorial levels (from local to national) and stakeholder groups. In this way, objective aspects (such as the characteristics of the scene, for example Visual openness) and perceptual aspects are combined.

All the above-mentioned methods are based on a preliminary classification of the views and characterization of the landscape. Many studies use Geographical information systems to perform these operations automatically: GIS in fact can establish the recurrences in the presence of certain landscape components (for example the presence of water or vegetation) and, if the spatial databases are accurate, can calculate the magnitude and depth of visual basins (viewsheds). For example, the method used in the New Zealand Landscape Classification (version 2) (Brabyn 2009) compares visual basins with types of landscapes and land use, allowing for the categories present on the area borders. The classes established attempt to represent the cognitive categories through which landscape is perceived (the hills and mountains for example), with particular focus on "preferential" elements for the population (a view of water for example). The author indicates that this classification is not yet representative of aesthetic values (or cultural values), and must be compared to the perception of the population, but it does however provide foundations.

While in the New Zealand method, GIS is used to calculate the presence of appreciated elements (such as water courses) in the views, GIS is used in others to calculate the range of influence of visual detractors. For example, the Enplan project proposed measuring the *perceptual quality* of periurban agricultural spaces as a result of the distance from constructed elements considered sources of visual and sonorous impact (urbanized areas and infrastructures) (Socco 2005). The method

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[1] One of the most recent and ambitious is the *Qualitative Visual Assessment* of the City of London (Mayor of London 2007), which was not however expressed in the form of indicators. See also CABE methods. In the USA, we can refer to a review of experiences in the City of Cincinnati (2007), on methods and regulations for the protection of views in various locations, including regulations based on parameters and indexes.

[2] "Sensitivity levels are a measure of public concern for scenic quality" (USDI, BLM); Sensitivity on the other hand has another meaning in England: "the extent to which a landscape can accept change of a particular type and scale without unacceptable adverse effects to its character" (Landscape Institute 2002).

does not let us identify constructions as elements of impact or qualifying elements; and is more closely related to calculating the visual integrity of an agricultural area.

The Lombardy Regional Authority has drawn up a method based on GIS to classify the *Landscape significance* of the territory on an exclusively cartographic basis: the *significance* is calculated as a mean of the values of morphology, vegetation and historical heritage, in the equivalent cells (Lombardy Regional Authority 2007, see Table 6.6).

Turin Polytechnic, in the Corona Verde project (a study on the Turin metropolitan area) proposed calculating the concept of *imageability* as a product of the density of morphological signs, water, vegetation, historical features, and scenic components such as picturesque and panoramic views and landmarks (Cassatella and Castelnovi 2007, see Box 6.1). The method used involves direct reconnaissance on the territory and the cross-referencing of variables using GIS for each landscape unit.

In Italy until today, studies and applications have concentrated on the assessment of environmental impact (in particular, visual impact), and this creates a different prospect in the formulation of indexes and indicators, expressed in the form of a relationship between an element (the new intervention) and its context. In fact, EIA regulations on the "landscape" component, envisage "the strictly visual or cultural-semiological study of the relationship between the subject and the environment" (Prime Ministerial Decree 27/12/88). In the EIA manual of the Italian Association of Environmental Analyst (Colombo and Malcevschi 1999) perceptual indicators are classified in three fields: *Generic perceptual, Perceptual from single points of view, Perceptual in relation to new interventions*.

The verification of interventions in designated sites in terms of landscape compatibility, introduced by the new Cultural Heritage and Landscape Code (Italian Republic (2004) and s.m.i., Prime Ministerial Decree 12/12/2005) was a new impetus for studies of this type; the Ministry of National Heritage and Culture provided guidelines (Scazzosi and Di Bene 2006) with parameters on the evaluation of quality, criticality and alterations of the landscape. We propose a reworking in Table 6.1.

All the above are based on expert analysis. We will now consider methods based on public opinion. As we will see, some of the same indicators are used, but with another subject expressing the opinion. Surveys on visual preferences were mainly developed in the late twenteith century and in particular in the USA in the 1970s. The method used by authors such as Kaplan and Kaplan, Appleton, Zube, Shafer, is still used as a reference to implement or falsify. They suggested that people prefer settings that support the need to understand their surrounding and, simultaneously, the need for exploration.

Numerous applicative and also comparative studies have been published in the journals 'Environment & Behaviour' and 'Landscape and Urban Planning' (for example Daniel 2001; Rogge et al. 2007). There are two main approaches: the first aims to obtain a holistic judgment on types of landscape, the second for components; this second method attempts to estimate landscape appreciation on the basis of the presence of certain elements or structures, correlating the declared preferenc-

Table 6.1 Parameters for landscape assessment and modifications (reworking on Scazzosi and Di Bene 2006)

Quality	Scenic quality
	Richness of visual stimuli (visual diversity)
	Imageability (probability that the scene remains impressed in the mind of the observer)
	Social (presence of visual and historically consolidated scenes)
	Acknowledgement, integrity (permanence of distinctive characters in natural systems and historical anthropic systems)
	Rarity (presence of characteristic elements, in a reduced number and/or concentrated in some sites or special areas)
Criticality	Degradation (loss, damage to natural resources and cultural, historical, visual, morphological, testimonial characters)
Alterations	Intrusion
	Division
	Fragmentation
	Reduction
	Concentration
	Destruction
	De-connotation

Table 6.2 Matrix of environmental preference (Kaplan et al. 1989)

Information variables	
Making sense	Involvement
Coherence	*Complexity*
Legibility	*Mystery*
Perceptual variables	
Openness	
Smoothness	
Locomotion	

es to land use structures. Some authors try to establish correlations with elements of landscape ecology (dimension of spots, length of perimeters and so on), therefore attempting to establish relations between two normally separate approaches (see, for example, Schüpbach 2003).

There are some indicators the use of which is generally accepted, and these are considered “predictors” of preference, nevertheless, every form of research in the field redefines the set on the basis of the characteristics of the landscape observed. For this reason, it is not a good idea to isolate the single indicator, but better to think of them in groups, for example:

- *Legibility, coherence, complexity, mystery, prospect-refuge* (Kaplan 1979)
- *Variety/unity, vividness/harmony, visual penetration, focality, complexity* (in Daniel 2001)
- *Naturalness, vividness, variety, unity* (Clay and Smidt 2004)

- *Naturalness, openness, maintenance, variety; to which the parameters vegetation, buildings and human constructions, openness, maintenance or tidiness, agricultural crops and variety correspond* (Rogge et al. 2007)
- *Wilderness, presence of well-preserved man-made elements, percentage of plant cover, amount of water, presence of mountains, colour contrast* (Arriaza et al. 2004)
- *Unity, use, maintenance, naturalness, spaciousness, development in time, soil and water, sensory qualities (colour, smell)* (Coeterier 1996)
- *Amount of nature, ruralness, calmness, unity/coherence, accessibility, historical identity, quietness, wide horizon, spontaneity of nature, water, relief* (Farjon et al. 2009).

The latter studies are European; not by chance, "historical character" can only be found in these. The emphasis on naturalness is particularly relevant to methods developed in the forestry field. The set of attributes are determined culturally by national or continental factors[3]. In any case, generalizing and interpreting, the most common are: *perceptual naturalness, visual openness, variety, vividness* (brightness and contrast), *historicity* and *care* (order, maintenance, cleaning).

One fundamental aspect of studies on landscape preferences is the choice of the sample, normally divided into groups; one of these groups can be the group of experts. These are undoubtedly useful for facilitating a comparison between the various groups, forcing them to clearly express (or have clarified) the implicit values of their judgements.

A Dutch study on the population's appreciation of the landscape, done by Alterra on a national basis and set up to monitor the effectiveness of landscape policies in time (every three years), is worthy of note: the objective of the policies is a 25% increase in appreciation from 2007 to 2020 (Farjon et al. 2009, see the above parameters). The survey was done in 2006 on two samples, one representative of the social groups, and the other of the types of national landscape. The preferred physical characteristics (for example the openness of the horizon) where included in a map; in this way an appreciation model based on GIS lets us make forecasts on the impact of potential transformations[4]. Nevertheless, according to the authors, comparisons show that the GIS system is not very effective as a predictor, and surveys done using questionnaires are invaluable.

The refinement and diffusion of three-dimensional simulation models has also resulted in the use of renderings in surveys on visual preferences (Ode et al. 2010). Like photography, this medium also has limits of verisimilitude, and researchers have still to reach an agreement on the appropriateness of its use.

[3] This is not the opinion of all the researchers involved in these studies: some studies have the aim of verifying the predictors in relation to groups of people from different cultural groups, to reach a conclusion on the universal nature of the same (Yang and Brown 1992).

[4] In particular, the authors' argument is that the most dangerous phenomena is *landscape cluttering*, in other words fragmentation, which limits the horizon and encloses it in urban-type backdrops, and the introduction in rural contexts of alien and industrial type elements.

6.2.2 The Social Value of Landscape and the Relevant Indicators

As mentioned above, in this field there are only some experimental studies. First and foremost we should focus on studies that put the emphasis on *the types of value* attributed to landscape by social groups, to categorize the values in question, for example the research done by Luginbühl, Palang, the Landscape Observatory of Catalunya, and English Heritage.

Indicateurs sociaux du paysage (social indicators of landscape) is an essay by Luginbühl (2009). This refers to studies done in French Departments, based on interviews with town mayors, and one national survey, based on interviews with Conseillers généraux; politicians are therefore chosen on the basis of being representative of the respective community. The questions aim to highlight social landscape representations, the dynamics, and the practices of the stakeholders. In the first case, on a cartographical basis, the questionnaire indicates: landscapes of local interest, the transformation of local landscapes, landscape management projects. In the second, the questionnaire concerns: the interviewee, the landscape of the district and its evolution, as well as the landscape in general. We cannot refer to indicators in the strictest sense, but nevertheless, through statistical analyses (factor analyses of correspondence) key concepts emerge, preferences in relation to the landscape in general and certain types of landscape (almost models), which could probably be used subsequently as indicators.

Another French study, on a local scale however, concerning "Suisse normande" (Germaine 2008), the purpose of which is to obtain information on the identity of the place, is based on the same theoretical and methodological setup. The research involves three phases: characterization of the visible landscape (landscape diversity), assessment of the residents' and planners' representations of landscape, description of the relations between the physical properties of the landscape and the perceptions of the stakeholders. The opinions are analysed using WordMapper© software to establish the word recurrence and associations; the iconography of places produced on a local scale (in particular for tourist promotion) is drawn up in a table to establish: citations, borders, characteristics, spaces used, activities.

A simpler method pursuant to iconography alone is used in the *Piemonte landscape atlas* (Cassatella 2007, see Box 6.2). Two groups of representations of regional landscapes are analysed: the images of Piemonte in wide-known publications on the Italian landscape, and those used by the Regional Tourist Agency. The result is data on the frequency of citations for the places and values associated with the images (in the form of *morphological, naturalistic, historical-cultural, aesthetic, economic, disvalues*). *Fame* (which is measured using a citation index) can therefore be used as an indicator to try and obtain an identitary value, but it will probably represent the point of view of outsiders rather than that of inhabitants.

Representativeness ("whether the landscape contains a particular character, and/or features and elements, which is felt by stakeholders to be worthy of representing", Swanwick 2002) and "Associations with particular people, artists, writers, or other media, or events in history" (idem) are value criteria which are considered by Landscape Character Assessment.

The Catalan Regional Government landscape law considers various landscape values, including symbolic and identitary values, other intangible values and fruition values. Landscapes are assessed and indicators defined in the landscape cataloguing process of the Landscape observatory (Sala 2009). As the perceptual aspect is believed to be qualitative, "the catalogues avoid the hierarchization in levels of landscape quality and the quantification of its values" (Nogué 2008). The methods envisage in depth interviews and workshops, in the conviction that participatory processes in the choice of policies are facilitated by involvement in the early stages of drawing up the catalogues. The Observatory has published a volume *Landscape Indicators* on the theme (Nogué et al. 2009), proposing a set of 10 indicators; of these, the following are pertinent to the theme: *knowledge of the landscape, landscape satisfaction, landscape sociability, landscape and communications*. Furthermore, the two indicators regarding "the application of the landscape law" and "the public and private implementation on the protection, management and planning of landscapes", can be associated with social sensitivity.

In England some values are already clearly expressed in policy statements, in particular with reference to the protection of the countryside. The studies can therefore progress from the postulation of the existence of common values, and concentrate on the methods for measuring the same. This is the case in studies on *Tranquillity* (see Table 6.8), the social function of which for psychophysical wellbeing is ratified by the British Government's Rural White Paper (Defra 2004), therefore this value is used locally in the assessments of plans. Developed in particular by the Forestry Commission and the Countryside Agency (1995), it is associated with *wildness* and *naturalness*, and the absence of urban influences (note that in this way the "tranquillity" of small villages is not considered, even if relevant). Areas characterised by noise, visual intrusion, and recreational use are classified on the basis of measurable parameters, such as the distances from urban areas, roads, airports, to create a map of *tranquil areas* and *vulnerable areas* (tranquil areas with disturbances). The Countryside Agency (2005, cf. Haggett et al. 2009) proposes a more refined method, which attempts to consider which are the appreciated elements and which are the unwelcome elements for the local community, establishing criteria and influence on the basis of public surveys (direct interviews using questionnaires). The result is a *Map of relative tranquillity*, where "relative" means "locally significant". In the application illustrated by Haggett et al. (with a certain level of complexity concerning the use of GIS with the cross-referencing of variables) the decisive factors are: human presence, some landscape characteristics (the perceptual naturalness) and noise. Once again this indicator is significant in an agricultural context, but not in an urban context.

One of the generally social functions attributed to landscape is the recreational function, and tourism in particular. The indicators can register current use, by indexes such as the presence of tourists or number of guests in holiday farms (MTT 2002), although it is hard to distinguish between the different reasons for which tourists choose a site for holidays. This is pursuant to the field of economic landscape assessment, covered in Chap. 8; here we will simply mention the fact that these techniques can be used to help estimate the values of use (for example tourist demand, residential demand), and to estimate the value attributed to landscape in itself and the conservation of the same (Marangon and Tempesta 2008). Economic analysis methods would seem to be promising in relation to the problem of estimating the *social acknowledgement* of landscapes in general terms, with due caution and preconditions; consider for example, an index such as the "percentage of agricultural products sold with the regional trademark" (Wascher 2000): this can only suggest the identitary value of a territory, if we assume there is a relationship between the image of the territory and the product.

Finally, we should mention a landscape indicator frequently adopted for many uses: the presence (or percentage) of listed/designated elements or sites. From the point of view of social perception, this is indicative of interest in protection; nevertheless, it is a static indicator with no parameters and threshold values.

6.2.3 Catalogue of Landscape Perception Indicators

Published indicators can be divided as follows:

(a) Visual and multisensorial perception indicators (Table 6.3)

- visibility
- visual and perceptive detractors
- relationship between new interventions and context
- multisensoriality
- characterization
- parameters for the analysis of preferences

(b) Social perception indicators (Table 6.4)

- general and holistic
- cultural, symbolic and identity value
- fruition, recreational value
- ratified value
- social sensitivity

The name of the indicator was given by the author, while we provided the necessarily brief description; similar indicators or indicators with different names that refer to the same phenomenon have been grouped together. The source is the source from which the indicator was obtained, which may not always be the primary source, because many comparative studies were used, and some are so common they cannot be attributed to one single author.

Table 6.3 Catalogue of visual and multisensorial indicators

Visibility	Scenic quality, vantage points	Vallega 2008
	Openness vs. closedness	OECD 1997
	Focality, depth of visual field	Kaplan 1979
	Visibility (n. of views, type, aperture, depth, frequency)	Colombo and Malcevschi 1999; Malcevschi and Poli 2008; USDA 1995; LI 2002
	Skyline visibility	Colombo and Malcevschi 1999; Greater London Authority 2007
	Presence of historical scenes (consolidated views)	Scazzosi and Di Bene 2006
	Scenic attractiveness (Distinctive, Typical, Indistinctive), scenic quality	USDA Forest Service 1995; USDI Bureau of Land Management; Swanwick 2002
	Scenic Integrity	USDA Forest Service 1995
Perceptive and visual detractors	Visual detraction (n./area of elements in a specific area of reference)	Colombo and Malcevschi 1999; IFEN 2001
	Obstructions of panoramic views	Colombo and Malcevschi 1999
	Verified unauthorized buildings	Malcevschi and Poli 2008
Visual impacts of new interventions in a given context	Quality of the intervention, compatibility, mimicry with regard to the landscape lines	Colombo and Malcevschi 1999
	Visual obstruction (score), distance from vantage points, angle of view; contrast, bulk	Colombo and Malcevschi 1999; LI 2002; Greater London Authority 2007; Kearney et al. 2008
	Loss of landscape diversity	Scazzosi and Di Bene 2006
	Intrusion, division, fragmentation, reduction, concentration, destruction, de-connotation	Scazzosi and Di Bene 2006
Multisensorial perception	Tranquillity	Countryside Agency 2005; Swanwick 2002; Haggett et al. 2009
	Perceptive quality (integrity of a rural area in terms of distance from settlements and infrastructures)	Socco 2005
	Landscape sonority (presence of singing animals, silence)	Colombo and Malcevschi 1999; IFEN 2001
	Atmospheric and seasonal effects (limpidity, fogginess, seasonal changings, etc.), "special effects"	Colombo and Malcevschi 1999; Pachaki 2003

Table 6.3 (continued)

Landscape characterization	Visual diversity, variety	EEA 1998
	Heterogeneity vs. homogeneity	OECD 1997
	Coherence, unity	EEA 1998
	Imageability	Cassatella and Castelnovi 2007
	Significance	Lombardy Regional Authority 2007
	Singular features; presence/adequateness of key cultural features	EEA 1998; ECNC, ELISA: Wascher 2000
	Number and diversity of memorable elements	EC DG-AGr, cit. in MTT 2002; Pachaki 2003
	Appearance and materials (texture, scale, colour, patterns…)	Swanwick 2002
	Land use patterns	OECD 2001
	Tree canopy coverage	Dwyer and Miller 1999; American Forests 2002; Zhu and Zhang 2007
Parameters for the analysis of preferences	Imageability	Potschin and Haines-Young 2005
	Legibility	Kaplan et al. 1989
	Coherence	Kaplan et al. 1989
	Complexity	Kaplan et al. 1989
	Mystery	Kaplan et al. 1989
Parameters for the analysis of preferences	Openness; Spaciousness	Kaplan et al. 1989; Coeterier 1996
	Smoothness	Kaplan et al. 1989
	Focality, Prospect-refuge, visual penetration	Kaplan et al. 1989; Daniel 2001
	Variety vs. unity	Daniel 2001; Coeterier 1996
	Vividness vs. harmony, contrast	Daniel 2001
	Naturalness, Spontaneity of nature	Clay and Smidt 2004; Rogge et al. 2007; Farjon et al. 2009
	Ruralness	Farjon et al. 2009
	Calmness, quietness	Farjon et al. 2009
	Maintenance, tidiness, use	Coeterier 1996; Rogge et al. 2007
	Development in time; historical identity	Coeterier 1996; Farjon et al. 2009
	Sensory qualities (colour, smell)	Coeterier 1996

Table 6.4 Catalogue of social perception indicators

General and holistic perception	Intrinsic value (willingness to pay for the conservation of a given landscape)	Marangon and Tempesta 2008
	Benefits for society, opinions and expressions of the stakeholders	Potschin and Haines-Young 2005; USDA 1995; LI 2002
	Sensitivity (level of public concern)	USDI, no date
	Attractiveness for the public	USDA 1995; Farjon et al. 2009
	Fame (citation index in various kinds of representations)	Cassatella 2007
Cultural, symbolic, and identity value	Fame (citation index in various kinds of representations)	Cassatella 2007
	Cultural identity	EEA 1998
	Representativeness	Swanwick 2002
	Associations with particular people or events in history	Swanwick 2002; Vallega 2008
	Association with typical products and tastes (percentage of agricultural products sold with the regional trademark)	Wascher 2000; Vallega 2008
	Share of traditional land covers types	Wascher 2000
	Rarity	Swanwick 2002
Fruition, recreational value	Appropriateness of the landscape with respect to different use	Daniel 2001
	Land used for recreation	OECD 2003
	“Experiences of landscapes”	ELCAI: Wascher 2005
	Recreational value, amenity	Palang 2008; Swanwick 2002
	Accessibility	Pachaki 2003
	Tranquillity	Countryside Agency 2005; Haggett et al. 2009; Wascher 2005
	Wildness, perception of naturalness	Swanwick 2002; USDA 1995
Ratified value	Presence (/number, /area) of protected landscapes, listed/designated elements or sites	Vallega 2008
	Land recognized for its scenic and scientific value	ECNC, ELISA: Wascher 2000
	Landscape protection, protection of typical landscapes	Vallega 2008
Social sensitivity for landscape	Actions for the protection and valorisation of landscape	
	Effectiveness and efficiency of landscape policies	
	Knowledge of the landscape	Sala 2009
	Landscape and communications, Presence of landscape in social communication	Sala 2009
	Landscape satisfaction	Sala 2009
	Landscape sociability	Sala 2009
	Loss of maintenance (abandoned areas)	Colombo et al. 2008

6.3 Proposal for Landscape Perception Indicators

The number of indicators found in literature is a sign of the diversity of use and the experimental phase the subject is currently going through, rather than a sign of rich content. Many of these "indicators" are unsuitable for formalization, and those that could be formalized and consolidated are only suitable for detailed assessment, typically for the assessment of visual impact for single works. In other cases, the problem with the indicator is that it has no thresholds of reference (for example, the total number of panoramic views is insignificant, while the variation in time may be of some significance).

When making a selection and a proposal we will consider the main aims of this study, in other words the application of the principles of the ELC, and the two chosen scales of reference (regional and local) (Table 6.5).

The indicator *landscape diversity*, clearly changed by ecology, but referring to perceptual diversity, is the most commonly mentioned and perhaps the only indicator that maintains the same meaning at any scale. Nevertheless, there are different measurement methods, both qualitative (based on the interpretation of signs and cultural elements) and quantitative, using the concept of the richness of heteroge-

Table 6.5 Proposed perceptual landscape indicators

Indicator	Category	DPSIR	Scale	Use
1. *Variety (or visual diversity)*	Visual perception (characterization)	S	Regional, Local	Frequently applied
2. *Landscape significance*	Visual perception (characterization)	S	Regional	One case of application
3. *Imageability*	Visual perception (characterization)	S	Local	One case of application
4. *Obstruction of view from viewpoints*	Visual perception	I	Regional, Local	Applied, reworking
5. *Visibility of the sky at night and silence (Absence of pollution from lighting and noise)*	Multisensorial perception	S	Regional	Proposal for experimentation
6. *Fame, variation in time*	Social perception, cultural/identity value	S/I	Regional, Local	Proposal for experimentation
7. *Tranquillity*	Social perception, fruitive value	S	Local	Applied
8. *Amenity*	Social perception, fruitive value	S	Regional, Local	Applied
9. *Landscape protection (see Table 7.12)*	Social sensitivity	R	National/ Regional/ Local	Applied
10. *Tree canopy coverage*	Visual perception	D	Local	Applied in environmental report, to be adapted

neous objects. We propose using the term *variety* (Table 6.12), to avoid any implicit ambiguity in the expression "diversity" and the risk of confusion with the concept of "richness", indicating some descriptors used[5].

The attempts to assign a value of *significance* (Lombardy Regional Authority 2007) or *imageability* (Cassatella and Castelnovi 2007), cross-referencing the presence of signs from the built-up environment or vegetation, etc., go along the same lines; the latter includes the visual aspect, while the first is based on physical elements and measurements, and is of a significantly automated nature (Tables 6.6 and 6.7).

The use of indicators on negative phenomena also seems to be effective, in other words on the loss of value of the landscape: for example *obstruction of panoramic views* or landmarks[6] (Table 6.10).

Of social values, *fame* has the advantage of being easy to verify (through an index of citation, although the choice of the field of observation remains open), certainly less problematic than verifying "identity" or identification in a landscape (Table 6.11). The frequency of citation can be measured through direct surveys (interviews), or using indirect methods, for example through a sample of representations (literary, artistic, journalism, web sites or using other means of communication). Depending on the sample chosen, we can obtain the point of view of the local community or more extensive or external groups, and using comparison (as in the

Table 6.6 Landscape significance

Indicator	Landscape significance
Definition	Density of natural and anthropic signs characterizing landscape
Description	Synthetic index for the characterization of landscape on the basis of the presence of physical and cultural characteristics. Calculated dividing the territory into equivalent cells
Category	Perception
Aims pursuant to landscape	Evaluation
Status/Process	Status
DPSIR Category	Status
Typology	Index
Component variables (if index)	• Morphological complexity • Significance of cultural landscape • Vegetational provision

[5] There is significant reference to the concept of visual variety-complexity in the works of Kaplan (1979), Nohl (2001) and Roth (2006): In particular, the more complex the scene, the more complex the possibility of interpreting the same, with the resulting implicit uncertainty in the difficulty of "dominating" the surrounding landscape.

[6] In Italy, an indicator on the existence of *verified unauthorized building* was proposed (Municipality of Caivano, in Malcevschi and Poli 2008). This does not necessarily indicate the existence of damage to the landscape, but may indicate scarce social sensitivity for the protection of heritage and community interest. Nevertheless, this indicator could paradoxically penalize the regional or municipal authorities who are most committed to fighting and reporting such phenomena. Another proposal is the "number of authorizations requested for intervention in protected areas" (Franceschetti and Pagan 2007).

Table 6.6 (continued)

Indicator	Landscape significance
Unit of measure	Five value classes; the value is calculated according to the simple mean of three indexes, calculated for each cell: • Level of morphological complexity: for the mountainous part, the difference between the two extreme values for altitude in the cells of the grid was calculated; for the plains, the presence of a series of geomorphological elements selected on the basis of the significance for the characterization of the Lombardy plains was indicated. • Level of significance of the cultural landscape: presence of restrictions (designated sites) and connotative elements of the landscape indicated in the Regional Territorial Plan. • Level of naturalness: presence of natural elements, with differentiation between those in the hills/mountains and those in the plains
Territorial scale of reference	Regional scale
Time scale of reference	Not reported
Characteristics of use	Various technical-administrative uses proposed
Availability of data source	GIS cartographic database available
Method of representation	GIS thematic map on grid (cells 500 × 500 m)
Other explanatory notes	The significance of cultural landscape is only defined using quantitative type indexes
Fields/work in which it was used	Lombardy Regional Authority 2007

Piemonte landscape atlas, Cassatella 2007, see Box 6.2) indications can emerge, in fact the indicator has no thresholds of reference and a relative meaning. For this reason it would seem to be more significant to observe the variation in time, which means having to choose a sample that can presumably be referred to at a later date (certain tourist guidebooks for example).

Of the numerous values that can be socially attributed to landscape, "tranquillity" and "amenity" represent two distinct and sometimes antithetical extremes, often subject to experimentation. On the theme of amenity, see the chapter on economic assessment. On the theme of tranquillity, we have already quoted British studies based on the rich Landscape Character Assessment knowledge-base and used throughout the territory, in all probability too onerous for many other contexts. Some elements associated with tranquillity can be extrapolated and used as indicators: in particular, the *visibility of the sky at night and silence*, which also make it possible to consider the multisensorial dimension of landscape[7] (Table 6.9).

[7] In Italy, the visibility of the sky at night has been declared an "identity asset" by the Sardinian Regional Authority; as such it is protected.

Table 6.7 Imageability

Indicator	Imageability
Definition	Density of distinctive signs in an ambit, of a natural, cultural and scenic character
Description	Synthetic index on the potential of a place to be remembered, on the basis of the presence of signs useful for orientation or common signs characterizing the identity of the ambit, of a natural, cultural and scenic type. It is calculated by dividing the territory into landscape units
Category	Perception (visual)
Aims pursuant to landscape	Evaluation
Status/Process	Status
DPSIR category	Status
Typology	Index
Component variables (if index)	Density, in the landscape unit, of: Signs of the common documentary historical system (value scale: zero, low, medium, high). The density of the signs of a traditional settlement (farmhouses, chapels, votive shrines, buildings pursuant to channels, farmsteads, roads and hedgerows) and registered historical-cultural heritage is considered. Signs of nature (value scale). The density of elements pursuant to the use of morphology (rivers, lakes, versants) and vegetation (woods, hedges and hedgerows, arboreal cultivations or other characterizing elements) is considered. Scenic-perceptive components (the presence of viewpoints of the natural and built-up environment, protected panoramic views and other panoramic views)
Unit of measure	Value scale of three classes (high, medium, low)
Territorial scale of reference	Local scale
Time scale of reference	Not reported
Characteristics of use	Expert technical-scientific analysis of a qualitative and quantitative type using a geographical information system.
Availability of data source	Geographical database and direct surveys on the territory
Method of representation	Thematic map created using overlay mapping with maps for each single component
Other explanatory notes	Can be calculated for each landscape unit or cell; the synthesis between the different components can be based on algebraic factors or on expert qualitative estimation, attributing weights to notable elements (for example the presence of a famous or symbolic monument, which will have a greater value than a single unit)
Fields/work in which it was used	Cassatella C and Castelnovi P 2007 (see Box 6.1)

The proposed indicator is therefore experimental, but may be based on available data and could be particularly significant if a new European Resolution is passed on the subject—current draft: “Noise and light pollution. Draft Resolution and Recommendation” (CoE 2010) (see Table 6.9).

Finally, we include *tree canopy coverage* in the list, as a suggestion to use in highly urbanized contexts, where the indicators for open landscape can be less significant (Table 6.13). In reality, this indicator is used in balances of environmental sustainability, but the proposed use is based on the assumption that a good level of coverage provided by the foliage is beneficial not only in ecological and climatic terms and to reduce atmospheric pollution, but also for the perception and aesthetic qualities of the urban landscape (in fact, the presence of vegetation is one of the most common predictors of visual preference).

In brief, the following indicators are proposed.

On a regional scale:

- Variety
- Landscape significance
- Obstruction of views from viewpoints
- Fame, variation in time
- Visibility of the sky at night and silence (in other words the absence of pollution from lighting and noise)

On a local scale:

- Variety
- Imageability
- Obstruction of views from viewpoints and of landmarks
- Tranquillity
- Amenity
- Tree canopy coverage

Box 6.1 Example of “Imageability” Indicator Application The “Corona Verde project. Strategic planning and governance” is a master plan pursuant to environmental and landscape planning, the protection of resources and the fruitive valorisation of open spaces in an area which roughly corresponds to the Turin metropolitan area: ninety municipalities, 25,000 ha, 11 protected areas, including the Turin Po Valley park; a hub of ecological networks in the area, subject to the pressure of urbanization. The territory is also rich in stratified historical heritage, with important routes and centres from both a historical and landscape point of view; in particular the Savoy Residences, a Unesco Heritage Site, in the circuit of royal residences around the city called the “Crown of delights”. The goals of the project (drawn up by the Inter-University Department of Territorial Studies of Turin Polytechnic for the Piemonte Regional Authority, head of scientific research R. Gambino) are to consolidate environmental and cultural networks, improve fruition and the landscape.

The research and assessment concerned all the open spaces in the metropolitan area: natural spaces, farmland, periurban areas. The research on landscape and fruition is done in extremely small landscape units, due to the fragmentation of the area, the identification of which is based on the dynamics perceived in relation to the categories: natural, agricultural, settled, urban, with facilities.

The following values (low, medium, high) are attributed to each unit, on the basis of cartographical analyses and surveys in the field:

- density of natural signs (morphology, hydrography, woods and other elements of the vegetation such as hedges or linear systems)
- density of signs in the diffused historical-documentary system (rural buildings, registered historical-architectural assets, historical-architectural elements in the landscape)
- diversity and visual richness (presence of views, panoramic routes, viewpoints).

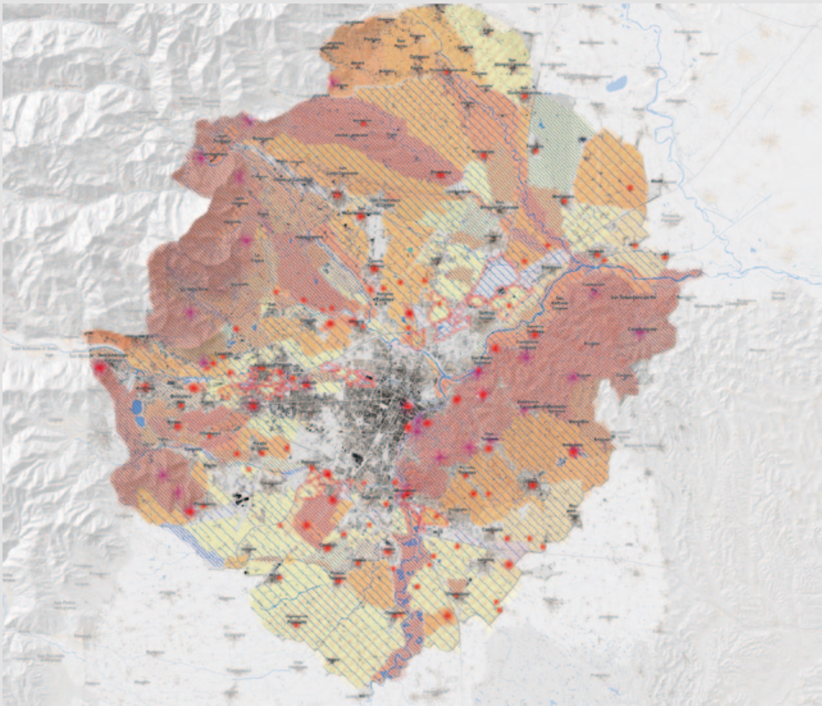

Fig. 6.1 The Corona Verde project. Landscape classification, Table C.2, Imageability, (original in scale 1:50,000). The full-colour fields represent the values of imageability (low, medium, high), the halftone areas represent the source values (density of natural signs, density of signs of the diffused historical-documentary system), the points indicate viewpoints and landmarks

The suitably interpreted cross-referencing of these values, gives us the imageability value (low, medium, high).

The cartographic representation is therefore drawn up in area fields based on units; to express the concept clearly, the original values were also included in the form of shading and points.

The value of imageability was used to obtain the overall landscape value, and in some cases, for places of notable interest, a low level of imageability was considered indicative of landscape criticality (Fig. 6.1).

The attribution of the value of imageability within certain limits can be based on the interpretation of cartographic bases, with a necessary information layer on visual characters, requiring direct surveys. The field study is also required to verify the sign value of known cartographical elements (historical-architectural assets, water courses, etc.) but which are not necessarily appreciated on routes usually used.

Cassatella C and Castelnovi P (2007) 'The landscape' in the Corona Verde project, strategic planning and governance, research report (research contract with the Piemonte Regional Authority, Protected Areas Planning Sector), Inter-University Department of Territorial Studies of Turin Polytechnic.

Table 6.8 Tranquillity

Indicator	Tranquillity
Definition	"Places which are sufficiently far away from the visual or noise intrusion of development or traffic to be considered unspoilt by urban influences" (Countryside Agency 2005); "A composite feature related to low levels of built development, traffic, noise, and artificial lighting" (Swanwick 2002)
Description	Condition—absence of perceptive disturbances and the possibility of experiencing the natural and rural landscape, without the intrusion of the urban environment
Category	Perception (social)
Aims pursuant to landscape	Identification
Status/Process	Status
DPSIR category	Status
Typology	Index
Component variables (if index)	Impact of people; Openness, Perceived naturalness; Presence and visibility of rivers, of the sea, of broad-leaved woodland and mixed woodland; Visibility of roads, urban areas, and others overt signs of human development (negative factor); Overhead skyglow (light pollution) (negative factor); Visibility of coniferous plantations (negative factor); Noise (road, military, aircraft noise) (negative factor)

Table 6.8 (continued)

Indicator	Tranquillity
Unit of measure	Value scale in classes, based on the presence of positive and negative factors, with the cross-referencing of different components in each cell of the territory (250 × 250 m)
Territorial scale of reference	Local scale
Time scale of reference	Not reported
Characteristics of use	The declared aims are the protection of "tranquil" rural landscapes (objective of Countryside Agency policies, UK) and the promotion of the territory image
Availability of data source	Geographical data relevant to morphology, settlements and infrastructures
Method of representation	Thematic map on "Relevant tranquillity", created using overlay mapping with maps of the single indicator variables
Other explanatory notes	The assessment, according to the authors, allows for the cumulative effects and interaction between the different variables of the indicator, and the intermittency and variability of perceptive disturbance factors. The disturbance factors are also identified by interviewing the local population, therefore the method uses both expert analysis and the analysis of preferences
Fields/work in which it was used	Method developed by Northumbria University and presented by Haggett et al. 2009. There are various subsequent definitions and applications for the indicator, including: Countryside Agency 2005; Bell 1999

Table 6.9 Visibility of the sky at night and silence

Indicator	Visibility of the sky at night and silence
Definition	Enjoyability of the nocturnal landscape
Description	Contemporaneous visibility of the stars with the naked eye and the absence of noise disturbance. Admissible for the concept of tranquillity
Category	Perception (multisensorial)
Aims pursuant to landscape	Description/Assessment
Status/Process	Status. The indicator can be transformed into an indicator of process, in terms of variation
DPSIR category	Status
Typology	Index
Component variables (if index)	• Naked eye stellar visibility • Silence, in other words the absence of environmental noise disturbance
Unit of measure	Percentage of surfaces (simultaneous presence of two indexes) in relation to total
Territorial scale of reference	Local and regional scale
Time scale of reference	The entity depends of the when the source data was updated
Characteristics of use	Environmental reporting; SEA. The indicator could be particularly significant if a new European resolution is passed on the subject (CoE 2010)

Table 6.9 (continued)

Indicator	Visibility of the sky at night and silence
Availability of data source	On the status of the sky at night: the indicators are processed by Scientific and non-profit institutions, first and foremost using satellite photographs. For example, in Italy the Light Pollution Science and Technology Institute (ISTIL) draws up maps for the indicator "naked eye stellar visibility"; in the USA the International Dark Sky Association uses other light pollution indicators. Larger towns and cities draw up noise maps according to EU Directive 2002/49/EC; based on the distance from potential noise sources, direct surveys (measurements) are preferable
Method of representation	Thematic map, temporal diagrams (or thematic maps) on the variation
Other explanatory notes	The indicator is susceptible to variation. For example it can be expressed in negative terms for light and acoustic pollution, or dynamic terms as a percentage of loss of value. It can refer to the territorial surface or population affected
Fields/work in which it was used	None. Light pollution and the distance from noise sources are indexes of the indicator "tranquillity" (see Table 6.8). The method proposed is a reworking. The CoE Report Draft resolution on Noise and light pollution (2010) contains numerous references to studies, indicators, measurement methods and thresholds

Table 6.10 Obstruction of panoramic views

Indicator	Obstruction of panoramic views
Definition	Negative effect on picturesque views caused by a loss of visibility, in other words by the partial (or total) restriction of the field of vision
Description	On a regional scale: percentage of protected picturesque views with a restriction of the total field of vision; on a local scale: percentage of the obstructed field of vision (amplitude) compared to the total number of registered picturesque viewpoints (and/or panoramic routes)
Category	Perception (visual)
Aims pursuant to landscape	Evaluation
Status/Process	Status
DPSIR category	Impact
Typology	Simple
Component variables (if index)	–
Unit of measure	On a regional scale: percentage of protected picturesque views with a restriction of the total field of vision; On a local scale: percentage of the obstructed field of vision (amplitude) compared to the total number of registered picturesque viewpoints
Territorial scale of reference	Local and regional scale
Time scale of reference	Not reported, requires periodic monitoring
Characteristics of use	Strategic Environmental Assessment; assessment of the compatibility of interventions with landscape

Table 6.10 (continued)

Indicator	Obstruction of panoramic views
Availability of data source	Survey and mapping of picturesque viewpoints (for example, in Italy, the National Register of protected landscape sites); requires in situ monitoring
Method of representation	Thematic map, temporal diagrams if expressed as a variation
Other explanatory notes	On a local scale it is possible to develop the indicator by verifying the visibility of views from chosen observation points, therefore indicating the most significant range of the view
Fields/work in which it was used	Colombo and Malcevschi 1999; Greater London Authority 2007. The current version is a reworking

Table 6.11 Fame (variation in time)

Indicator	Fame (variation in time)
Definition	Presence of landscape in social communication
Description	Frequency of citation of a regional landscape or a certain landscape in a sample of representation (direct interviews, electronic media, printed media, artistic representations, etc.), variation in time. Can be considered an indicator of social acknowledgement and identity value
Category	Perception (social, identity value)
Aims pursuant to landscape	Evaluation
Status/Process	Status
DPSIR category	Status
Typology	Simple
Component variables (if index)	–
Unit of measure	Percentage; Frequency of citation of the place or landscape ambit in relation to the total number of places/ambits mentioned in the chosen sample; variation in the period of reference
Territorial scale of reference	Regional scale
Time scale of reference	Multiple years (ex. 5 years)
Characteristics of use	Policies for the promotion of the territory and to measure the effectiveness of these policies
Availability of data source	A sample that can be referred to at a later date must be chosen, certain tourist guides, the products of the Regional Tourism Agency, or a sample of the population, for example
Method of representation	Temporal tables and diagrams; the result can be represented as a thematic map, for example by giving the place-names a dimension which is proportional to the percentage of citation
Other explanatory notes	Citation means: iconographic representation of the place, associated with the identification of the place/ambit and the use of the place-name. The indicator is interesting from the point of view of the social perception of the landscape as it reflects the level of acknowledgement of the protected ambit by part of the population
Fields/work in which it was used	Cassatella 2007 (see Box 6.2)

Box 6.2 Example of "Fame" Indicator Application The Atlas for the management and valorisation of the Piemonte landscapes contains information on both a regional and local scale. On a regional scale, as well as the interpretation of geographical and historical characters, we propose an interpretation of imageability and social acknowledgement for the Piemonte landscapes, based on the presence of the same in widely-used iconographic representations. This gives us a collective image based on circulating images and popular icons, often with repetitive known characters. The choice of the sample was from two groups of images:

- images published in illustrated books on the Italian landscape published by the Italian Touring Club;
- images used by the Regional Tourism Agency for territorial promotion.

The initial hypothesis is that the first group can (circumstantially) represent the supra-local, in other words national view, the second the internal view, self-representation (at least externally). Obviously, the sample can be developed. There is the advantage that the two samples chosen are fairly wide-ranging.

The method involves registering all the images in these publications, on the basis of the following interpretation:

- places
- geographical-territorial ambit (for example Langhe, Monferrato)
- types of geographical landscape (plains, hills, mountains, rivers and lakes)
- landscape categories (urban, rural, natural)
- subject (for example panorama, monument)
- landscape values (morphological and naturalistic, historical-cultural, aesthetic, social-economic, or relevant to tourist industry production and fruition, disvalues)

Statistical processing and comparison suggest numerous considerations on the "collective" image (with reference to the sample) of regional landscapes. The primary indication, less subject to interpretation by the subject doing the research, is the frequency of citation of the places and ambits, which we propose using as an indicator of fame and therefore, indirectly, of identity.

The value represents the percentage of citation for each place in relation to the total representations registered; the result is a table which can be transferred onto a map, for example (as in the case of the Atlas) attributing a proportional dimension for the value to place-names (Fig. 6.2).

Obviously the result does not refer to threshold values, and the only real threshold is the presence or absence (value zero). There are however significant relative differences between places and the same places in relation to different samples. These differences in fact can provide guidelines for policies of valorisation, or measure the effectiveness of policies for the promotion of the territory, and therefore they are more meaningful when analysed on the basis of variation in time.

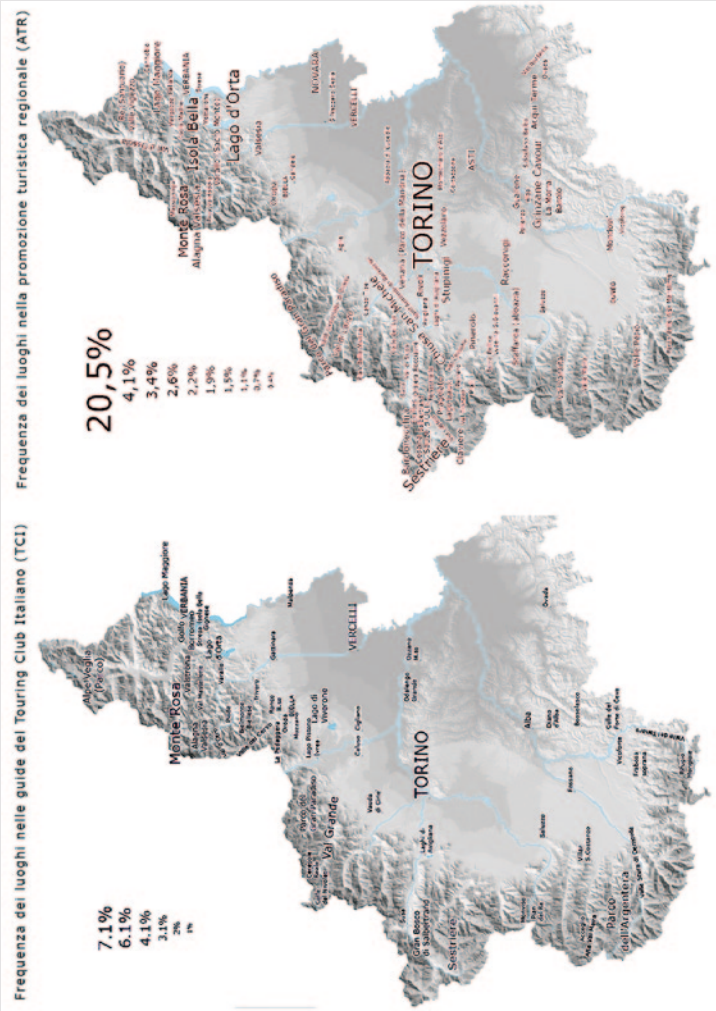

Fig. 6.2 Atlas for the management and valorisation of the Piemonte landscape. Image, illustrations. The most representative landscapes in the Italian Touring Club guides and the most representative landscapes used by the Regional Tourism Agency

The Atlas for the management and valorisation of the Piemonte landscapes is the result of research done by the Inter-University Department of Territorial Studies of Turin Polytechnic (with the contribution of the Turin CRT Foundation Alfieri project, head of scientific research A. Peano).

Cassatella C (2007) 'The acknowledged landscape', in the Atlas of Piemonte landscapes, research report of the Inter-University Department of Territorial Studies of Turin Polytechnic.

Cassatella C (2009) Social perception of the landscape and the Atlases, in Urbanistica, 138:13–17.

Table 6.12 Variety or visual diversity

Indicator	Variety or visual diversity
Definition	The indicator of the variety (or visual diversity) of the landscape represents the level of heterogeneity and the richness of visual stimuli of the landscape on the basis of the presence of vegetation, water, notable elements, the heterogeneity and structure of land use
Description	There are many different definitions and methods of calculation, some of which are qualitative, while some are based only of objective information. Consequently, the following are calculated: • as a mean, on the basis of the function of mapped biophysical elements, or • as a score, on the basis of the score attributed to each component by experts • as a score attributed in a holistic way by non-experts, in interviews or questionnaires (visual preferences method) Here are some examples of the first approach, used by each single author. Note the differences in the variables: Schüpbach 2003. "Variety describes how landscape is seen on the perceptive and on the symptomatic level. A landscape rich in variety is a landscape with trees and hedgerows stimulates the observer and helps him to orientate oneself in space." The elements of the landscape that help define landscape diversity are classified as point, linear and area elements (Single tree, Hedgerow, High stem orchard, Forest edge, Edge of settlement area). The reciprocal distance in relation to their effects on the scene is considered. The result is added up and divided by the area of each cell and standardized. $\left\{ \frac{\sum \left[(areapuntual/D) + (arealinear/D) + (areal/D) \right]}{area\_grid\_cell} \right\} * 2.5$ Pachaki 2003. Fundamental parameters: • Number of practised cultivations, average or typical size of plots, index of concentration of crops • Number and area of cultivations which present high seasonal variability (arable crops, spring blossom, winter falling leaves, etc.)

Table 6.12 (continued)

Indicator	Variety or visual diversity
	European Commission 2000 (quoted in Reho 2007). Number of sites and hectares/kilometres of farmland that contribute to the perceptive/cognitive differentiation (homogeneity/diversity) of the landscape: • Method of use of the land/type of crop (extension, height, colours) • Environmental characteristics • Manmade objects
Category	Perception (visual)
Aims pursuant to landscape	Identification
Status/Process	Status
DPSIR category	Status
Typology	Index
Component variables (if index)	The choice of the variables can change on the basis of the characteristics of the landscape in question. For the purpose of calculation using GIS, they are generally divided into: point, linear, area elements of the landscape
Unit of measure	Percentage, adimensional index from 0 to 1 (Schüpbach) Position, function: N, index of concentration (Pachaki) Score, function: N, ha/km (European Commission)
Territorial scale of reference	Local scale
Time scale of reference	Not reported, requires periodic monitoring
Characteristics of use	Strategic Environmental Assessment; assessment of the compatibility of interventions with landscape
Availability of data source	Field research, cartographic interpretation using GIS
Method of representation	Thematic map, temporal diagrams
Other explanatory notes	The perceptive variety is referred to by the authors (for example Nohl 2001) especially for agricultural landscape, in terms of the coexistence of anthropic and natural elements. The choice of variables can change on the basis of the characteristics of the landscape in question
Fields/work in which it was used	Numerous, but with various different definitions. For example Hoisl 1989 quoted by Schüpbach 2003; Nohl 2001. For the second method (score attributed by experts), see Roth 2006 for example, who uses Internet as a research instrument. For the third method of visual preferences, see the bibliography mentioned in Sect. 6.2.1

Table 6.13 Tree canopy coverage

Indicator	Tree canopy coverage
Definition	The quantity of surfaces covered by treetops
Description	Represents an indicator of the physical-perceptive and ecological quality of the landscape, especially in urban contexts. The tree canopy coverage is compared to the different categories of principal land use, to forecast different levels of integration of these surfaces
Category	Multisensorial perception
Aims pursuant to landscape	Identification—Assessment
Status/Process	Status
DPSIR category	Determinant
Typology	Index
Component variables (if index)	Number of trees Main categories of land use (source: Dwyer and Miller 1999): residential, mobile home, commercial, institutional, parks, cemeteries, golf courses, undeveloped/conservancy, agriculture, roads, water
Unit of measure	Percentage, N. trees/acres
Territorial scale of reference	Local scale
Time scale of reference	Not reported, requires periodic monitoring
Characteristics of use	Strategic Environmental Assessment, environmental reporting
Availability of data source	Local town planning, park plans, forest surveys, satellite images (ex. Landsat). The proposed indicator is based on the interpretation of satellite images and cross-referenced with the quantification of trees in forest surveys
Method of representation	Thematic maps using GIS
Other explanatory notes	The indicator is generally used for environmental sustainability. The proposed use is based on the assumption that a good level of tree canopy coverage not only results in benefits in ecological and climatic terms, and for the reduction of atmospheric pollution, but also on the perception and aesthetic qualities of the urban landscape. The weak point is the definition of thresholds, in other words the percentages of adequate coverage for the single landscape contexts. For example, for Washington DC "American Forests" recommends: 40% tree canopy overall 50% tree canopy in suburban residential 25% tree canopy in urban residential 15% tree canopy in the central business district
Fields/work in which it was used	Dwyer and Miller 1999; American Forests 2002; City of San Francisco 2006; Zhu and Zhang 2007 and numerous others

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Chapter 7
Land Use Indicators for Landscape Assessment

Angioletta Voghera

Abstract The function of this type of indicators is to evaluate the "territorial conditions" of territorial use and processes, and the related landscape transformations. Territorial indicators are also used to provide guidelines for strategies and programmes for protection, management, and innovation, and their participation processes. They are useful for monitoring territorial and landscape conditions, estimating the impact of policies and territorial actions on the landscape, and guiding the actions of territorial and landscape planning. The following indicators are analysed: land use capacity, landscape capacity to support transformations, degraded landscapes and landscapes under pressure, protected natural areas, rural areas, protected landscape, ecological and landscape networks, actions of valorisation, effectiveness of the planning aims for the landscape, and sensibility of the planning aims for the landscape.

Keywords Territorial indicators • Territorial and landscape assessment • Territorial and landscape planning

7.1 Principles and Definitions

The function of territorial use indicators is to assess the "conditions" of use and territorial processes, and the relevant landscape transformations, but also provide guidelines for strategies and programmes aimed at the protection, management and innovation of landscape and interventions.

Vallega (2008) includes these indicators in the classification of "denotative" indicators, in other words indicators that "let you see and know" like a "process for deducing one thing from something else, to deduce the intended function of an object". These indicators let us interpret the forms, the tangible events of the

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territorialization processes (Kušar and Černe 2006), in causal terms, on the basis of the relationships between the elements that characterise the "structure" of a given territory and its landscape; therefore they let us to:

- monitor territorial and landscape conditions, with reference to the natural and anthropic environment;
- assess territorial policies and actions with repercussions on landscape;
- provide guidelines for territorial planning and sectorial actions.

In fact, these indicators make it possible to simplify and, sometimes, quantify the information in a synthesis useful for interpreting the landscape through territorial use, comparing alternative scenarios and establishing monitoring activities, simplifying communication and decision-making.

The choice of the territorial use indicators in this study allows for some criteria: their application in international research, the capacity to represent and monitor the major characters of the relationship between use of the territory and landscape in time, easy interpretation and communication to people outside the sector, effective representation of results (in tables, alphanumeric data and/or geo-referenced or thematic maps, etc.), availability of data and reliable basic information (brought up-to-date and compared in time).

The brief notes below, with reference to the DPSIR model, show some samples of indicators of state, driving forces, impact and response with reference to land use and territorial policies, defined by territorial planning and sector and experimented in research and practices (CSD 2007). These indicators derive mainly from European experiences in the assessment of the sustainability of land use (Haines-Young and Potschin 2005), current policies or policies envisaged by planning instruments and/or in studies monitoring rural landscape conditions (diversity, naturalness, stability); in fact these are used to measure the sustainability and quality of the landscapes from an ecological, aesthetic and social-economic point of view (see Table 7.1), interpreting territorial use.

It is essential to say that the indicators proposed come mainly from countries where there is widespread use of sustainability strategies in policies and territorial and sector planning, such as in Germanic-British countries (The Netherlands, Germany, England, Austria; Voghera 2006; Brunetta and Voghera 2008). In these countries, sustainability has been interpreted in terms of protection, management and creation of landscapes, consolidating innovative methods of landscape interpretation and assessment. The function and goals of the indicators in the critical review are in line with the rural matrix of European and national landscape policies, where valorisation must—in accordance with the latest EEC documents for planning policies[1]—help promote the multifunctional and multisectorial management of agriculture, while also being aimed at the preservation of the environment and

[1] See: European Commission (1996) The Cork Declaration. The European Conference on rural development; European Agricultural Guidance and Guarantee Fund (CE Regulation n. 1257/1999); European Commission, Directorate-General for agriculture (2003) Reform of the common agricultural policy a long-term perspective for sustainable agriculture. Impact analysis; EC, DG VI (2000) State of application of regulation (EEC) No 2078/92: evaluation of agri-environment programmes. Working paper.

biodiversity, the recovery of historical-cultural heritage and the development of the system of touristic uses and accommodation (Voghera 2006). A good example is in United Kingdom and in The Netherlands—where the protection and use of rural landscape are subject to specific and consolidated political and cultural interventions—in accordance with the goal of promoting relations between the policies to support agricultural-productive activities and those for the valorisation of the visual, perceptive and recreational aspects.

7.2 Critical Review of Territorial Use Indicators

The critical analysis of territorial use indicators started with a study on the main national and international research methods for monitoring the sustainability of territory, environment and landscape. The following 11 indicators have been defined (see Tables 7.1 and 7.4):

- *land capability*, measures the extensification or intensification of agricultural production through the assessment of use and activities that put pressures on the landscape, with direct and indirect effects on the ecological and social-economic quality of the territory and environment;
- *capacity to support transformations*, establishes the capacity to support and respond to transformation processes on the long term for any kind of landscape, without significant effects or changes to the main characters and social-economic, cultural, ecological and perceptive values of the landscape;

Table 7.1 Indicators based on the DPSIR model in relation to various aspects of sustainability

Indicators		Sustain-ability	Ecological quality	Aesthetic quality	Social economic quality
Driving forces	Land capability	X	X		X
Pressure	Capacity to support transformations	X	X	X	X
	Land consumption	X	X	X	X
	Degraded landscapes—landscapes under pressure	X	X	X	
State	Protected natural areas	X	X	X	
	Rural area	X	X	X	X
	Landscape protection	X	X	X	X
	Ecological and landscape networks	X	X	X	X
Impact	Actions of valorisation	X	X	X	X
Response	Effectiveness of the planning aims for the landscape	X	X	X	X
	Sensibility of the planning aims for the landscape	X	X	X	X

- *land consumption*, assesses and monitors the relationship between the artificial surfaces for types of land consumption and the total surfaces of reference in time, assessing the sustainability of territorial policies;
- *degraded landscapes and/or landscapes under pressure*, interprets the negative values and the deficiencies in ecological and aesthetic quality, but also the pressures to which a certain territory is subject;
- *protected natural areas*, calculates the surfaces of the territory classified in different national and international categories for the protection of nature and landscape, in relation to the surfaces of the territory subject to research to assess the ecological and aesthetic sustainability of the same, and interpret the awareness of institutions on the themes of nature and landscape;
- *rural areas*, measures the number of rural areas in the territory, providing indications on sustainability, diversity and landscape attractiveness;
- *landscape protection*, measures the relationship between the territory and the landscape subject to restrictions for the preservation of social-cultural, ecological, aesthetic and landscape values and the total surface of the territorial entity of reference;
- *ecological and landscape networks*, assesses social and institutional awareness on sustainability, by measuring the amount of the territory used for interconnection between parks, Sites of Community Interest (SCI) and Special Protected Areas (SPA), and protected landscapes in relation to national/regional/provincial territory;
- *actions of valorisation*, measures the number of landscape valorisation actions envisaged in planning documents on various territorial scales and *implemented* at a local scale;
- *effectiveness of the planning aims for the landscape*, measures the operative effectiveness of the territorial planning and use policies with reference to landscape, assessing the number of specific actions envisaged and implemented by the plans on various scales;
- *sensibility of the planning aims for the landscape*, assesses the focus on landscape of territorial planning and use policies, on the basis of the number of landscape valorisation actions envisaged in the plans on various scales.

The methodology used for the above indicators refers to DPSIR categories, useful for interpreting the social-economic and territorial factors that put pressure on the landscape in terms of consumption of territorial and environmental resources, which—when exceeding the load capacity of the territory in question—cause inevitable direct effects, compromising the sustainability of the system and causing environmental and landscape degradation. The impacts, closely associated with the state of the territory and landscape are contrasted by the efforts of the social system to mitigate, compensate and/or overcome these problems, with the various responses from the institutional bodies governing the territory, landscape and environment.

As well as classifying the indicators—in relation to their role to highlight the basic factors that influence the territorial and landscape system, the direct cause of pressure, the current state, the effects of the impact, and the response of the social-institutional system (Wascher 2004, 2005)—the critical analysis method considers

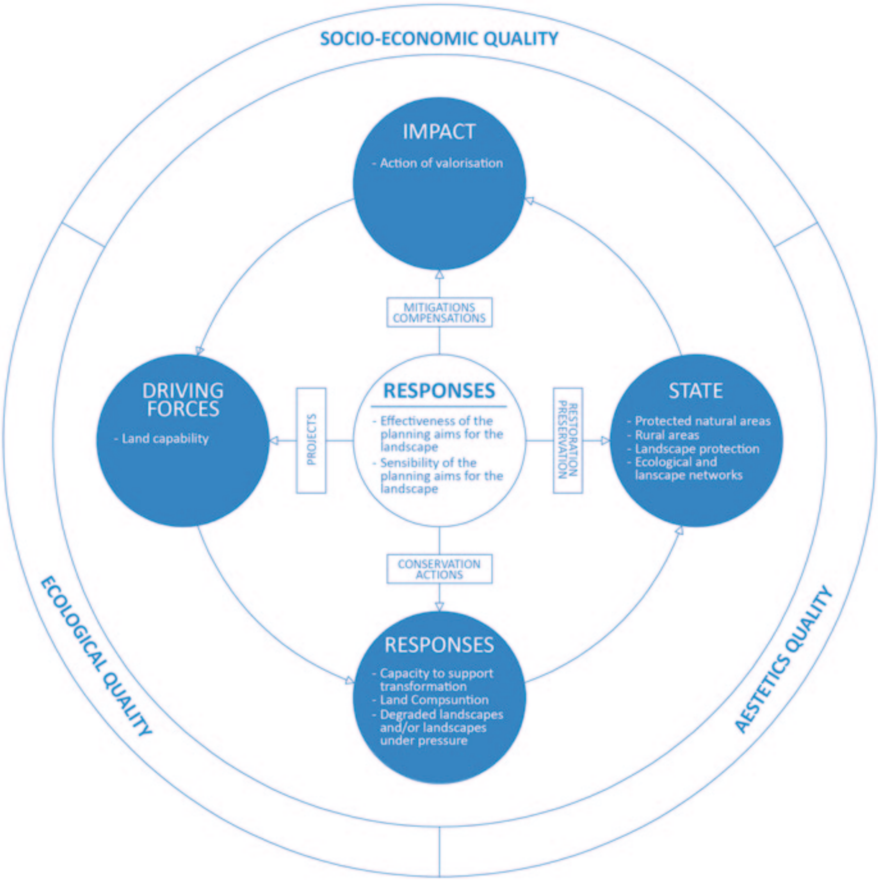

Fig. 7.1 Method used for indicator classification

the role of each indicator in the sustainability of territorial use and of the relevant transformations, expounding the ecological, aesthetic and social-economic components of the landscape quality it is related to (Fig. 7.1).

The critical review of the indicators is shown below, with reference to the categories of the DPSIR model, explaining the role of each in the assessment and monitoring of sustainability in the territorial and landscape system.

7.2.1 Driving Forces or "Determinant" Type Indicators

These indicators identify the use and activities that put pressure on the landscape, so we can describe and assess the changes underway in urbanization, mobility, agricultural practices, etc. Land Capability refers to this category of indicators (Weber and Hall 2001).

Land Capability (Table 7.5) is an indicator of the extensification or intensification of agricultural production on a regional and local scale (IRENA, Emilia Romagna Regional Authority, VALSAT).

Changes in agricultural practices and production methods influence the environmental and landscape conditions of the rural territory. In fact, changes in the rural use of land also indicate the intensification, extensification or marginalization of production (IRENA 2005). Land capability is a territorial classification based on characters of potential land use (8 categories and 5 sub-categories that indicate the type of limitation in the use of the particular land in question, if any). The indicator is expressed in mapped surfaces intended for a certain use. The loss of use indicates the transition from a higher category to a lower capacity of use; vice versa there will be an increment in use. This indicator is frequently used in national and international research, it is easy to interpret, and data is readily available as it is based on Corine Land Cover (European mapped database, available on line).

7.2.2 Pressure Indexes and Indicators

These indexes and indicators describe the cause of the modifications induced by land use and anthropical activities on environmental and landscape resources (EEA 1995). The meaning of the results provided by these indicators can vary notably as the territorial scale of reference for the analysis changes (EC 1999).

Note: the index *capacity to support transformations*, and the indicators *land consumption* and *degraded landscapes and/or landscapes under pressure*.

The *capacity to support transformations* is used in English Landscape Assessment to interpret the current state of the landscape (the conditions and integrity of the elements) and assess the processes, dynamics, trends and potential pressures caused by scenarios of development. For any landscape type it establishes the capacity to sustain and respond to transformation processes (landscape capacity) on the long term, without significant effects or changes to the main landscape characters and values. Landscape capacity assessment is used to establish criteria to identify the potential effects of landscape policies and strategies on some landscape elements, characters and values (Countryside Agency and Scottish Natural Heritage 2002).

The capacity depends on: the cultural, ecological and perceptive sensibility of the landscape, associated with changes induced by landscape policies, and the "measuring" of the overall perceptive, ecological, economic, etc. value of the landscape and its specific elements. Sensibility depends on: natural and cultural factors, the quality and condition of the landscape and its aesthetic-perceptive characters. The method used in the South Pennines Landscape Character Assessment (1999) is worthy of note, in which quality is assessed using the following indicators: importance, strengthness (in other words fragility) and condition. Condition in particular is a useful indicator, as it provides information on the state of preservation of a landscape value and/or character; it measures the level of integrity (intactness) and the quality of the territorial government. The quality of the territorial government can be measured through qualitative categories: ranging from degraded to excellent.

The capacity to support transformations index is used in Great Britain to assess landscape on various scales: national, regional and local, but some of the data must be obtained directly.

Land consumption (Table 7.8) is a widely used indicator at a national and international level. It is in fact defined in different ways on the basis of the aims of the research in which it is used, the territorial context of reference, how easy data is to obtain, etc. In some cases, "land consumption" is the quantity of new or envisaged settlements in an urban territory on rural territory (with reference to administrative boundaries) to measure the settlement pressures and the erosion of rural landscapes (used in reports on the state of the environment and town planning analysis, in the planning of extensive and local areas, in Dutch planning with reference to medium-sized cities and metropolitan areas); in this way we can monitor active processes and assess anthropical pressure on rural landscapes. In other cases, land consumption is the relationship between the artificial surfaces for various types of consumption and the total surfaces of reference. In both cases, this is a complex indicator, requiring high competence from the user, and it can be negatively affected by a lack of homogeneity and difficulty in obtaining data on the territory (different territorial units and data quality).

This indicator is used on a regional and local scale, based on the data in regional and/or municipal databases. In this sense the research is epitomized by the definition "relationship between artificial surfaces for various types of land consumption and total surfaces of reference", currently used in the Piemonte Regional Authority Table for monitoring land consumption, providing up-to-date data (Fig. 7.2).

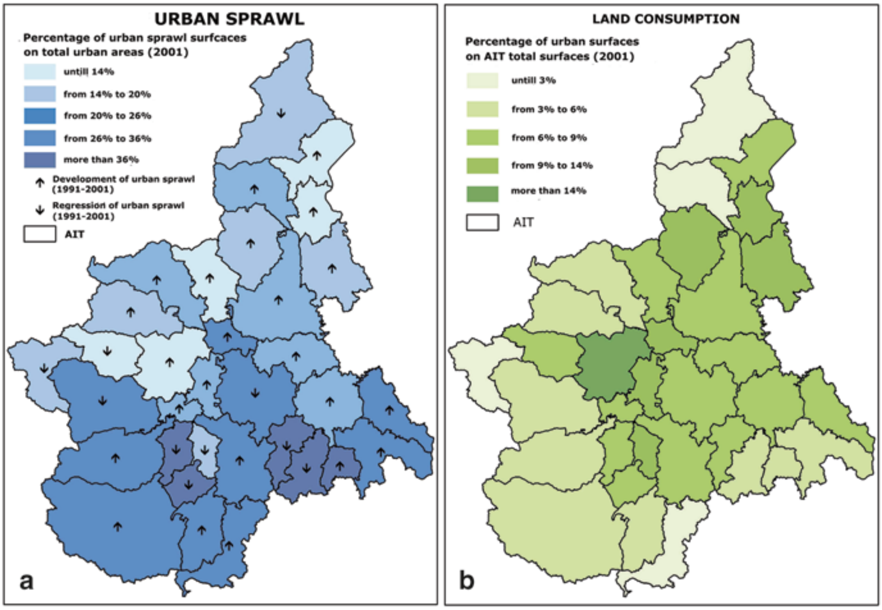

Fig. 7.2 Urban dispersion (**a**) and land consumption (**b**) in Piemonte. (Source: PTR 2009)

Box 7.1 Land Consumption At a European level, the evolution of land consumption and the relevant increase in impermeabilized areas has been studied in two major projects, Murbandy (http://murbandy.jrc.it/) and Moland (http://moland.jrc.it/). These projects are related, the first started in 1998 (under the name of MURBANDY Monitoring Urban Dynamics) with the aim of monitoring the development of urban areas and identifying trends on the European scale. The work includes the computation of indicators and the assessment of the impact caused by anthropogenic stress factors (with a focus on expanding settlements, transportation and tourism) in and around urban areas, and along development corridors.

The theme is subject to debate also in Italy, and the National Observatory of Land Consumption uses a national monitoring table which was drawn up by Milan Polytechnic with the National Town Planning Institute and Legambiente.

In Piemonte, a method for monitoring and propagating major territorial dynamics, through a common Geographical Information System, with the aim of assessing the urbanized surfaces was drawn up to implement the co-planning process by the Strategic Planning, Territorial and Building Policies Office—Territorial Information System Sector of the Piemonte Regional Authority and Territorial, Transportation, and Civil Defence Area of Turin Province—in collaboration with the CSI Piemonte (consortium of public bodies which promotes innovation in the Public Administration through ICT technologies).

To measure land consumption and environmental sustainability in various territorial interventions as an indication in territorial planning, the following actions were taken:

- a system was created for monitoring land consumption and a first balance on land transformation was drawn up;
- a new indicator was defined, to be applied on a different territorial government scale, to assess the eco-sustainability of territorial policies promoted by the various bodies governing the territory;
- the various systems developed for monitoring land consumption were integrated, and the information was shared by regional and provincial authorities, making it also available to the public.

This round table on land consumption studies the trend in time of the evolution of built-up surfaces by: monitoring the increase in new urbanized surfaces in a certain time interval and studying the trend of this phenomenon in terms of entity, its dispersion and impact on the territory.

For this purpose, the work used the following indicator types:

- the percentage of land consumption for new buildings, which defines the quantitative dimension of the phenomenon;
- an indicator of dispersion (percentage of the type of land bordering the new buildings) which makes it possible to interpret fragmentation and/or continuity in relation to the existing urban fabric;

- an indicator for the assessment of environmental fragility generated by anthropical pressure associated with land consumption, obtained by cross-referencing data on new buildings with some environmental data families.

These indicators are processed on the basis of data from the regional technical map, scale 1:10,000 (1991), brought up-to-date through the georeferencing of territorial data obtained from satellite images. At this point, the resulting data is processed and cross-referenced with other data families such as, current restrictions, and the physical characteristics and administrative aspects of the territory for example.

The processing refers to the first Report on the State of the Territory and Regional Territorial Information System[2], with its natural expression at a municipal level, also in the form of guidelines for general town planning schemes; reorganized data is also propagated on a supra-municipal scale, as a result of the greater effectiveness for some themes such as landscape, and the point of reference required for the Regional table to interpret the state of the territory. The indicator, on the basis of the satellite data processed at a municipal and supra-municipal level, provides a picture of the regional territory, identifying more or less dynamic areas in relation to the development of built-up areas in the period of time in question. The application of the quantitative indicator on land consumption is propaedeutic for investigating the nature of the land consumed, the causes of the same and the effects of the phenomenon, in order to attempt to elaborate the indicators of dispersion and qualification of environmental fragility in relation to anthropical pressure.

The *degraded landscapes and/or landscapes under pressure* (Table 7.9) indicator lets us interpret the negative values and deficiencies in aesthetic quality—by measuring the quantity of the areas used in the extractive (or mining) industry, dumps, quarries, unstable landscapes and landscapes subject to erosion in a given territory—and also the pressures to which a given territory is subject; it provides indications for defining ad hoc planning actions indirectly.

It is used to interpret (on a local or regional scale) the pressures to which a given territory is subject, but information must be obtained from local and/or regional databases.

In order to guarantee that the indicator considers current processes of degradation and/or landscapes threatened by anthropical pressures, which can generate irreversible disturbances in the quality and identity of the territory and landscape, a list of interventions and works has been drawn up which could put the "landscapes" under pressure; this list, created on the basis of indications in the regulations of reference for assessing the landscape compatibility of interventions (landscape and EIA report—enclosure A1), focuses on the following:

[2] http://www.regione.piemonte.it/sit/argomenti/pianifica/osservatorio/analisi.htm.

(a) area interventions: energy generation plants, waste burning plants, storage plants; dams, weirs and reservoirs[3]; goods depots or storage facilities for materials; port and airport infrastructures; dumps and waste disposal plants; mining and surveying; quarries and peat-bog utilization[4]; solid mineral extraction; utilization of hydrocarbons and geothermal resources on land; long-distance power lines with a nominal voltage of over 100 kV more than 10 km long; energy generation plants, waste burning plants, storage plants; production complexes; goods depots or storage facilities for materials.
(b) linear or network interventions and/or works: road and rail infrastructures/works; infrastructural networks; masts, pylons and telecommunications relay stations; cable cars, ski lifts and chair lifts; hydrogeological interventions; agricultural irrigation systems.

The list of works and interventions in letters a) and b) must be considered for the application of the degraded landscapes—under pressure landscapes indicator, as these can generate processes of degradation and/or anthropical pressure; furthermore, the specific updating of regional databases is required, which should assess also the types of interventions in letter a) on a per area basis, with the relevant territorial surfaces kept up-to-date.

7.2.3 Indicators Concerning the State of Territorial Use

These indicators describe the situation of the landscape, measuring the quality of the physical, ecological-natural, social-economic components of the various elements in the landscape system. These indicators, when correlated with pressure indicators, help provide a balance of "sustainability" for the landscape in relation to territorial use.

Corine Land Cover is a useful starting point for interpreting the state of use as it quantifies the intended use of the territory in terms of surfaces.

The following indicators are considered: *protected natural areas, rural areas, landscape protection, ecological* and *landscape networks*.

Protected natural areas is a useful indicator at various territorial scales to assess the sustainability of a certain territory and its naturalness, a quality which makes a landscape attractive (Table 7.10). In The Netherlands, the Ministry of

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[3] Elements associated with the non-energetic use of surface waters in the cases in which the maximum outlet capacity exceeds 1,000 l/s, dams and other plants for containing, regulating or accumulating water on the long-term, for non-energetic purposes, with a height of over 10 m and/or a capacity of over 100,000 m^3, water purification plants with a potential of over 100,000 equivalent inhabitants.

[4] In particular: activities connecting to the water table, tunnels for the exploration of underground quarries for the extraction of industrial materials, excavations used to obtain material for public works, quarries in fluvial zones A and B of Plans regulating the more urgent aspects of the Po Basin Project, quarries extracting over 500,000 m^3/year of material or with an operating area of over 20 ha.

Housing, Physical Planning and Environment (VROM) and, also the National programme for monitoring the perception and appreciation of landscapes, use this indicator (Farjon 2007) to interpret the naturalness of the territory, one of the main aspects of landscape sustainability and quality.

By calculating the territorial surfaces subject to the various categories of national and international nature and landscape protection in relation to the surfaces of the territory in question, we can obtain indications on the ecology efficiency and attractiveness of a given landscape.

In order to apply this indicator, we must consider the territory in the various nature and landscape protection categories: categories of UNESCO World Heritage Sites and the Man And the Biosphere (MAB) programme; EEC categories such as for sites protected in accordance with Habitat and Wild Birds—Sites of Community Interest (SCI) and Special Protected Areas (SPA) Directives; national categories—with notable differences in European countries—such as natural parks, protected landscapes (category V of the IUCN), regional categories of protection of the territory and the landscape, etc.

In the urban context we refer to the calculation of green spaces. This is a consolidated indicator in international research, used to assess the sustainability of a territory on different scales (European/national/regional/local); furthermore, data is easy to obtain for the application of the indicator, from the databases of the IUCN, the European Environment Agency, ESPON and EUROSTAT, and/or research centres like the CED-PPN of the DITER—Polytechnic of Turin.

Box 7.2 Application of the Protected Natural Areas Indicator An interesting application of the Protected natural areas indicator has been implemented in the research "*Parks for Europe. Towards a European policy for protected areas*", developed by the CED PPN (European Documentation Centre on Natural Park Planning—Dipartimento Interateneo Territorio—Inter-University Department of Territorial Studies of Turin Polytechnic) in 2008, with the collaboration of FEDERPARCHI and AIDAP, and the contribution of the Piemonte regional Authority (Environment Councillor's Office).

With the aim of assessing the impact of protected natural areas on the European territory, the research has considered two sets of European Protected Areas:

- a general set (tPAs, "total" Protected Areas), containing 75,388 Protected Areas (for which alphanumeric data were available);
- a more reduced set (mPAs, "mapped" Protected Areas), containing 42,354 Protected Areas, for which, in addition to alphanumeric data, geometric and georeferenced data were also available.

Both the alphanumeric and georeferenced data have been obtained from the Common Database on Designated Areas (CDDA, European Environment

Agency—EEA[5]) (EEA 2005). Nevertheless, this database did not provide accessible and homogeneous alphanumeric and georeferenced data for all countries; therefore, in order to make up for the lack of data, the research has referred also to the IUCN World Database of Protected Areas (WDPA—IUCN[6]).

While on the first set of Protected Areas (tPAs) an analysis has been conducted for consistency, growth dynamics and diversification by categories, on the second set (mPAs), it has been possibile to conduct, trough the use of GIS tools, an analysis of the relationships existing between Protected Areas and the environmental and socioeconomic contexts (the principal sources for land use data has been Corine Land Cover 2000, while for socio-economic data, the ESPON Programme).

The research has higlighted that the European Protected Areas are a very wide set, spread out over the entire European territory: over 75,000 areas, covering roughly 90 million ha of surface, corresponding to almost the 18% of the sum of territories of 39 countries (see Tables 7.2 and 7.3 and Figs. 7.3 and 7.4).

Nevertheless, the territorial incidence varies notably from country to country:

- in Germany, the United Kingdom, Malta, Switzerland and Estonia, the incidence of the protected surface on the national territory is more than twice the European average;
- some other countries, on the contrary, still have not reached a figure of 10% protected surface, such as Albania, Belgium, Bulgaria, Bosnia, Cyprus, Denmark, Croatia, Ireland, Macedonia, Portugal, Romania and Serbia;

On the whole, there is a greater incidence of protected surface in Central Europe (29%), where anthropical interference is more marked; the incidence is slightly lower than average in Northern Europe (16%), where the territories have a lower population density and greater natural characters.

These elaborations let us assess the attention of the countries to the protection of nature and landscape, that seem to be more vital where the pressure from anthropical use of the territory is greater.

Table 7.2 Number, surface land incidence of total Protected Areas (Apt) by European countries groups. (Source: CDDA, EEA; elaboration by CED PPN)

	n.	%	Surface (ha)	%	Land incidence %
EU15	47,149	62.5	61,109,463	67.6	18.9
EU12	21,125	28.0	20,238,749	22.4	18.6
EU7	5,720	7.6	7,695,452	8.5	16.4
EU5	1,394	1.8	1,408,880	1.6	5.6
EU39	75,388	100	90,452,544	100	17.9

[5] http://dd.eionet.europa.eu/dataset.jsp?mode=view&ds_idf=CDDA, updated to 2007.
[6] http://www.WDPA.org, updated to 2007.

Table 7.3 Number, surface, territorial incidence of total Protected Areas (APt) by European countries. (Source: CDDA—EEA; elaboration by CED PPN)

Countries	n.	%	Surface (ha)	%	Land incidence %
Albania	802	1.1	240,075	0.3	8.4
Andorra	5	0.0	8,031	0.0	17.2
Austria[a]	1,090	1.4	2,347,879	2.6	28.0
Belgium	1,601	2.1	143,587	0.2	4.7
Bosnia and Herzegovina	155	0.2	38,528	0.0	0.8
Bulgaria	874	1.2	611,002	0.7	5.5
Ciprum	19	0.0	20,559	0.0	2.2
Croatia	195	0.3	421,096	0.5	7.4
Denmark	3,833	5.1	172,205	0.2	4.0
Estonia	12,041	16.0	1,640,431	1.8	36.3
Finland	5,979	7.9	3,234,701	3.6	9.6
France	1,543	2.0	8,625,049	9.5	15.9
Germany	14,791	19.6	21,202,618	23.4	59.4
Gibraltar	1	0.0	35	0.0	5.8
Greece	749	1.0	2,948,125	3.3	22.3
Ireland	208	0.3	304,485	0.3	4.3
Iceland	79	0.1	980,650	1.1	9.5
Italy[a]	771	1.0	3,175,304	3.5	10.5
Latvia	702	0.9	1,259,107	1.4	19.5
Liechtenstein	40	0.1	8,159	0.0	51.0
Lithuania	331	0.4	1,002,533	1.1	15.4
Luxembourg	36	0.0	54,599	0.1	21.1
Macedonia	77	0.1	188,774	0.2	7.3
Malta	150	0.2	12,044	0.0	38.1
Monaco	2	0.0	51	0.0	25.5
Norway	2,507	3.3	5,046,225	5.6	15.6
The Netherlands	2,006	2.7	1,006,073	1.1	24.2
Poland	2,058	2.7	9,126,648	10.1	29.2
Portugal	67	0.1	779,016	0.9	8.4
United Kingdom	8,842	11.7	9,063,952	10.0	37.4
Czech Republic	2,250	3.0	2,044,958	2.3	25.9
Romania	963	1.3	2,066,683	2.3	8.7
Serbia	165	0.2	520,407	0.6	5.9
Slovakia	1,145	1.5	1,322,043	1.5	27.0
Slovenia	350	0.5	253,397	0.3	12.5
Spain[a]	295	0.4	2,767,633	3.1	5.5
Switzerland	3,086	4.1	1,652,300	1.8	40.0
Sweden	5,338	7.1	5,284,239	5.8	11.7
Hungary	242	0.3	879,343	1.0	9.5
EU39	75,388	100.0	90,452,544	100.0	17.9

[a] Nonstandard datum to others official data sources

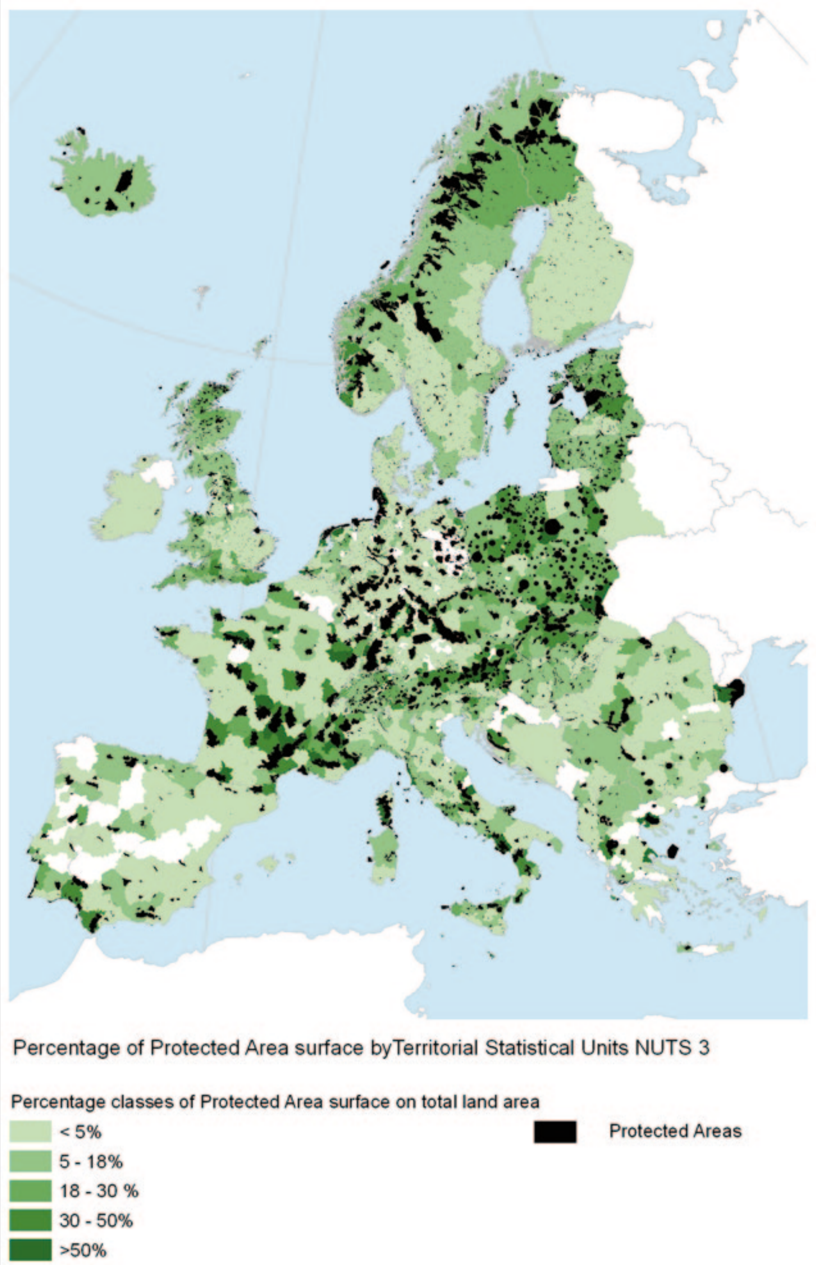

Fig. 7.3 Percentage of protected areas surfaces by NUTS 3. (Source: Gambino et al. 2008)

Fig. 7.4 Natural protected areas and urban territory. (Source: Gambino et al. 2008)

Table 7.4 List of indicators

No.	Origin	Indicator or Index	Source
1	Studies on rural landscape	Land capability	EEA, IRENA 2005; Emilia Romagna Regional Authority, VALSAT
2	Studies and programmes for the countryside valorisation	Capacity to support transformations	English Landscape Assessment; Countryside Agency 2005
3	Studies on rural landscape	Land consumption	Dutch local and provincial planning
4	Environmental reporting	Degraded landscapes	Vallega 2008
5	Environmental reporting	Protected natural areas	In The Netherlands' Ministry of Housing, Physical Planning and Environment (VROM) and the National programme for monitoring the perception and appreciation of landscapes; Vallega 2008
6	Rural landscape studies	Rural areas	Rural and landscape development plans; Vallega 2008
7	Environmental reporting/ Rural landscape studies	Landscape protection	National and provincial programmes in The Netherlands; Vallega 2008
8	Environmental reporting	Ecological and landscape networks	Plans in The Netherlands, Germany, Austria…
9	Environmental reporting	Actions of valorisation	Evaluation Effects of alternative plan in Trendscenario of Overijssel Province (The Netherlands)
10	Studies for the implementation of the ELC	Effectiveness of the planning aims for the landscape	Landscape Observatory of Cataluña
11	Studies for the implementation of the ELC	Sensibility of the planning aims for the landscape	Landscape Observatory of Cataluña

Rural areas (Table 7.11) measures the quantity of rural territory in relation to the total territory in question (Germany, Austria, England, The Netherlands), providing indications on sustainability, diversity and landscape attractiveness; this indicator is used at various territorial scales (European, national, regional and local) (Delbaere and Nieto Serradilla 2005)—with data obtained from EUROSTAT, ESPON, etc. databases—in international (EC 2006) research and rural development plans.

Landscape protection (Table 7.12) measures the relationship between the sum of the protected surfaces (landscape goods, areas protected by law, protected areas) and the total surfaces of the territorial entity of reference. This indicator is used in The Netherlands in national and provincial landscape programmes for example to assess the quality and value of the landscape in a given territory; furthermore the indicator is used at a national and/or regional scale, with data obtained from the databases of the competent Ministries concerned with the protection of the landscape, or from the IUCN, EEA, EUROSTAT, and ESPON.

Ecological and landscape networks is an indicator used (in The Netherlands, Germany, Austria and other countries) to measure the quantity of territory used for the interconnection of parks, Sites of Community Interest (SCI), Special Protected Areas (SPA) and protected landscapes which constitute the core areas of the ecological network—in relation to the national/regional/provincial territory (number of existing and planned networks); the indicator is useful for assessing biodiversity at a national or regional scale, providing a comparison between natural spaces and cultural resources. The aim is to highlight the identity values of a landscape through the interrelation of natural and cultural factors.

7.2.4 Indicators of Impact

These types of indicators let us interpret the effects of changes in the state of the territory and landscape, by describing the cause/effect relations between pressures and state. The indicator *actions of valorisation* is particularly worthy of note.

Actions of valorisation (Table 7.13) measures the number of landscape valorisation actions envisaged in the planning documents on various territorial scales and *implemented* at a local scale; this indicator is often used to assess the effectiveness and effects on sustainability of plans and programmes (sometimes also to simulate the effects of transformation scenarios for the alternative territory); in the reports in which this indicator is used, the actions are assessed in relation to their effects on sustainability (and on ecological, aesthetic and social quality).

7.2.5 Territorial Use Response Indicators Envisaged by Planning at Various Scales of Territorial Governance

These indicators describe the various actions taken by society as a whole (institutions, planners, etc.) to solve major landscape-environmental problems and valorise the quality of the territory. The following indicators are presented: *Effectiveness of the planning aims for the landscape* and *Sensibility of the planning aims for the landscape.*

Effectiveness of the planning aims for the landscape is an indicator that measures the operative effectiveness of territorial planning and use policies with reference to landscape, assessing the number of landscape actions envisaged and implemented by the plans on various scales (Table 7.6). The assessment of the quality of instruments used in the planning of landscape is one of the European Convention's goals; the Landscape Observatory of Cataluña (Sala 2009) has already tested two such indicators: "application of the instruments required by law for landscape" and

Table 7.5 Land capability

Indicator	Land capability
Definition	Measures the extensification or intensification of agricultural production
Category	Territorial use
Aims pursuant to landscape	Individuation
Status/Process	State and process
DPSIR category	Driving forces
Typology	Simple
Component variables (if index)	–
Unit of measure	m^2
Territorial scale of reference	Regional/Local
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, assessment of plans and programmes
Availability of data source	Corine land cover
Method of representation	Thematic maps
Other explanatory notes	–
Fields/work in which it was used	EEA, IRENA 2005; EMILIA-ROMAGNA Regional Authority, VALSAT; research done by the EU Directorate-General for agriculture and rural development

"public and private implementation of actions for the preservation, planning and management of landscape". The first measures the operative effectiveness of Act 8-2005 ("Ley de protecció, gestió i ordenació del paisatge") which established the Landscape Observatory of Cataluña as the instrument for introducing landscape goals in urban and territorial planning and sectorial policies, adopting the principles

Table 7.6 Effectiveness of the planning aims for the landscape

Indicator	Effectiveness of the planning aims for the landscape
Definition	Measures the operative effectiveness of territorial planning and use policies with reference to landscape, assessing the number of landscape actions envisaged and implemented by the plans on various scales
Category	Territorial use
Aims pursuant to landscape	Evaluation
Status/Process	State
DPSIR category	Response
Typology	Simple
Component variables (if index)	–
Unit of measure	n.
Territorial scale of reference	National/Regional/Provincial/Local
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, plan assessment
Availability of data source	Territorial planning strategies and instruments
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Landscape Observatory of Cataluña

Table 7.7 Sensibility of the planning aims for the landscape

Indicator	Sensibility of the planning aims for the landscape
Definition	Measures the focus of territorial planning and use policies on landscape, assessing the number of landscape actions envisaged and implemented by the plans on various scales
Category	Territorial use
Aims pursuant to landscape	Evaluation
Status/Process	State
DPSIR category	Response
Typology	Simple
Component variables (if index)	–
Unit of measure	n.
Territorial scale of reference	National/regional/provincial/local
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, plan assessment
Availability of data source	Territorial planning instruments, regional and/or municipal databases
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Landscape Observatory of Cataluña

Table 7.8 Land consumption

Indicator	Land consumption
Definition	Relationship between artificial surfaces for types of land consumption and the total surfaces of reference
Category	Territorial use
Aims pursuant to landscape	Evaluation
Status/Process	Process
DPSIR category	Pressures
Typology	Simple
Component variables (if index)	–
Unit of measure	ha, %
Territorial scale of reference	Regional/local
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, plan assessment
Availability of data source	Territorial planning instruments, regional and/or municipal databases
Method of representation	Tables, thematic maps, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	In reports on the state of the environment and in the analysis of town planning such as planning on a local scale and for a vast area (used for medium-sized cities and metropolitan areas)

Table 7.9 Degraded landscapes and/or landscapes under pressure

Indicator	Degraded landscapes and/or landscapes under pressure
Definition	Relationship between the sum of surfaces used for extractive/mining activities, dumps, quarries, unstable landscapes and landscapes subject to erosion, and the total surfaces of the territorial entity of reference
Category	Territorial use
Aims pursuant to landscape	Identification
Status/Process	State and process
DPSIR category	Pressure
Typology	Simple
Component variables (if index)	–
Unit of measure	%
Territorial scale of reference	Regional/local
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring, plan assessment
Availability of data source	Territorial planning instruments, regional and/or municipal databases
Method of representation	Databases, thematic maps, GIS, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Reworking from Vallega 2008

Table 7.10 Protected areas

Indicator	Protected areas
Definition	Indicator useful for assessing the sustainability of a given territory and its naturalness, the quality that makes a landscape attractive; by calculating the surfaces of the protected areas (territory in Sites of Community Interest (SCI)—Special Protected Areas (SPA), World Heritage Sites UNESCO, of the Man And the Biosphere (MAB) programme, national parks, regional and protected landscapes) in relation to the surfaces of the territory in question it is possible to interpret the ecology efficiency and attractiveness of a given landscape. In the urban context we refer to the calculation of green spaces
Category	Territorial use
Aims pursuant to landscape	Evaluation
Status/Process	State
DPSIR category	State
Typology	Simple
Component variables (if index)	–
Unit of measure	m^2/m^2
Territorial scale of reference	European/national/regional/local
Time scale of reference	Year

Table 7.10 (continued)

Indicator	Protected areas
Characteristics of use	Technical-scientific analysis, monitoring, plan assessment
Availability of data source	ESPON, EUROSTAT, ECNC or EDC-NPP databases
Method of representation	Databases, thematic maps, GIS, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	In The Netherlands' Ministry of Housing, Physical Planning and Environment (VROM) and, the National programme for monitoring the perception and appreciation of landscapes; Vallega 2008

of the European Landscape Convention. The indicator assesses the number and quality of: landscape catalogues, directives, landscape goals incorporated in territorial and sector strategies on various scales, to highlight also the effects of the Observatory's actions. The second "public and private implementation of the actions for landscape preservation, planning and management" assesses the number of actions envisaged in planning with financial instruments for implementation, which help valorise landscape. This indicator requires direct research.

Sensibility of the planning aims for the landscape measures the focus of policies for the planning and use of the territory on landscape, by assessing the number of landscape actions envisaged in plans at various scales (Table 7.7). This indicator is

Table 7.11 Rural areas

Indicator	Rural areas
Definition	The quantity of rural territory in relation to the total territory in question, useful for providing indications on sustainability, diversity and landscape attractiveness
Category	Territorial use
Aims pursuant to landscape	Identification
Status/Process	State
DPSIR category	State
Typology	Simple
Component variables (if index)	–
Unit of measure	m^2/m^2
Territorial scale of reference	European/national/regional/local
Time scale of reference	Year
Characteristics of use	SOE (State of the Environment reports) technical-scientific analysis, monitoring, assessment of rural development plans
Availability of data source	SOE, local planning instruments, Databases, ESPON, EUROSTAT
Method of representation	Databases, thematic maps, GIS, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Rural development and landscape plans in Germany, Austria, England, The Netherlands; …; Vallega 2008; Landsis et al. 2002

Table 7.12 Landscape protection

Indicator	Landscape protection
Definition	Relationship between the sum of the protected surfaces (landscape goods, areas protected by law, protected areas) and the total surfaces of the territorial entity of reference
Category	Territorial use
Aims pursuant to landscape	Evaluation
Status/Process	State
DPSIR category	State
Typology	Simple
Categories variables (if index)	–
Unit of measure	m^2/m^2
Territorial scale of reference	National/regional
Time scale of reference	Year
Characteristics of use	Technical-scientific analysis, monitoring
Availability of data source	Databases, ESPON, EUROSTAT
Method of representation	Databases, thematic maps, GIS, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	National and provincial programmes in The Netherlands; Vallega 2008

Table 7.13 Actions of valorisation

Indicator	Actions of valorisation
Definition	Number of landscape actions of valorisation envisaged in the planning and implemented
Category	Territorial use
Aims pursuant to landscape	Evaluation
Status/Process	State
DPSIR category	Impact
Typology	Simple
Component variables (if index)	–
Unit of measure	n.
Territorial scale of reference	Local
Time scale of reference	Year/period
Characteristics of use	Monitoring, SEA
Availability of data source	Data-base or direct research
Method of representation	Databases, thematic maps
Other explanatory notes	–
Fields/work in which it was used	Effects of alternative plan in Trendscenario of Overijssel in Overijssel Province (The Netherlands)

widely used, in various contexts, by landscape observatories, and also by the Landscape Observatory of Cataluña (2006).

7.3 Proposal for Territorial Use Indicators

Of the indicators discussed in the critical review, the following are proposed for applicative experimentation: land capability, the effectiveness of the planning aims for the landscape, the sensibility of the planning aims for the landscape, land consumption, degraded landscapes—under pressure landscapes, protected natural areas, rural areas, landscape protection and actions of valorisation.

This choice is based on the following factors:

- the suitability of the indicator for monitoring and expressing elements, processes and values of interest in relation to the use of the territory and the effects of said use on landscape;
- the effectiveness of the indicator in the assessment of landscape, from a point of view of territorial use, identifying the modification of said use in space and time as a result of policies, interventions and projects for landscape transformation (state and process);
- the versatility of the indicator, which can be used to monitor and assess territorial and landscape transformations and processes in the implementation of the European Landscape Convention (regional and local), as well as in other fields of application such as technical-scientific analysis, environmental reporting, monitoring, strategic environmental evaluations or environmental impact, in territorial and landscape planning;
- the applicability of the indicator, which depends on the basic availability of source data in existing international and regional databases, and the possibility of presenting the information in thematic maps, geo-referenced maps and temporal diagrams, also for the non-expert public.
- the results obtained with the indicator in other national and international research and experimentation contexts on the field.

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Chapter 8
Assessing the Economic Aspects of Landscape

Marta Bottero

Abstract There are many economic aspects associated with landscape. Firstly, landscape is an "externality", as the economic activities involving the use and transformation of landscape have different effects and repercussions on the same; secondly, landscape, especially in modern society, is seen more and more as a limited resource, and is therefore perceived as an "economic good". In consideration of these assumptions, the current chapter will examine the main indicators used in literature to assess the economic aspects of landscape, with an interpretation on the basis of two major approaches to analysis: the "economic value" of landscape and the "economic strength" of landscape. Finally we will propose a set of indicators based on the DPSIR model on two different scales for monitoring macro transformations (regional scale) and the following in-depth study (local scale).

Keywords Total Economic Value • Externalities • Economic analysis • Evaluation

8.1 Principles and Definitions

There are many economic aspects associated with landscape. The economic activities related to the use and transformation of landscape have various effects and repercussions on the same; according to the literature in the field of economic analysis this is tantamount to saying that landscape is a (positive or negative) externality (Marangon and Tempesta 2008). In general terms, externalities are defined on the basis of the effects (favourable or unfavourable) on the production or consumption of one person by the production or consumption of another, without there being any kind of monetary transaction between the two to balance the costs or benefits of these effects.

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Furthermore, landscape, especially in modern society, is seen all the more as a limited resource. From the point of view of economic analysis, this is the same as saying that landscape can be considered an "economic good", in other words a good available in an insufficient quantity to meet requirements for the same, and for which there is a problem of efficient allocation of resources, guaranteed or not as the case may be by the spontaneous actions of the market (Santos 1998).

In consideration of said characterization, the use of evaluation tools to estimate the value of landscape can be explained on the basis of two main themes. First and foremost we must have tools to establish and assess the foreseeable benefits of certain actions involving the use and transformation of landscape. Secondly, techniques must be established for the assessment of the effectiveness and efficiency of public expenditure for interventions on landscape.Therefore landscape assessment can be translated into economic indicators used to draw up policies for the protection and requalification of landscape.

Indicators have only recently been used in the assessment of the economic aspects of landscape, and are still subject to development. Available publications on the subject indicate two main approaches in the study of economic landscape indicators. The first, more experimental approach, refers to the so-called "economic value" of landscape (Marangon and Tempesta 2008; Marone 2007). According to this approach, the value of landscape is generally established by the so-called existence value, theoretically unrelated to the benefit each person could obtain from a resource, substantially a value closely associated with the many functions it may have for man. In this perspective, landscape has a historical, cultural, recreational, panoramic and aesthetic value; it represents a value for the spirit, for its contribution to biodiversity and ecosystems, security and stability, the production of goods, and employment (Reho 2007).

These aspects/functions of landscape refer to various parties with a vested interest: for farmers (in the case of farmland) and rural communities it is a place to live and work; for society it is a recreational place; but landscape also provides specific environmental services associated with maintaining biodiversity and ecosystems, etc., of interest for generations both present and future.

With the first approach, there are two types of landscape demands (and components of the value).The first demand derives from the tendency of people to try and pass part of their time in more pleasant or more interesting environments from an aesthetic and perceptive point of view. Therefore, the quality of landscape influences the real estate market and recreational behaviour, while a second type of landscape demand is related to the need to protect cultural heritage in its various forms.

A second, more consolidated, approach, that has been called "economic strength" (Nordregio 2000), establishes a connection between the value of landscape and the contribution of the same to the economic system of reference. Therefore, this involves assessing landscape on the basis of the effects that utilization and transformation have on the economic system. These effects are connected, for example, with an increase in tourist flow deriving from the implementation of policies for landscape development of a site or job losses in the agricultural sector as a result of financial measures implemented to support agricultural production of specific value for landscape.

8.2 A Review of Economic Landscape Indicators

The search for specific indicators able to represent the economic aspects of landscape is used in a recent and quite expertimental literature.

The OECD (2001b), as part of its activities associated with the assessment of agricultural policies, lists a series of indicators for landscape assessment, including also some indicators based on economic value.

These indicators were used and studied in depth in a recent Italian study (Marangon and Tempesta 2008), with a precise classification of economic indicators, applicable assessment techniques, and references to specific studies of the past.

In particular, in the authors' opinion, the value of landscape is attributable to the benefits produced by the same. In this sense, the categories of benefits that landscape can produce are associated with the following aspects:

1. Benefits from direct non-extractive use, in other words when a person uses an area with an attractive landscape for recreational purposes. To establish this value, the importance of landscape essentially depends on the type of recreational activity;
2. Benefits from indirect use associated with owning a home in a certain area with an attractive landscape;
3. Benefits from the non-use of the landscape due to the conservation of historical-cultural heritage.

We must emphasise that the use of these indicators is dictated by the availability of very specific data and information, which can only be obtained through direct interviews and surveys examining the benefits produced by landscape from the point of view of potential users (inhabitants or tourists for example). With this approach, the indicators relevant to the value of landscape can substantially be divided into monetary and non-monetary indicators.

For non-monetary indicators, according to Marangon and Tempesta (2008), the result in quantitative or qualitative terms depends on the criteria used in the various fields of interest (with reference to diversity, connectivity, etc. from an ecological point of view, visual quality, complexity, coherence, mystery, etc. from a perceptive point of view, etc.).

There are many publications on the question, from a variety of disciplines. The methods of assessment to which these criteria refer are divided into objective methods (indirect, historical for example) and subjective methods (direct, visual perception for example) by convention. The first are based on the opinions of experts in the assessment of material and formal aspects; the second are based on the level of satisfaction of the community of users in relation to the more intangible aspects of landscape (the identity, symbolic and cultural value, …). The use of these indicators lets us attribute a value to landscape to draw up policies, and comprehend the level of satisfaction in landscape and transformations by society (Tempesta 2006).

As for monetary indicators however, there are some methods that can provide an economic assessment of value for landscape (Stellin and Rosato 1998). These methods can be divided into two major categories, depending on whether they are based on the costs to bear for producing and maintaining the asset, or on the demand of the same asset.

Therefore, we have:

- Methods based on supply analysis (costs)
- Methods based on demand (benefits)

In other words, the monetary value of landscape refers to two main categories of indicators relevant to:

- the cost to maintain and develop certain landscapes;
- the willingness to pay to use a certain landscape, or accept compensation for not using the same.

The analyses of the cost/opportunities for alternative landscape and cultivation assets and the quantification of the costs necessary for the conservation of landscape (defensive expenditures) belong to the first group. The assessment of the benefits produced by the landscape, which can be calculated using methods based on the stated preferences (the willingness to pay to keep a certain landscape intact for example) or on revealed preferences (travel costs to use a certain landscape for example) belong to the second.

Table 8.1 contains a classification of the indicators available for the assessment of the economic value of landscape.

Table 8.1 Economic value of landscape: indicators for assessment. (Source: Marangon and Tempesta 2008)

Assessment methods				Economic indicators
Non-monetary				Average score of landscape as a whole Average score of single landscape element
Monetary	Based on demand (benefits)	Revealed preferences	Travel costs	Recreational benefits per hectare for the single elements of landscape or as a whole
			Hedonic pricing	Variation in housing price per m^2 with reference to the overall quality of landscape or visibility of single elements
		Stated preferences	Contingent valuation	Willingness to pay per hectare to maintain or improve landscape as a whole
			Choice experiments	Willingness to pay per hectare for each single landscape element
	Based on supply (costs)	Cost/opportunities		Reduction per hectare of income per unit to increase landscape quality
		Defensive expenditures		Costs for the conservation of single elements or the landscape as a whole

Box 8.1 Estimate of the Landscape Value Using the Contingent Valuation Method (Verbič and Slabe-Erker 2009) The Contingent Valuation method was applied to estimate willingness-to-pay for the implementation of a plan for the development and conservation of the Volcji Potok landscape area in Slovenia. In particular, this is chiefly an agricultural area currently in a condition of degradation/abandonment, which the landscape plan would help preserve and reorganize, making the area more attractive for tourists.

The Contingent Valuation method was applied in various steps:

1. Data collection
   The sample used in the estimate consisted of 312 individuals, classified as inhabitants and tourists. The interviews held with the sample aimed to establish the willingness-to-pay (WTP) for the realisation of the development scenario of the area in question over the next 5 years.

Table 8.2 Results of the regression model. (Source: Verbič and Slabe-Erker 2009)

Variable	Description	Regression coefficient
CONSTANT	Regression function constant	−275.20
INCOME	This variable represents the monthly income level of the respondent	3.021
CONSC	The variable reflects the conscientious respondents, who place natural and cultural heritage conservation for current and future generations ahead of their momentary life standard	569.83
DAMAGE	The variable takes into account if the individual perceives the size of damage to the area due to unscheduled development as very large	238.48
HERITAGE	The variable represents the value attributed by the respondent to natural and cultural heritage	518.03
FUNCT	The variable represents the value attributed by the respondent to the functional characteristics of the area (cycle paths, footpaths..)	657.50
VALSCL	The variable expresses the number of values embodied in the area's environmental goods that the respondent deems important	154.89
PROTEST	The variable takes into account the fact that an individual may think the implementation of the targeted development scenario should be financed by someone else	−204.99
Other parameters of the regression model		
Dependent variable	WTP	
n	312	
s_e	899.70	
R^2	0.420	
F(7,304)	24.65	
p(F)	0.000	

2. Data elaboration
   The data collected was elaborated using a regression model. Table 8.2 shows the regression coefficients obtained; these coefficients indicate the contribution of the various elements in the model used to calculate the final WTP. As we can see, the most significant element in the formation of the WTP refers to the practical characteristics of the area such as, for example, the presence of cycle paths, footpaths and other features attractive for tourists (FUNCT variable). Furthermore, great importance is attributed to the conservation of natural and cultural heritage (CONSC variable).

The WTP value calculated with the regression model was corrected using more sophisticated estimates to obtain a final value indicating a willingness-to-pay per individual equal to 419 SIT/month/individual (equal to roughly 1.75 €/month/individual). Multiplying the figure obtained by the number of residents and tourists in the area (19,332) and calculating the value for one year, the result is a willingness-to-pay equal to 97.4 million SIT/year (roughly 406,000 €/year). Finally, the willingness-to-pay value for the development period of the plan (5 years) is equal to 486.8 million SIT (roughly 2 billion €).

Despite the many difficulties involved in the application of calculations for the proposed indicators (monetary in particular), the same certainly provide a major contribution in assessing demand and supply for the landscape good. The use of these indicators can therefore be a useful support in the development of landscape policies, providing information on the importance attributed to the same by the local population, and also a trade-off between costs and benefits associated with the management of a certain landscape.

The approach used to establish landscape value based on the contribution of said landscape to the economic system of which it is part ("economic strength") refers to more consolidated publications on the theme of assessment of the economic structure and performance for a certain area (Eser 1999; Nordregio 2000).

With this approach the indicators are used for the assessment of agro-environmental policies and refer to interscalar type applications ranging from a national level (assessment of economic performance in the agro-environmental sector of the various member states of the European Union) to a local level (assessment of the effects of financial measures to support single rural enterprises).

It must be said that, unlike the first approach, this approach does not explicitly refer to the theme of landscape, but rather to a series of policies and actions in the territory which envisage, amongst other things, also interventions for the protection and reclamation of landscape.

This approach is usually followed in Rural Development Programmes promoted by the European Union where the aim is to assess and test the effectiveness of public expenditure to reach planned goals.

The main references to this approach are the indicators of the PAIS project—*Proposal on Agri-Environmental Indicators* (Landsis et al. 2002) and the CMEF model (*Common Monitoring Evaluation Framework*), recently implemented by the European Commission (2006) to assess Rural Development Programmes.

Table 8.3 Themes of reference for PAIS project indicators

Quality of life and social wellbeing	
	Environmental themes
	Availability of services (health, education, local government)
	Housing
	Safety
	Income and deprivation
Economic structure and performance	
General	Sectoral shares
	Enterprises
	Investment
	Labour force attributes
	Performance and competitiveness
	Business infrastructures
	Single industry dependence
Primary sector	Agricultural multifunctionality
	Diversification and productivity
	Financial resources
Tourism sector	Physical features of consumption and supply
	Employment features
	Economic repercussions
Demography	
	Population density
	Change and structures
	Commuting and migration patterns
	Cultural issues

In particular, the PAIS project proposes a set of economic type indicators to apply in the assessment of rural development at a European level. These are descriptive social-economic indicators concerning the quality of life; economic structure and performance; population and migration (Table 8.3).

In the CMEF model however, there are a series of indicators that provide a quantitative figure on the contribution of landscape policies (agricultural policies in this case) for the overall economic requalification of the area in question.

The studies on indicators for the sustainable development of the agricultural sector (Wascher 2000; Waarts 2005; EEA 2005; MTT 2002; Van Heuckelom 2004), the cattle-farming sector (Wright et al. 1999) and the forestry sector (MCPFE 1998) also refer to this approach.

Finally, there are a series of studies on landscape assessment through multicriteria analysis, in which economic indicators are used with others for global landscape assessment (Gómez et al. 2003).

8.2.1 Catalogue of Indicators

Below you will find a list of the main economic indicators used for the assessment of landscape in current publications, on the basis of the two approaches described above. The indicators have been organized in brief categories on the basis of the subject (Table 8.4).

Table 8.4 Indicators for assessing the economic aspects of landscape

	Indicator	Source
Economic value of landscape	1. *Value attributed by population* Value attributed by population to farmland Average score of landscape as a whole Average score of single landscape element	OECD 2001b; Marangon and Tempesta 2008
	2. *Recreational benefits* Recreational benefits per hectare for the single elements of landscape or as a whole	Marangon and Tempesta 2008
	3. *Housing prices* Variation in housing price per m^2 with reference to the overall quality of landscape or visibility of single elements	Marangon and Tempesta 2008
	4. *Willingness to pay* Willingness to pay per hectare to maintain or improve landscape as a whole	Marangon and Tempesta 2008
	5. *Income/landscape quality ratio* Reduction per hectare of income per unit to increase landscape quality	OECD 2001b; Marangon and Tempesta 2008
	6. *Conservation costs* Costs for the conservation of single elements or landscape as a whole Maintenance costs of rural buildings	OECD 2001a, b; Marangon and Tempesta 2008
Economic strength of landscape	7. *Value added—agricultural sector* Value added increase for farms receiving support Value added of agricultural sector Value added per hectare Value added per agricultural work unit	Duchateau 2002; European Commission 2006
	8. *Contribution to gross domestic product* Regional GDP percentage attributed to agriculture, forestry and cattle-farming sector	MCPFE 1998; Wright et al. 1999
	9. *Number of farms* Number of farms and cattle-farms Rate at which new enterprises are established in the agricultural and cattle-farming sector	Wright et al. 1999; OECD 2001b; Duchateau 2002; European Commission 2006
	10. *Structure of enterprises* Number of employees on farms and cattle-farms	Wright et al. 1999; Duchateau 2002
	11. *Employment* Net increase in employment Workforce in the agricultural, cattle-farming and forestry sector Salaried labour (hours/year) Rural employment rate	MCPFE 1998; OECD 2001b; Duchateau 2002; European Commission 2006
	12. *Income in the agricultural and cattle-farming sectors* Income pro capita in the agricultural and cattle-farming sector Agricultural income of organic farmers	Duchateau 2002; EEA 2003; Van Heuckelom 2004

Table 8.4 (continued)

	Indicator	Source
Economic strength of landscape (cont.)	13. *Income from extra-agricultural activities* Income from tourism sector Percentage of income from off-farming activities	Duchateau 2002; Waarts 2005; European Commission 2006
	14. *Subsidies* Total amount of price supports and subsidies obtained per year Agricultural subsidies per worker	Gómez et al. 2003; Waarts 2005
	15. *Tourism* Number of bedspaces per 1000 inhabitants Accommodation occupancy rate Increase in tourist flow	Duchateau 2002; European Commission 2006
	16. *Farm tourism* Farm tourism enterprises Accommodation occupancy rate in farm tourism	OECD 2001a; MTT 2002
	17. Quality of agricultural production Value of the agricultural production under recognized label/standard	Wascher 2000; European Commission 2006

8.3 Proposal for Economic Landscape Indicators

On the basis of the published indicators described above we will now propose a selection, which will later be studied in depth from the point of view of application.

For the selection of the indicators we decided to adopt some criteria for establishing the significance of the same, taking for granted that all the published indicators meet essential requirements for environmental indicators (see Sect. 2.1.1 of this report).

The criteria used to select the indicators refer to:

- Field of application: the criterion is used to measure the level of technical and operational difficulty and to calculate the indicator (holding ad hoc interviews, static elaborations, …), and to interpret the results;
- Completeness: the criterion indicates whether the indicator considers (from an economic point of view) the various aspects involved in the landscape system in a comprehensive way: not only agricultural structure, but also aspects associated with perception, tourism flows …;
- Specificity: the criterion establishes whether the indicator is essential or not in the economic characterization of landscape.

When selecting the indicators we chose to favour those characterised by completeness and high specificity; furthermore, we decided to consider indicators that can be used in both approaches.

The selection resulted in the following indicators (Table 8.5).

Note that each of the indicators proposed corresponds to a specific scale of application. The scale is closely linked to the availability of source data for calculating

Table 8.5 Indicators proposed for the assessment of economic landscape aspects

Indicator	Scale of application	Dpsir
1. Recreational benefits	Sub-provincial/local	S
2. Housing prices	Sub-provincial/local	I
3. Willingness to pay	Sub-provincial/local	S
4. Conservation costs	Sub-provincial/local	R
5. Tourism flows	Regional/provincial/sub-provincial/local	S/I
6. Value added	Regional/provincial	S/I
7. Employment	Regional/provincial	S/I
8. Amount of subsidies obtained	Regional/provincial	P

the indicators, in order to obtain a legible result. In this way, two different systems of economic indicators are created: one for monitoring macro transformations (regional and provincial) and the other for studying the analyses in-depth (sub-provincial and local level).

Furthermore, as can be seen in the last column of Table 8.5, the proposed indicators guarantee coverage of all the DPSIR model categories.

8.3.1 Presentation of the Indicators Proposed

Below you will find an in-depth presentation of the indicators proposed (Tables 8.6, 8.9, 8.12, 8.13, 8.16, 8.17, 8.18, and 8.19), on the basis of the presentation table used for the study (Sect. 2.2.2). Where possible, the indicators have specific boxes to illustrate their application. The boxes contain some examples related to real cases where the different indicators have been calculated.

Table 8.6 Recreational benefits

Indicator	Recreational benefits
Definition	Assessment of the recreational benefits per hectare deriving from the use of single landscape elements or the landscape as a whole
Description	The calculation of the indicator is based on the travel costs (TC) technique. The travel costs method assesses the recreational value of the territory, analyzing the relationship between the number of visits by a visitor to one or more recreational areas, and the cost born to reach the same. This technique lets us comprehend the benefits deriving from the development of landscape oriented recreational activities (activities in which landscape is the base element such as walking, hiking or cycle tourism, for example …)
Category	Economy
Aims pursuant to landscape	Evaluation
Status/Process	Process

Table 8.6 (continued)

Indicator	Recreational benefits
DPSIR category	State
Typology	Simple
Component variables (if index)	–
Unit of measure	€
Territorial scale of reference	Local
Time scale of reference	Year
Characteristics of use	Scientific
Availability of data source	Direct surveys
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	While there are numerous applications of the travel costs method for analyzing the effects of environmental quality, very few studies have used this technique to analyze the effects of landscape quality Interviews held to gather data and the following elaboration of statistical data make the procedure for calculating the indicator complex and well-organized
Fields/work in which it was used	The literature related to the indicator is quite recent; however it is possible to find some scientific works where the travel costs method has been applied with the aim of assessing the landscape value (for example, Tempesta et al. 2002; Boxall et al. 2003; Bujosa Bestard & Riera Font 2009)

Box 8.2 Estimate of the Landscape-Recreational Value of Forest Landscape Using the Travel Costs Method (Tempesta et al. 2002) This study aims to verify the effects of territorial characteristics and activities on recreational demand. In particular, the territorial context of the research refers to various forest areas in the Friuli Venezia Giulia region of Italy.

The work involved several steps, described briefly below.

(a) Data collection
The first phase of the work refers to the creation of a territorial database containing information on landscape and territorial use, with geo-morphological variables (altimetry, presence of quarries/landslides, …), vegetation variables (arboreal coverage, tree species and relevant surfaces, …), anthropical variables (land use, cultivated surfaces, population density, …) and naturalistic variables (presence of parks, reserves, …). With reference to landscape use, data has been collected on the presence of refuges, high altitude camps and other accommodation facilities for tourists, along with the presence of paths. The information collected was integrated by numerous phone interviews with a sample of 516 people to collect information on their town, and find out how much they spent to take trips to the areas in question, their recreational habits, the accommodation facilities used on trips, their job, family unit and level of education, …

(b) Elaboration and analysis of the results
The data collected was elaborated using regression models to estimate the recreational value of the forest areas. The model developed compares the number of trips with the percentage of overall forest surfaces in the area (Table 8.7). The first column of the table shows the regression estimate, which gives an idea of the importance of the various parameters in determining the frequency of the number of trips; the following columns contain some coefficients used to assess the significance of the parameters obtained in statistical terms.

The influence of the percentage of woodland and grassland shows how important these are to guarantee a pleasant landscape and result, along with other factors, in greater attractive power for the visitor who will be willing to travel great distances to reach districts with a higher distribution of woodland. In consideration of the functional form calculated using the regression model, consumer surplus is equal to 3.22 € per trip. To obtain an initial estimate of the woodland landscape value, the number of trips was simulated with a 1% reduction of the forest surfaces in the areas considered. The result is that the reduction would be equal to 49,060 trips and the recreational benefits would drop by 157,776 €. The landscape value of a hectare of woodland is therefore equal to 58.77 € (Table 8.8).

Table 8.7 Results of the estimate with the initial regression model. (Source: Tempesta et al. 2002)

Variable	Coefficient	Standard error	Statistic t	Significance	Mean
Constant	−2.62	0.1592	−16.4780	0.0000	–
Travel cost	−0.31	0.0000	−37.3600	0.0000	9777.4310
Percentage of woodland surfaces in district	0.03	0.0012	21.0240	0.0000	46.1080
Percentage of meadow surfaces in district	0.03	0.0050	5.2100	0.0000	10.5920
Reason for walks	2.41	0.0573	42.1130	0.0000	0.2980
Spruce-beech, category found mainly in woods	2.29	0.0519	44.0640	0.0000	0.0830
Number of refuges per 100 km^3	0.03	0.0033	8.3350	0.0000	2.5830
Reason for sport trip	1.56	0.0896	17.3990	0.0000	0.0140
Diploma degree	0.83	0.0441	18.8300	0.0000	0.1400
Number of people in family unit	−0.09	0.0170	−5.5730	0.0000	2.8540
Age	−0.01	0.0016	−3.9570	0.0001	56.2430
Reason for hunting trip	0.30	0.0714	4.2630	0.0000	0.0140
LogL	−6758.5010				
Chi square	7781.9600				
Pseudo Chi square	0.5747				

Table 8.8 Simulated effect of a reduction in forest surfaces on the number of trips and the consequent reduction in benefits. (Source: Tempesta et al. 2002)

Current forest surface (ha)	Reduction 1% (ha)	% new woods	Estimate of trips			Tot. Variat. trips	Surplus variat.	
			Current	Reduced	Variat. %		Total (€)	Per ha (€)
268.48	−2,684.80	35.2	2.8514	2.8100	−1.45	−49,060	−157,776	−58.77

Table 8.9 Housing prices

Indicator	Housing prices
Definition	The variation in housing price per m^2 with reference to the overall quality of landscape or visibility of single elements is assessed
Description	The Hedonic Pricing (HP) assessment technique is used to calculate the indicator. This method is based on the hypothesis that the real estate market value depends both on its intrinsic qualities (surface area, state of repair, age, …) and extrinsic qualities (the vicinity of services and town centres, accessibility, the quality of the landscape and air, …). With a significant amount of data we can estimate the relationship between the price and the quality of the landscape
Category	Economy
Aims pursuant to landscape	Evaluation
Status/Process	Process
DPSIR category	Impact
Tipology	Simple
Component variables (if index)	–
Unit of measure	€
Territorial scale of reference	Local
Time scale of reference	Year
Characteristics of use	Scientific
Availability of data source	Direct surveys
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	The data gathered and the subsequent statistical elaboration make the procedure for calculating the indicator complex and well-organized
Fields/work in which it was used	Several scientific works are available in the literature where the hedonic pricing method has been applied with the aim of assessing the landscape value (for example, Tyrvainen 1996; Oueslati et al. 2008; Tagliaferro 2005; Gao and Asami 2007; Kong et al. 2007; Cho et al. 2009)

Box 8.3 Landscape Value Estimate Using Hedonic Models (Tyrvainen 1996) The application aims at evaluating external effects of urban forests associated with housing. Particularly, through the hedonic pricing method the works examines the benefits derived from pleasant landscape, clean air, peace and quiet and screening, as well as recreational activities. The research was developed according to different phases:

1. Data collection
   Apartment sales data (1,006 apartments) were collected in Joensuu, a town of 48,000 inhabitants in North Carelia, Finland. The information on purchase price and apartment characteristics were collected from documents received from local tax authorities. Furthermore, environmental and locality data were measured with respect to each specific house.
2. Elaboration
   According to the hedonic pricing method, the data collected was elaborated in order to explain purchase prices (P). Particularly, the model used the general formula $P = f(A_i, L_i, E_i)$, where A_i is a vector of the apartment characteristics such as size, age and type of construction, L_i is a vector of the locality attributes such as accessibility to town centre, schools and shops, E_i is a vector of the characteristics describing the environmental quality in the housing district including variables such as accessibility to watercourse, recreation areas and relative amount of green spaces. Table 8.10 represents the observed characteristics.

Table 8.10 Housing attributes considered in the model. (Source: Tyrvainen 1996)

Apartment characteristics (A_i)
Apartment size
Number of rooms
Age
Flat roof
Renovations
Facade material brick
Location (L_i)
Town centre
School
Shops
Other public services
Environment (E_i)
Watercourse
Wooded recreation area
Wooded park
Low housing density
Own garden
Traffic noise
Pollution
Low 'status' of the housing area

Table 8.11 Hedonic price model (dependent variable: price per square meter). (Source: Tyrvainen 1996)

Independent variable	Coefficient/ implicit price	t-ratio	Coefficient/ implicit price	t-ratio
Low 'status' housing area	−378.23	−7.47	−0.137	−7.547
2 rooms	−332.58	−9.56	−0.118	−9.473
3 rooms	−513.86	−13.56	−0.182	−13.372
4 rooms	−565.7	−11.27	−0.199	−11.027
5 rooms	−620.41	−8.18	−0.229	−8.386
Age	−43.28	−15.73	−0.016	−15.721
Sauna	119.95	3.51	0.039	3.163
Flat roof	−116.92	−4.80	−0.042	−4.791
Distance to town centre	−158.42	−7.32	−0.053	−6.793
Distance to school	42.97	2.01	0.012	1.615
Distance to shop	72.17	2.45	0.023	2.118
Distance to recreation area	−41.78	−1.76	−0.016	−1.896
Distance to 'forest park'	471.46	3.94	0.146	3.39
Green space	7.36	3.37	0.003	3.291
Direct distance to watercourse	−153.97	−4.03	−0.60	−4.391
Distance to nearest beach	40.38	2.03	0.016	2.165
Size of lot	0.23	2.04	1.148×10^{-4}	2.818
Constant	3991.68		8.332	
	Linear model $R^2=0.664$		Semilog model $R^2=0.651$	

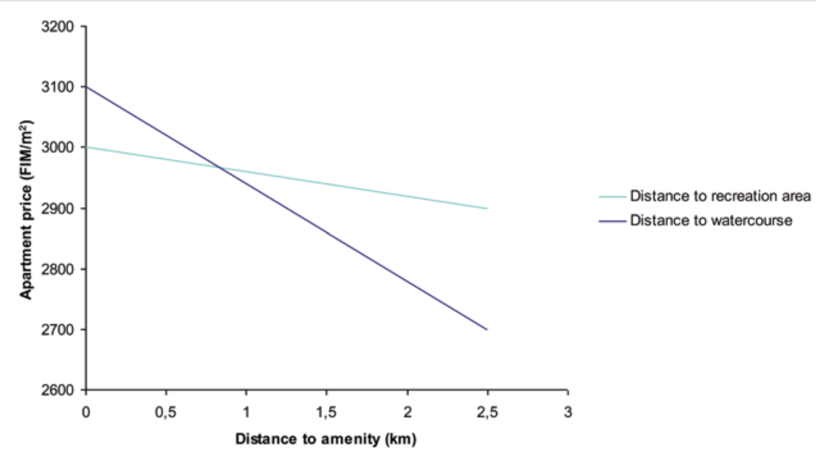

Fig. 8.1 Effects of changes in distance to recreation area and watercourse on apartment price per square meter. (Source: Tyrvainen 1996)

Linear and log-linear hedonic price functions were calculated with multiple regression analysis. Table 8.11 shows the results of the regression models.

3. Results

Results indicate that urban forests are an appreciated environmental characteristic and that their benefits are reflected in the property prices. Proximity of watercourses and wooden recreation areas as well as increasing proportion of total forested area in the housing district had a positive influence on apartment price. Particularly, Fig. 8.1 shows an application of the estimated implicit prices in evaluation of changes in the environmental quality: the greater the distance to the recreation area and watercourses, the lower the apartment price per square meter.

Table 8.12 Willingness to pay per hectare

Indicator	Willingness to pay per hectare
Definition	The willingness of the users of landscape (inhabitants or tourists) to pay to maintain or improve the landscape as a whole is measured
Description	The indicator can be assessed using the Contingent Valuation method (CV) or the Choice Experiment technique (CE) The CV method is based on the possibility of outlining a hypothetical market for the asset with which the consumer can express their willingness to pay to maintain or improve the quality of the asset, or be reimbursed in the case of qualitative deterioration or less availability. The CE technique is based on an approach used in marketing to reflect consumer preference for the characteristics of new products
Category	Economy
Aims pursuant to landscape	Evaluation
Status/Process	Process
DPSIR category	State
Typology	Simple
Component variables (if index)	–
Unit of measure	€/hectare
Territorial scale of reference	Local
Time scale of reference	Year
Characteristics of use	Scientific
Availability of data source	Direct surveys
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	There are numerous applications for the landscape using CV, while at the moment only a few studies on landscape assets have been carried out using CE. In both cases interviews held to gather data and the subsequent statistical elaboration make the procedure for calculating the indicator complex and well-organized
Fields/work in which it was used	The use of the indicator for the assessment of the landscape value is limited to the scientific literature (for example Bonnieux and Le Goffe 1997; Hanley et al. 1998; Cicia and Scarpa 2000; Sayadi et al. 2009; Verbič and Slabe-Erker 2009)

Table 8.13 Conservation costs

Indicator	Conservation costs
Definition	The costs for the conservation of single elements or the landscape as a whole are assessed
Description	The indicator is based on costs born by private entities or the public administration to prevent the degradation of environmental assets caused by the modification of the environment. To assess these costs we have to identify interventions for the conservation of landscape, the time dedicated to the same and the cost of the means used for said purpose. Once a cost has been attributed to the work (in general the mean hourly salary paid to subjects doing similar work) we can assess the overall maintenance costs of the territory and landscape
Category	Economy
Aims pursuant to landscape	Acknowledgement/Identification/Assessment
Status/Process	Process
DPSIR category	Response
Typology	Simple
Component variables (if index)	–
Unit of measure	€
Territorial scale of reference	Local
Time scale of reference	Year
Characteristics of use	Scientific
Availability of data source	Direct surveys
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Some scientific works are available which aim at assessing the costs related to on-farm landscape conservation activities (for example, Tempesta 1993, 1994; Berentsen et al. 2007; Finco and Tempesta 1997)

Box 8.4 Assessment of Expenses for the Conservation of Natural Landscape (Marangon and Tempesta 2008) The results of various studies done in the Italian regions of Veneto and Friuli Venezia Giulia (Italy) in the 1990s to estimate the expenses born for the conservation of natural landscape are shown below. The innovative elements were: (a) maintenance of farm service roads; (b) maintenance of massive walls, dry walls, roadsides and terracing; (c) maintenance of historical artefacts (capitals, drinking troughs …); (d) maintenance of ditches and waterworks; (e) cleaning third party waste; (f) mowing plots of land for aesthetic reasons or safety; (g) cutting back shrubbery on pastures not used for productive purposes; (h) maintenance of non-productive woodland; (i) removal of fallen rocks from meadows; (j) maintenance of fences; (k) maintenance of hedges and trees. The interventions concern both the landscape in the strictest sense, and some functional actions for the use of the territory by visitors, and are therefore relevant for the utilization of the landscape goods.

The results of the specific analysis in the Colli Euganei area (in the province of Padua) are shown in Table 8.14 and Fig. 8.2.

Table 8.14 Average values of the costs borne by farms for territorial maintenance. (Source: Tempesta 1994, reworking)

Type of interventions	Total cost (€)	%	Average cost		
			% of marketable production	Per farm	Per hectare
Roads and road system	15,019.40	22.30	0.54	715.06	30.21
Hydrogeological system	7,182.76	10.70	0.26	341.85	14.07
Historical artifacts	165.19	0.20	0.01	7.65	0.31
Waterworks	13,490.61	20.00	0.51	642.41	25.85
Cleaning waste	45.89	0.10	0.00	2.29	0.08
Mowing	8,455.34	12.60	0.31	402.27	16.60
Maintenance of hedges and trees	15,983.78	23.80	0.60	760.95	31.36
Maintenance of woodland	6,959.44	10.30	0.25	331.15	13.61
Total	67,302.41	100.00	2.48	3,203.63	132.09

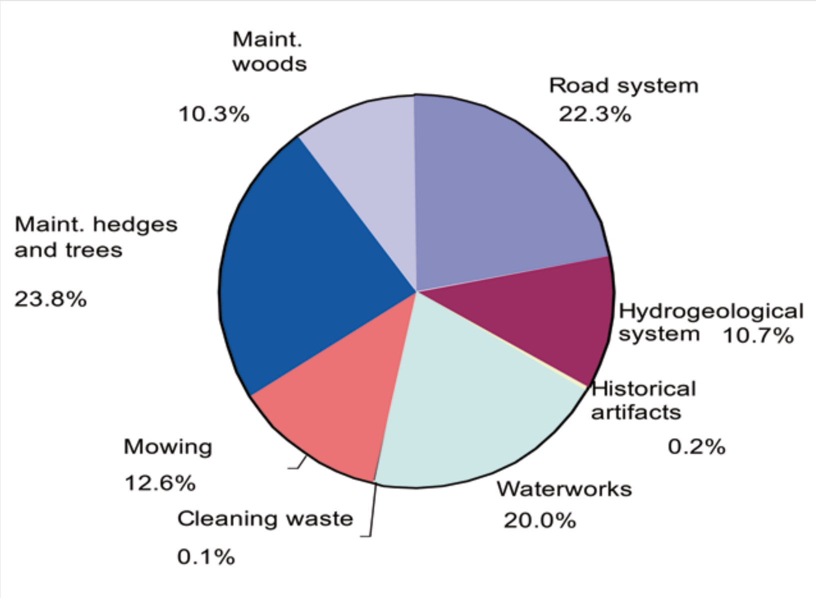

Fig. 8.2 Distribution of the costs borne by farms for landscape conservation. (Source: Tempesta 1994, reworking)

In more general terms, Table 8.15 shows the detailed results of three specific studies carried out to establish the costs borne by farmers for the conservation of landscape in three different territorial contexts: a mountain community, hill country and lowlands. As we can see the costs decrease with the highest in the mountain community (179 €/ha), dropping for the hill country (132 €/ha), and

Table 8.15 Costs borne by farmers for the conservation of rural landscape elements. (Source: Marangon and Tempesta 2008)

Area	Schio (VI)	Colli Euganei (PD)	Udine Plains
Geographical zone	Alp foothills	Wine-growing low hill country	Lowlands
Year	1990	1991	1993
No. of farms	19	21	13
Total per ha (€ 2004)	179.15	132.09	48.17
% marketable production	16.3	2.48	1.76

lowlands (48 €/ha). In the mountain community the maintenance costs of the territory and landscape amount to over 16% of the farm's marketable production. Furthermore, the composition of the costs differs on the basis of the zone: in the mountain community the costs for mowing meadows for aesthetic purposes, the maintenance of woodland and non-productive meadows are particularly high; in hill country and the lowlands there are more interventions for the conservation of the waterworks, hedges and of the inter-ponderal roads.

Table 8.16 Tourism flows

Indicator	Tourism flows
Definition	The increase in tourism flows is assessed in a specific area of reference
Description	The indicator is based on the variation in arrivals and tourists presences measured in a specific territorial area in a certain temporal period of reference
Category	Economy
Aims pursuant to landscape	Evaluation
Status/Process	Process
DPSIR category	State/Impact
Typology	Simple
Component variables (if index)	–
Unit of measure	%
Territorial scale of reference	Local (municipal, supramunicipal), provincial, regional
Time scale of reference	Year
Characteristics of use	Environmental reports, monitoring
Availability of data source	Tourism databases (Regional tourism observers) Arrivals and presences of tourists monitored at a municipal level
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	–
Fields in which it was used	Social-economic reports, Regional tourism observatories

Box 8.5 Analysis of Tourist Movements in the Piemonte Region

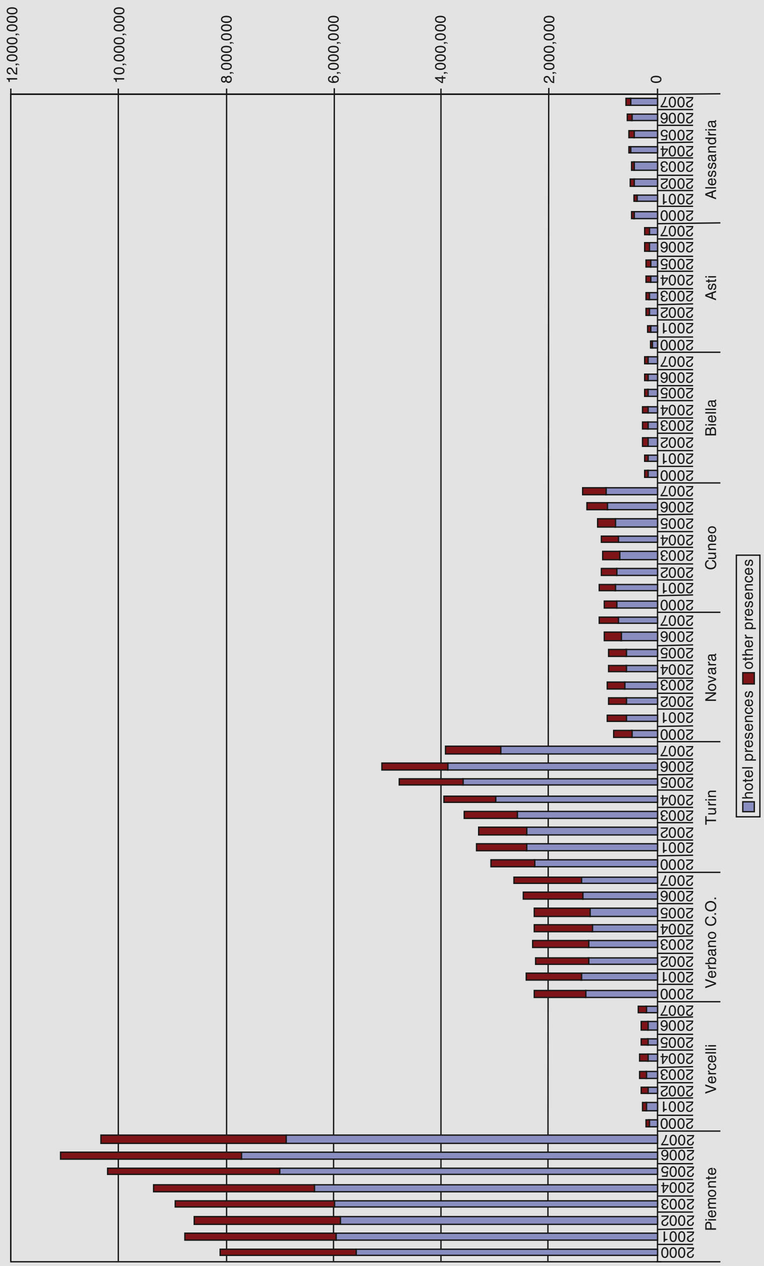

Fig. 8.3 Tourist presences in the Piemonte Region in hotels and other accommodation facilities (2000–2007). (Source: Piemonte in cifre 2007, reworking)

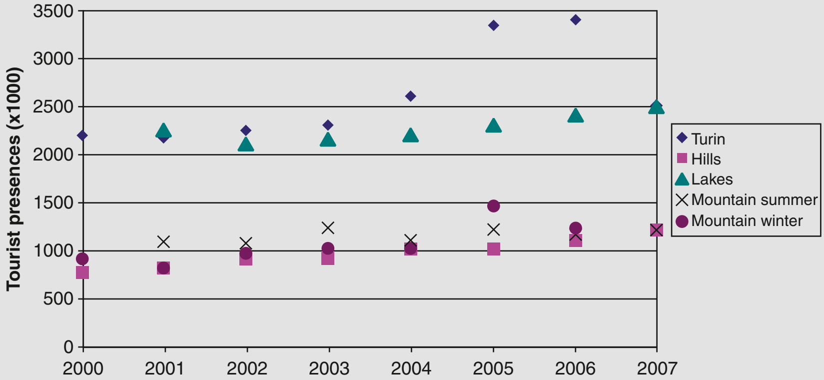

Fig. 8.4 Tourist presences in the Piemonte regional territory in various geographical areas (2000–2007). (Source: Regional Tourism Observatory and Piemonte in cifre 2007, reworking)

Some data on tourist movements in the Piemonte Region of Italy is presented. On the basis of the data, we can examine the distribution of the presences in the various provinces and the accommodation structures used (hotels and other).

The elaborations of the data (Fig. 8.3) show that in general the movements on the regional territory have a positive trend, with a growth rate diversified between hotel presences and presences in other accommodation facilities. The latter, with accommodation in campsites, farm tourism enterprises and similar, is associated in particular with forms of "slow" tourism and territorial use.

It may be interesting to examine the distribution of tourist presences in the various geographical areas of the region (Fig. 8.4). The elaboration of data from the Regional Tourism Observatory shows that the hill country, combining the beauty of landscapes with the food-and-wine offer, represents the destination with the highest rate of growth in the regional territory. This is also evident in the following values from 2007, calculated in relation to 2006: +7.2% arrivals (529,953) and +4.6% presences (1,221,741).

Furthermore, the data on the tourist sector can be used to create thematic maps, to show the geographical distribution of the phenomena. The example in Fig. 8.5 indicates the data on the tourist sector in the Piemonte Region.

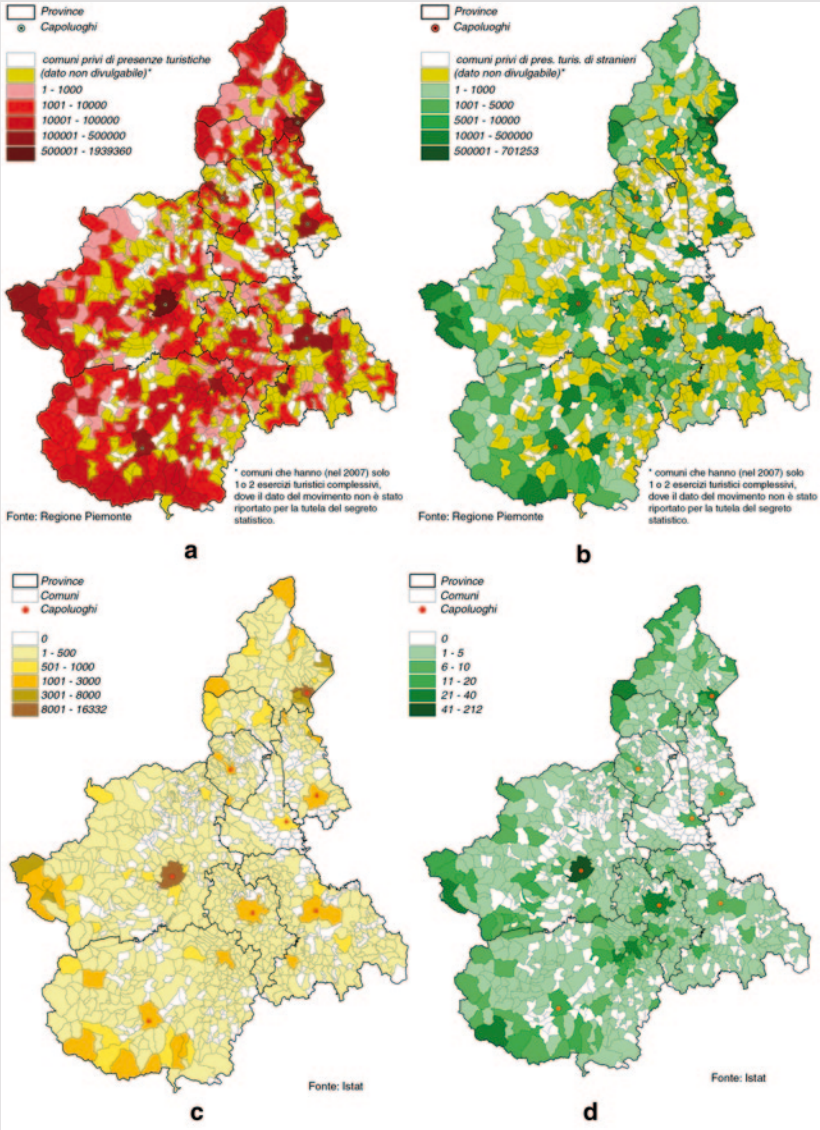

Fig. 8.5 Examples of thematic maps representing the data on tourist flows in the Piemonte Region concerning the national tourist presences (**a**), the international tourist presences (**b**), the number of bedspaces in hotels (**c**) and the number of bedspaces in other accomodation structures (**d**). (Source: Piemonte in cifre 2007)

Table 8.17 Value added

Indicator	Value added
Definition	The development of economic sectors connected with landscape is assessed (typically agriculture and tourism) using an established net value added figure
Description	As for the agricultural sector, the indicator calculation is based on the net variation in the established value added for any agricultural product of value for landscape subsidized with specific financial instruments As for the tourism sector, the indicator calculation is based on the net variation of the established value added in the enterprises of that economic sector in a specific area of reference
Category	Economy
Aims pursuant to lanscape	Evaluation
Status/Process	Process
DPSIR category	State/Impact
Typology	Simple
Component variables (if index)	–
Unit of measure	€
Territorial scale of reference	Provincial and regional
Time scale of reference	Year
Characteristics of use	Monitoring, social-economic reports
Availability of data source	Direct surveys and social-economic databases
Method of representation	Thematic maps, temporal evolution, aerogramme distribution
Other explanatory notes	–
Fields/Work in which it was used	Social-economic reports, ex post assessment reports of Rural Development Plans (for example Regione Umbria 2007)

Table 8.18 Employment

Indicator	Employment
Definition	The employment effects in the economic sectors related to landscape are assessed (usually agriculture and tourism)
Description	The indicator calculation is based on the assessment of the net increase in employment in the agricultural and tourism economic sectors For the agricultural sector, the indicator calculation is based on the net variation in employment (or Annual Work Units, AWU) for agricultural products of value for landscape subsidized with specific financial instruments As for the tourism sector, the indicator calculation is based on the net variation of employment in the enterprises of that economic sector in a specific area of reference
Category	Economy
Aims pursuant to landscape	Evaluation
Status/Process	Process
DPSIR category	State/Impact

Table 8.18 (continued)

Indicator	Employment
Typology	Simple
Component variables (if index)	–
Unit of measure	%
Territorial scale of reference	Provincial and regional
Time scale of reference	Year
Characteristics of use	Monitoring, social-economic reports
Availability of data source	Direct surveys and social-economic databases
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Social-economic reports, ex post assessment reports of Rural Development Plans (for example Regione Umbria 2007)

Table 8.19 Amount of subsidies obtained

Indicator	Amount of subsidies obtained
Definition	The entity of the subsidy to enterprises in the agricultural, cattle-farming and forestry sectors is assessed
Description	The indicator calculation is based on the assessment of the total financial instruments used to subsidize agro-sylvo-pastoral production of value for landscape
Category	Economy
Aims pursuant to landscape	Acknowledgement/Assessment
Status/Process	Status
DPSIR category	Status/Impact
Typology	Simple
Component variables (if index)	–
Unit of measure	€
Territorial scale of reference	Provincial and regional
Time scale of reference	Year
Characteristics of use	Monitoring, social-economic reports
Availability of data source	Social-economic databases
Method of representation	Thematic maps, temporal evolution
Other explanatory notes	–
Fields/work in which it was used	Ex ante assessment reports of Rural Development Plans 2007–2013

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European Commission Directorate for Agriculture and Rural Development. http://ec.europa.eu/agriculture/index_en.htm
MTT Agrifood Research Finland. http://www.mtt.fi/english/
OECD Organization for Economic Co-operation and Development. http:// www.oecd.org/
SPESP Study Programme on European Spatial Planning. http://www.nordregio.se/spespn/welcome.htm

Chapter 9
Proposal for a Set of Indicators

Attilia Peano, Marta Bottero and Claudia Cassatella

Abstract The indicators proposed in the previous chapters for each profile of interpretation are selected and regrouped, to obtain two complete sets which, on a regional and local scale, can be used to assess landscape transformation. The indicators are selected with reference to a case study and the applicability of the indicators chosen is verified in a summary table with the necessary technical stages.

Keywords Composite indicator, set of indicators • Evaluation matrix • Landscape monitoring

9.1 In Search of Synthesis Indicators

In the previous chapters we dealt with the assessment of landscape on the basis of specialist disciplinary approaches. For each of these we are in the presence of not just one single indicator, but a set or series. In fact, in consideration of each of the disciplines, the theme is quite complex: there are different indicators for different goals and types of application, but also to cater for the many different dimensions of the problem. How to obtain a synthesis? There are at least two ways. The first is to choose an indicator believed to be more meaningful than the others. The second is to search for a method to arrange the values of the numerous indicators selected (using one of the possible assessment techniques).

Peano and Cassatella are the authors of paragraphs: 9.1–9.3, 9.6; Cassatella and Bottero: 9.4, 9.5. CSI-Piemonte collaborated in the formalization of the indicators described in the last paragraph.

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Let's consider the first hypothesis. On the basis of the experiences in the previous chapters, we can see some recurrences and superimposition, which might suggest the existence of indicators with a multidimensional value. At the same time, many possible interpretations for the same indicator could be a sign of weakness. Let's take a look a few examples. An emblematic case is the "presence (or percentage of surfaces) of protected areas" (or in any case of established and ratified value, such as protected natural areas, or assets of historical-cultural interest): this can be used as an indicator of landscape quality (although it cannot be taken for granted), or as an indicator of social sensitivity to landscape, or as an indicator of the response of public action and the effectiveness of policies. Therefore, should we say that it is a multipurpose indicator and therefore quite useful, or that it could be misleading, as it can be interpreted in many different ways?

Some easy-to-measure indicators are also adopted from a single profile of interpretation, attempting to broaden their value on the basis of certain, not always verified assumptions. This is the case with the land consumption indicator: which is often used to measure landscape degradation. In this case, any human settlement (including the areas to which we attribute historical cultural value) and any anthropical transformation represents landscape degradation, without the possibility of creating new landscape values and contradicting the concept of the European Landscape Convention (CoE 2000), which considers "everything as landscape", also urban landscape. Common sense would suggest that this indicator can however be very meaningful in the assessment of rural landscapes, where, with an increase in anthropic areas, we may also find some correlated phenomena on an ecological and perceptive scale: decrease in ecological heterogeneity and fragmentation of ecosystems, increase in disturbance such as noise and light pollution, and the presence of elements "out-of-place" from an aesthetical point of view. Therefore, in the assessment of rural landscape it can be used as a synthesis indicator, but not in a generalized way (Cassatella et al. 2009).

Other land use indicators (therefore relatively simple to measure) are used as predictors of the quality or criticality of the landscape. For example, the presence of degraded areas (quarries, dumps, or other categories which, on the basis of common sensors, are perceived negatively[1]), or, on the contrary, the presence of natural and rural areas. Or the presence or implementation of landscape-specific plans and projects: we know nothing of the real quality of these projects (which could be seen as having an impact on landscape) but we take it for granted that their existence is a positive factor.

Landscape ecology indicators are also subject to interpretation in an attempt to expand the meaning to include other dimensions, in particular scenic dimensions.

[1] The choice of categories is a very sensitive issue, and can vary on the basis of social contexts: for example, the public generally does not appreciate industrial areas (or special structures such as greenhouses, power stations, etc.), which can however have a significant effect on the economy and be important for the local population, also representing traditional activities. Quarries where material has been extracted for centuries, such as in the Carrara district in Tuscany are an example of this; or the greenhouses used for flower-growing in the Riviera.

The expression “landscape diversity” (which we would have preferred not to use, maintaining the distinction between “ecological heterogeneity” and “scenic variety”) contains this ambiguity.

It is based on the hypothesis that, in the presence of ecological heterogeneity there is a high probability also of the presence of scenic variety; this hypothesis has been the subject of numerous empirical studies, which aim to establish a correlation between components or features of the landscape and scenic preferences, with many practical and theoretical problems[2]; research into correlations is made easier by the use of Geographic Information Systems; but the subject is still open to debate and criticism[3].

Another category of indicators to which various values are attributed is economic indicators. Investments in resources for (historical, naturalistic or landscape) heritage, as well as having to be proportional to effects on the territory, also express a sense of political-social sensitivity. Unfortunately, we can only measure public investments, while it would be just as important to consider private investments. Other analysis techniques used to make hypotheses for a comparison of economic data and landscape phenomena (for example the economy of tourism, or agriculture, or the property market) offer interesting insights into understanding not only the costs and benefits associated with landscape management, but also appreciation, therefore intersecting the scenic dimension. Nevertheless, indicators based on these techniques are not consolidated, and require many distinctions for interpretation.

Finally, instead of trying to use one single indicator to interpret several landscape dimensions, it may be more advisable to follow the second road and look for a method to assess each dimension using an (albeit partially) appropriate indicator. The evaluation of the various aspects may also be conflicting (of the opposite sign for example, some positive, others negative): this provides interesting guidelines for decision-makers and for intervention. For example, the “Landscape significance index” used in Lombardy Region to assess the impact of major public works on landscape and establish the most appropriate compensation: this is a synthetic index, calculated as a mean of the values of three indicators (morphological complexity, cultural landscape significance, vegetation), in the clusters into which the regional territory is uniformly divided (Lombardy Regional Authority 2007). The result of this method (called *Val.Te.R—Valutazione del Territorio Rurale—Rural Territory Assessment,* Fig. 9.1) is considered “indicative”, as the recommendations for action (for example the decision to compensate the impact of a public work with interventions on the vegetation, or on the historical heritage) derive from the possibility of retracing one’s steps in the process of aggregation, and verifying which components

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[2] That a “good landscape” from the point of view of biodiversity is also a “pretty landscape” remains to be proven and there is also evidence to the contrary (for example, the greater part of the urban population is unable to appreciate the wild and spontaneous vegetation, while they will consider an urban park pretty and natural).

[3] For example a correlation between ecological and visual diversity is proposed by Schüpbach (2003). In the study of the AAMPB on the preferential landscape of the Dutch population, the predictions of the GIS model (GLAM, GIS-Based Landscape Appreciation model) was low (Farjon et al. 2009).

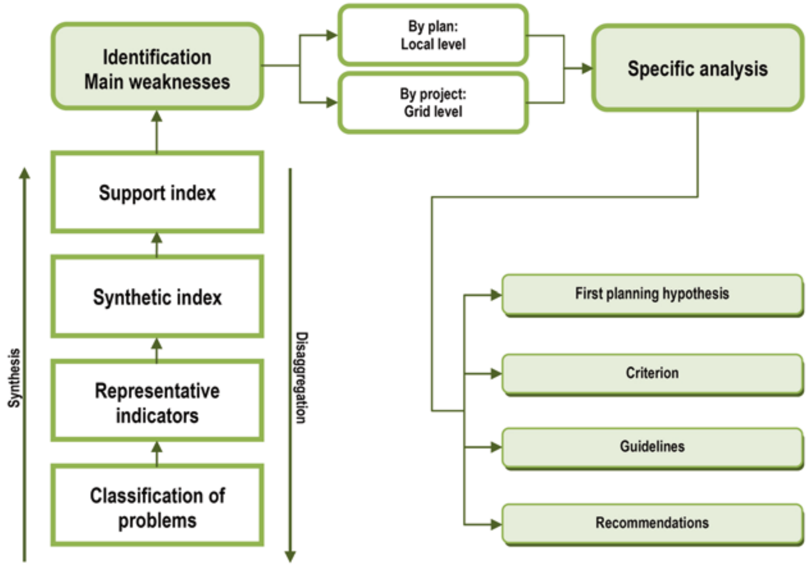

Fig. 9.1 Conceptual layout of the process of assessment used in the Val.Te.R method (Lombardia Regional Authority 2007, reworking)

represent a positive situation and which a negative situation. Furthermore, the results are interpreted with reference to significant spatial aggregations, such as the Landscape units or geographical macro-areas (plains, hills, mountains). Note that the three basic indicators are unequivocally associated with three series of goals for territorial planning and policies.

9.2 From a List for the Choice of the Application to a Concrete Case

Vallega (2008) distinguishes the functions of the indicators as follows: *recognition function* (monitoring and measuring conditions and processes), *evaluation function* (judgement of the value on the condition, on the process and on the human action in relation to these), *orientation function* (supplying indications on the ways in which human action should be implemented). These functions are well represented in the phases of the SEA process: screening, scoping, monitoring. Therefore, there can be different indicators in each phase to indicate the goals and risks, and value the changes. But, "A compatible set of indicators may be difficult to achieve and, frequently, the assessment process may reveal inconsistencies" (Fischer 2007, p. 40).

Table 9.1 Key conceptual relations between targets and vectors for the selection of landscape indicators (Wascher 2004)

TARGETS	VECTORS		
	Structures	**Management**	**Function**
Identity	Typology Diversity/Coherence Naturalness Man-made objects Patterns, lines, points		
Sustainability		Maintenance Mitigation Change Development Protection and education	
Value			Quality of life Cultural identification Productivity Biodiversity Environmental processes

Wascher proposes "a system that links three main targets to three main criteria on a one-to-one basis, suggesting three relational pairs for which indicators should be developed" (Wascher 2004, p. 242); the principal concept is sustainability (Table 9.1).

Our starting point is the list of indicators suggested by specialists in various thematic fields, used to analyse landscape. The aim of our test is to draw up a set of indicators for the Strategic Environmental Assessment (SEA) of territorial plans and town planning to assess landscape transformation. In the following paragraphs (Sects. 9.3, 9.4) we will propose a selection and an aggregation of indicators in two complete sets, on a regional scale and on a local scale, with reference to DPSIR categories. The aggregation, in some cases, involves the refinement and redefinition of the indicator and its method of measurement.

The following table (Table 9.2) shows a full list of the indicators proposed in the previous chapters for each profile of interpretation. For each of these, there is not just one single indicator, but a set or series. The choice of suitable indicators from the above may vary on the basis of:

- the type of application (assessment of landscape state, its transformation, or landscape policies) and the users of the assessment;
- the characteristics of the territory;

Table 9.2 List of indicators for each profile of interpretation

Category	Indicators	DPSIR	Scale	
			R	L
Ecological	Evenness	S/I	■	■
	Biological Territorial Capacity	S/I	■	■
Historic and cultural	Exceptionality of the historical-cultural characteristics of the landscape	S	■	■
	Fragility of the historical-cultural characteristics of the landscape	S	■	■
	Significance/typicality of the historical-cultural characteristics of the landscape	S	■	■
	Preservation of the assets and their relation system	S	■	■
	Promotion of actions for further knowledge of historical-cultural heritage	R	■	■
	Economic enhancement of historical-cultural heritage	R	■	■
	Use of historical-cultural heritage; networking	S	■	■
Visual and social perception	Variety (or visual diversity)	S	■	■
	Landscape significance	S	■	
	Imageability	S		■
	Obstruction of view from viewpoints	I	■	■
	Visibility of the sky at night and silence	S	■	
	Fame	S/I	■	■
	Tranquillity	S		■
	Amenity	S	■	■
	Tree canopy coverage	D		■
Land uses	Land capability	D	■	■
	Land consumption	P	■	■
	Degraded landscapes and/or landscapes under pressure	P	■	■
	Rural areas	S	■	■
	Sensibility of the planning aims for the landscape	R	■	■
	Actions of valorisation	I		■
	Effectiveness of the planning aims for the landscape	R	■	■
	Protected areas	S	■	■
	Landscape protection	S	■	
Economic	Recreational benefits	S		■
	Housing prices	I		■
	Willingness to pay per hectare	S		■
	Conservation costs	R		■
	Tourism flows	S/I	■	■
	Value added	S/I	■	
	Employment	S/I	■	
	Subsidies	S/I	■	

- the values socially attributed to that territory, in other words the attribution of importance to various aspects of the landscape and the relevant problems;
- the requisites of the indicator;
- the presence of existing and/or implemented databases.

As we can see, the set cannot be created without knowledge of the territory subject to assessment, in other words a concrete case: unlike some environmental indicators, landscape indicators seems to have a low level of transferability. The category of indicators (corresponding to the profiles of interpretation) is easier to generalize, within which the same aspects can be measured by different indicators in different contexts (cf. Sect. 3.1).

9.3 The Case Study

Our case study was done on the Piemonte Region, a region in northern Italy (Fig. 9.2) with a notable variety of landscape characters in its 2,540,246 ha (Fig. 9.3, Table 9.3): the landscapes of the Alps, the lakes in the foothills, the River Po, the hills (such as the Langhe and Monferrato famous for their vineyards). There are 1,200 towns or cities, all of which founded in ancient times; the capital Turin was the first capital of Italy after the unification in 1861. It has a rich historical patrimony (castles, villas and religious buildings, including some baroque classics, with fine examples of rural, alpine and industrial architecture) and there are also two UNESCO World Heritage Sites—the Residences of the Royal House of Savoy and the Sacri Monti (Sacred Mountains).

Fig. 9.2 The Piemonte region in the European context

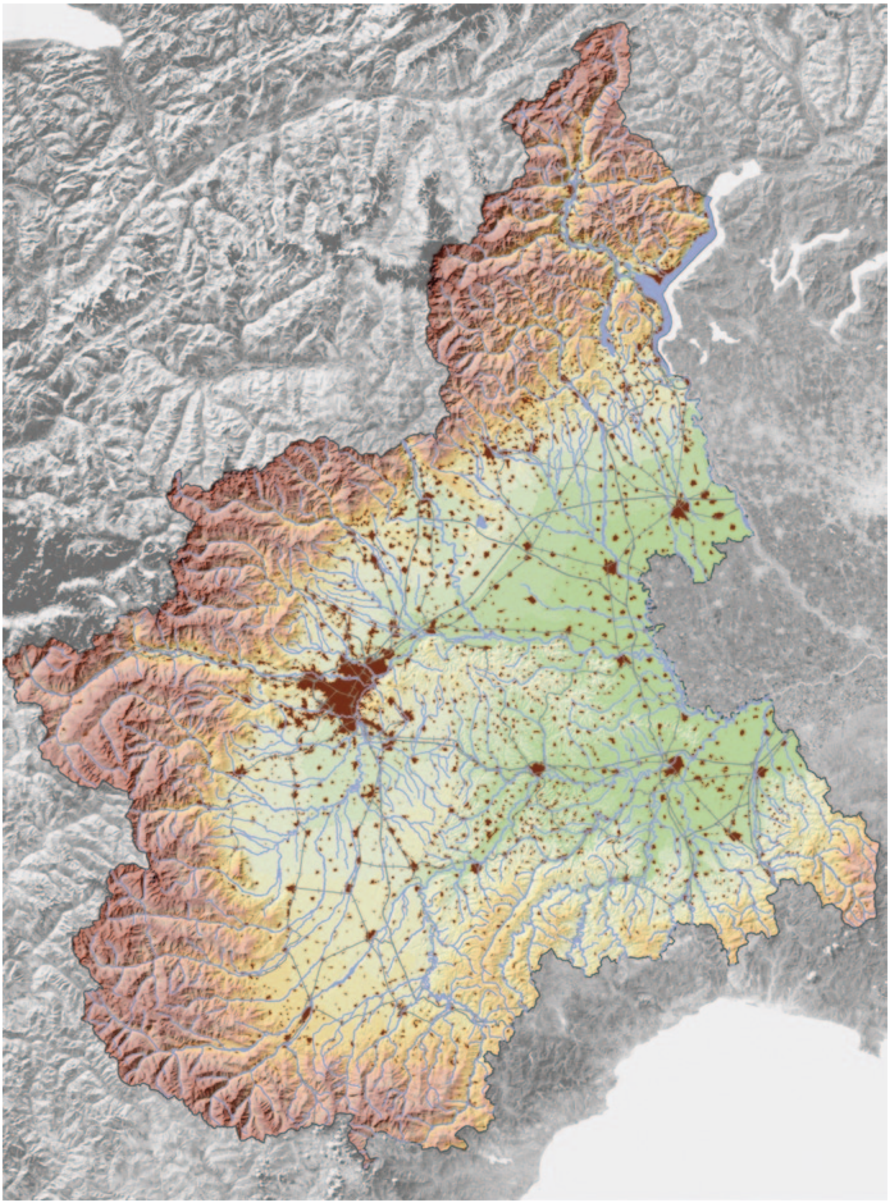

Fig. 9.3 The territory of the Piemonte region

Thanks also to presence of the biggest Italian automobile industry (Fiat), in the past there was considerable industrial growth in Piemonte, with a significant population increase. The substantial infrastructures, supported by the dense pre-existing urban network, emphasise the current phenomena of urban sprawl and land con-

Table 9.3 The Piemonte region: some statistical data (elaboration of data from the National Statistical Institute and the Italian Ministry of Cultural Heritage and Activities)

Territorial surfaces	Mountains	1,098,663 ha
	Hills	769,830 ha
	Plains	671,743 ha
	Total	2,540,246 ha
Total population		4,352,828
Territorial density		166 inhabitants/km^2
Number of towns/cities		1,206
Average municipal territorial surfaces		2,106,339 ha
Average number of inhabitants per municipality		3,609
Landscape conservation area in accordance with legislative decree n. 42/2004 (Art. 142)	52.84%	13,425 km^2

sumption. At the same time, the region has made its name in Italy for its commitment to environmental protection, the conservation of historical heritage, and the creation of protected areas.

Since 1977, when the administration of territory and town planning came under the competence of the Italian regional authorities, each of these has drawn up its own legislation, opening offices to create maps and geographical data bases, drawing up regional plans and approving the town planning of subordinate territorial bodies. The Piemonte Regional Authority town planning laws (Regional Law n. 56/1977 "Protection and use of land") obliges local bodies to acknowledge and protect "cultural and environmental assets" in municipal plans. Furthermore, Piemonte has a territorial-landscape plan drawn up in 1997 and a new plan specifically for landscape is awaiting approval (Piemonte Regional Authority 2009). Over half the surface area of the region is subject to special restrictions associated with the protection of landscape, a subject which remains the competence of the State (Legislative decree n. 42—22/01/2004 "Cultural Heritage and Landscape Code").

The landscape plan was an excellent chance to create and systematize new knowledge on the landscapes of the region, concerning different aspects: naturalistic, historical-cultural, morphological-settlements, scenic and identity. This knowledge can, at least partly, be used to create indicators.

The plan is subject to SEA, but until now only ecological indicators have been used for landscape (cf. Chap. 4, Box 4.2: "Application on a regional scale: the Strategic Environmental Assessment of the Piemonte Regional Landscape Plan"). In accordance with national legislation, the Regional Authority must set up a Regional Observatory to monitor landscape quality: this body could be useful for monitoring landscape using more wide-ranging indicators that are not tied to one single planning instrument.

The strategic framework of the Regional Landscape Plan can provide the target for establishing indicators for the Piemonte landscape. The "Territorial requalification, protection and valorisation of the landscape" strategy has several goals, including:

- the valorisation of polycentrism and the cultural and socio-economic identity of local systems
- the protection and valorisation of biodiversity and naturalistic-environmental heritage
- the valorisation of tangible and intangible territorial heritage
- the protection and requalification of the characters and images that identify landscape
- the requalification of the urban and periurban context
- the revitalization of mountains and hills
- the recovery and reclamation of degraded abandoned and disused areas

In general, we must say that the Region Authority is committed to the intense promotion of its own image and resources, to attract new investments and promote the tourist trade. It has managed to use considerable European funds for this purpose, to a greater extent than any other Italian region. These aspects are therefore relevant when choosing regional indicators (as we will see, the focus will be on reputation and tourist flow for example).

As for local indicators, considering the variety of the landscapes, some general themes were indicated that the Regional Authority could ask local bodies to verify with town planning SEA, to create a link with the goals of landscape policies. At the moment, in fact, the SEA of each local plan is free to choose its own indicators, with no directives regulating the subject.

9.4 Sets of Indicators for the Regional and Local Scale

Starting with the indicators selected in the research for each profile of landscape interpretation (Table 9.2), at this point we propose a set of specific indicators for the assessment and monitoring of the situation in Piemonte. In general, when changing from the indicators selected to those proposed, at times some re-elaborations were required to represent the complexity of the situation in a synthetic way.

As mentioned above, as the themes associated with landscape are particularly sensitive to the territorial scale of reference, the proposed set was divided into two different levels, region and local, which correspond to two levels for processing territorial policies and plans.

The sets of indicators proposed for the regional and local scale have some common fundamental characteristics used as guidelines for construction. Firstly, we wished to propose sets of indicators consisting of a limited number of elements to make them easier to use and apply, in other words about a dozen indicators. Secondly, the set was created to guarantee coverage of the "PSIR" categories in the DPSIR model and also the interpretation of all five profiles in the study.

Furthermore, in the choice of the indicators, great importance was given to the relationship with the characteristics of the territory in question. For example, the belvedere indicator reflects the importance of panoramic values in the Alpine re-

Table 9.4 The set of regional indicators with respect to DPSIR categories

Indicators	Pressure	State	Impact	Response
Ecological		R1 Evenness R2 Biological Territorial Capacity		
Historic and cultural		R3 Preservation of the assets		R4 Promotion
Visual and social perception		R5 Fame	R6 Obstruction of view from viewpoints	
Land uses	R7 Land consumption R8 Degraded Landscapes			R9 Landscape Protection
Economic		R10 Tourism Flows R11 Employment		

gions and hill country, the indicator relevant to employment in the agricultural sector is associated with the rural character of considerable parts of the territory. The indicators was also proposed in consideration of the goals established by the Piemonte Regional Authority in the field of policies for territorial government, such as the valorisation of cultural assets and the tourists system or restricting land consumption. The structure of these sets of indicators meet requirements for the assessment and monitoring of plans, both on a territorial and town planning scale, as established in SEA procedures. Finally, the existence of some operational limits, first and foremost the availability of data, also influenced the proposal. In this field, for example, note the survey of panoramic views setup for the Regional Landscape Plan.

With particular reference to the set for the regional scale, Tables 9.4 and 9.5 list the indicators proposed. Here, we will merely illustrated the set, explaining the profile of landscape interpretation for each indicator, with the definition and DPSIR category of reference, while a more detailed analysis of the indicators, with some examples of application, can be found in the tables of the previous chapters.

A detailed look at the set of indicators proposed.

- The interpretation for the ecological profile, as this is the most consolidated field of analysis, did not require additional selection and processing. The indicators proposed, on evenness and biological territorial capacity, correspond to two indicators initially used in research (see, respectively, the items of Tables 4.3 and 4.4).

Table 9.5 Set of indicators proposed for monitoring on a regional scale

Category	Indicator (regional scale)	Definition	DPSIR
Ecological	R1 Evenness	Assesses ecological diversity, as the richness of the landscape element types (biotopes) that characterise a landscape mosaic. Ratio between the real diversity of a landscape mosaic obtained with the Shannon formula (H) and the maximum possible (H_{max})	S/I
	R2 Biological territorial capacity (BTC)	Magnitude of the metabolism of the ecosystems in a territory and of its homeostatic and homeoretic capacity (for self/re-equilibrium), which measures the level of equilibrium of an environmental system. It is defined by the sum of the products of surfaces with different land use types, and the relevant unit biological territorial capacity value, and by the subsequent weighted average of this sum in relation to the total surfaces being studied	S/I
Historical and cultural	R3 Preservation of the assets	This index allow to individue the preservation dynamics of historical and cultural assets at the regional level, by observation of protected landscape elements in accordance with Italian Cultural Heritage and Landscape Code and the others protected by the planning instruments	S
	R4 Promotion of actions for further knowledge of historical-cultural heritage	This index allow to assess the level of historical and cultural promotion, since the observation of economic resources invested from public authorities (for example, funds for scientific and popular publication on specific goods, researches and studies, …)	R
Visual and social perception	R5 Obstruction of views from viewpoints	Negative effect on picturesque views caused by a loss of visibility, in other words by the partial (or total) restriction of the field of vision	I
	R6 Fame	Frequency of citation of a regional landscape or a certain landscape in a sample of representation (direct interviews, electronic media, printed media, artistic representations, etc.), variation in time. Can be considered an indicator of social acknowledgement and identity value	S/I
Land uses	R7 Land consumption	Relationship between artificial surfaces for types of land consumption and the total surfaces of reference	P
	R8 Degraded landscapes and/or landscapes under pressure	Relationship between the sum of surfaces used for extractive/mining activities, dumps, quarries, unstable landscapes and landscapes subject to erosion, and the total surfaces of the territorial entity of reference	P
	R9 Landscape protection	Relationship between the sum of the protected surfaces (landscape goods, areas protected by law, protected areas) and the total surfaces of the territorial entity of reference	R

Table 9.5 (continued)

Category	Indicator (regional scale)	Definition	DPSIR
Economical	R10 Tourism flows	The increase in tourism flows is assessed in a specific area of reference. The indicator is based on the variation in arrivals and tourists presences measured in a specific territorial area in a certain temporal period of reference	S/I
	R11 Employment	The employment effects in the economic sectors related to landscape are assessed (usually agriculture and tourism). The indicator calculation is based on the assessment of the net increase in employment in the agricultural and tourism economic sectors	S/I

- In the analysis of the historical-cultural profile we favoured indicators that allow for the preservation of the historical and cultural assets (Table 5.9) and the promotion of actions for further knowledge of historical-cultural heritage (Table 5.11).
- For the assessment and monitoring of the regional landscape for the perceptive profile, indicators relevant to the obstruction of panoramic views (Table 6.10) and fame (Table 6.11) were chosen.
- From a land use point of view, the set proposes indicators relevant to land use consumption (Table 7.8), degraded landscapes (Table 7.9) and landscape protection (Table 7.12).
- Finally, the assessment of the economic aspects of the landscape is based on the observation of tourist flows (Table 8.16) and phenomena associated with employment in the agricultural sector and tourist trade (Table 8.18).

The set of indicators proposed for the local scale is illustrated in Tables 9.6 and 9.7. Again, refer to the detailed information in previous chapters also in this case.

- Once again indicators relevant to evenness and biological territorial capacity (respectively, Table 4.3 and 4.4) which can also be applied to landscape assessment on a local scale, were identified for the ecological profile.
- With reference to the historical-cultural profile, as more detailed information can be managed on a local scale, the indicator relevant to the state of heritage conservation was considered in the most complete version which also allows for the preservation of the system of relations between assets (Table 5.10). Another historical-cultural indicator refers to the use of historical and cultural heritage (Table 5.13).
- To examine the scenic profile, the assessment on the local scale is based on the indicator relevant to the visibility of the night sky and silence (Table 6.9). Furthermore, as in the case of the regional scale, the set proposes the indicator relevant to the obstruction of panoramic views (Table 6.10), but on this scale it could be integrated with assessments on the quality of the transformations in the panorama observed.

Table 9.6 The set of local indicators with respect to DPSIR categories

Indicators	Pressure	State	Impact	Response
Ecological		L1 Evenness L2 Biological Territorial Capacity		
Historic and cultural		L3 Preservation of the assets L4 Use of historic and cultural heritage		
Visual and social perception		L5 Visibility of the sky at night and silence	L6 Obstruction of view from viewpoints	
Land uses	L7 Land consumption L8 Degraded Landscapes			L9 Sensibility of the planning aims for the landscape
Economic		L10 Recreational benefits	L11 Housing prices	L12 Conservation costs

Table 9.7 Set of indicators proposed for monitoring on a local scale

Category	Indicator (local scale)	Definition	DPSIR
Ecological	L1 Evenness	Assesses ecological diversity, as the richness of the landscape element types (biotopes) that characterise a landscape mosaic. Ratio between the real diversity of a landscape mosaic obtained with the Shannon formula (H) and the maximum possible (H_{max})	S/I
	L2 Biological territorial capacity (BTC)	Magnitude of the metabolism of the ecosystems in a territory and of its homeostatic and homeoretic capacity (for self/re-equilibrium), which measures the level of equilibrium of an environmental system. It is defined by the sum of the products of surfaces with different land use types, and the relevant unit biological territorial capacity value, and by the subsequent weighted average of this sum in relation to the total surfaces being studied	S/I
Historical and cultural	L3 Preservation of the assets and their relation system	This index allow to individue the preservation dynamics of historical and cultural assets at the local level, by observation of principal historical and architectural assets and analysis on the state of preservation of built heritage with reference to characterizing elements and their relation system	S

Table 9.7 (continued)

Category	Indicator (local scale)	Definition	DPSIR
	L4 Use of historical-cultural heritage, networking	In relation to a specific area, this indicators assess the level of landscape resources, both natural and historical-cultural, used by the public. This analysis is conducted by experts	S
Visual and social perception	L5 Visibility of the sky at night and silence	Contemporaneous visibility of the stars with the naked eye and the absence of noise disturbance. Admissible for the concept of tranquility	S
	L6 Obstruction of view from viewpoints	Negative effect on picturesque views caused by a loss of visibility, in other words by the partial (or total) restriction of the field of vision	I
Land uses	L7 Land consumption	Relationship between artificial surfaces for types of land consumption and the total surfaces of reference	P
	L8 Degraded landscapes and/or landscapes under pressure	Relationship between the sum of surfaces used for extractive/mining activities, dumps, quarries, unstable landscapes and landscapes subject to erosion, and the total surfaces of the territorial entity of reference	P
	L9 Sensibility of the planning aims for the landscape	Measures the focus of territorial planning and use policies on landscape, assessing the number of landscape actions envisaged and implemented by the plans on various scales	R
Economical	L10 Recreational benefits	Assessment of the recreational benefits per hectare deriving from the use of single landscape elements or the landscape as a whole	S
	L11 Housing prices	The variation in housing price per m^2 with reference to the overall quality of landscape or visibility of single elements is assessed	I
	L12 Conservation costs	The costs for the conservation of single elements or the landscape as a whole are assessed	R

- The analysis of the land use profile in this phase is also based on indicators used for the regional scale, in this case with detailed data and measurements. This is also the case with the indicators on land consumption (Table 7.8) and degraded landscapes (Table 7.9). Another indicator established in this profile refers to the effectiveness of the planning aims for the landscape (Table 7.6).
- The assessment of the economic aspects of the landscape on a local scale can be developed on the basis of the application of specific techniques and models, which cannot be tested on a large scale due to the quantity of data required for the assessment and the complexity of processing the same. Therefore, indicators relevant to the assessment of recreational benefits (Table 8.6) and housing prices were proposed (Table 8.9). Finally, in consideration of the cost of landscape conservation, an indicator on landscape investments was proposed, which integrates two previous indicators on the cost of the conservation of historical-cultural assets and environmental and natural assets (Table 8.13).

9.5 Which Indicators are Applicable? Data Management for the Feasibility Analysis of the Set of Regional Indicators Proposed

In order to verify the applicability of the set of indicators proposed on a regional scale for the analysis of the Piemonte landscape, a specific in-depth study of each indicator was developed. This in-depth study, in collaboration with the Piemonte Computer System Consortium (CSI-Piemonte), examined the operational conditions required for the application of the indicators proposed in order to test the real possibilities of use.

Firstly, the data (existing or which could be implemented and gathered) necessary for processing each indicator was identified; this data was then examined in detail, highlighting the sources of the basic information (subjects that manage the various territorial regional databases such as CSI-Piemonte, the Piemonte Regional Authority or information systems and detailed archives), as well as the relevant coverage, both in terms of time (periods in which the indicator is available, presence of historic series, recurrence of data updating, …) and from a spatial point of view (territory for which the basic data is availability, level of detail that can be obtained, …).

The type of representation (areal, linear or point) was also considered for the data necessary to construct the indicator. For others, the calculation algorithm and type of representation of the final information are indicated (tables, theme maps, temporal diagrams, …). Furthermore, any bibliographic references and regulations that support the indicator in question are quoted.

Finally, the criticalities associated with the use of the indicator proposed were considered, clarifying any limits of use; the excessive complexity of the indicator for example, which requires expert competence from potential users, or problems concerning the nature and quality of the basic data, which can lead to non-homogeneous processing.

The above information was studied in-depth for all the indicators proposed on the regional scales and systematized in the relevant summary table. The difficulties found in the construction of each of the indicators proposed involved obtaining the data, the high cost of data gathering, and the impossibility of periodically updating the data. This synthesis constitutes the starting point for the future implementation of the set of indicators presented. Regardless of the results in the case of Piemonte, the method of analysis illustrated in the summary table, represents a method with possibilities for general application.

Table 9.8 shows an example of a summary table for the indicator "degraded landscapes and/or landscapes under pressure", which also shows the type of problems that in-depth analysis can involve. As can be seen from the table, this is a useful indicator for monitoring the pressure on the regional territory, with repercussions also on aesthetic quality. The calculation algorithm used is based on a considerable amount of basic data from various sources, organized on the basis of different types of representation. The assessment showed the moderate complexity in the construction of the indicator mainly due to the difficulties associated with the integration

Table 9.8 Technical meta-documentation summary table for the assessment of the "degraded landscapes" indicator

Indicator characterization		
	Information	Explanation
Denomination	Degraded landscapes and/or landscapes under pressure	Indicator name
Description	The indicator assesses the areas subject to relevant landscape transformation (potential degradation) by calculating the relationship between the sum of surfaces used for extractive/mining activities, dumps, quarries, unstable landscapes and landscapes subject to erosion, and the total surfaces of the territorial entity of reference	Indicator description
Profile of interpretation	Land use	Profile of interpretation of the landscape provided by indicator: ecological, historical, perceptive, land use or economic
DPSIR category	P	DPSIR category: Driving forces (D), Pressures (P), State (S), Impact (I), Responses (R)
Aims pursuant to landscape	Identification	Indicator aims pursuant to landscape individuation, acknowledgement, assessment
Data necessary for construction	• RST elements (buildings and infrastructures) • Land register on sources of electromagnetic pollution—power lines • Dumps and waste disposal, electric productionsystems, thermo-valorisation and storing plants, industrial plants • Mining search and extraction activities, quarrying activities, solid minerals extraction activities, hydrocarbons and geothermic resources extraction activities • Abandoned areas • National and regional dumps • Hydrogeological settlement projects • Transport infrastructures • Ski-lifts • Agricultural irrigations systems • Communal administrative borders	List of data required for indicator (see the example schedules for the description of information data at the bottom of this table)
Calculation algorithm	$A = (S_D/S_T) \times 100$ S_D = surfaces intended for extraction activities, dumps, artificial quarries existing in the period in question S_T = total territorial surfaces of reference	Formulas, equations, statistical methods, calculation algorithm and any software instruments necessary for calculating the indicator

Table 9.8 (continued)

Indicator characterization			
	Information		Explanation
Unit of measure	Percentage		–
Source	CSI-Piemonte		Body elaborating the indicator
Type of representation	Table, Cartogram		Type of output information provided by indicator (table, graph, thematic paper, map, etc.)
Temporal characterization	Temporal coverage	1991–2008	Historical series of the indicator: specify period (periods) for which the indicator is available
	Update period	On the basis of data availability	Interval of reference
	Date of last elaboration	2010	–
	Level of temporal aggregation	Multi-year	Minimum temporal fractions for which the indicator is available. Example: daily, weekly, monthly
Spatial characterization	Spatial coverage	Piedmont region	Territory for which the indicator is available. Example: national, regional, provincial, municipal, basin or other
	Level of spatial aggregation	Town/city	Maximum level of territorial detail at which the indicator is available. Example: clusters of 1 km^2, municipality, province or other
Reference standards	–		Correlated regulations, any thresholds, values of reference, goals and target established by regulations
Bibliographic references	–		Bibliography providing information or in-depth study on indicator
Fields/work in which indicator was used	Elaboration by Vallega, 2008		–
Web site of reference	–		–

Table 9.8 (continued)

Indicator assessment		
	Information	Explanation
Accessibility	–	Method of access to indicator
Restrictions/limits of use	The updating of RST data isn't homogeneous for the entire territory The data does not include areas subject to erosion and occupied by unstable landscapes	For example: • Excessive complexity of the indicator and the consequent high competence required by user • Impossible to represent the spatial distribution of indicator values on the territory (lack of data homogeneity in different territorial units/different data quality) • Historical series of values unavailable
Significance of the indicator	The indicator partly represents the phenomenon of degradation in the aesthetic quality of the territory as it doesn't allow for the presence of relevant naturalistic, landscape, architectural aspects which could have different effects with the same impact	Capacity of the indicator to represent, in whole or in part, the phenomenon or goal of reference
Difficulties in the construction of the indicator	Average complexity Need to integrate and harmonize data from various sources, comparing the thematic archives with the RST polygons to obtain areal information when the datum of origin is point type The cost of updating also depends on the desired update period	For example: • Difficulties in obtaining data • High cost of data gathering and management • Impossible to repeat the calculation of the indicator periodically with data up-to-date • Difficulty in the aggregation or decomposition of the data, in relation to the methods used to construct the indicator • Special requirements in the methods used to gather data
Variations in the method of elaboration	–	Variation in the methods of elaboration/calculation of the indicator in the period in question

of most of the data from different sources, gathered for other purposes and of a non-homogeneous entity (point, linear, areal) and temporal and spatial coverage (Table 9.9). As well as the technical difficulties, in the assessment of the significance of the indicator, note that the "degraded landscapes" indicator could provide more meaningful results for the assessment of the aesthetic quality of the territory if the presence of elements considered to be predictors of degradation (quarries,

Table 9.9 Example: Datum 1. The remaining components (Data 2–11) are scheduled in the same way

Information data	Datum 1
Denomination	RST elements (buildings and infrastructures)
Unit of measurement	ha
Source	CSI Piemonte
Spatial coverage	Piemonte region
Temporal characterization	
Temporal coverage	1991, 2008
Periodicity of updating	According to data availability
Typology of representation	Surface
Accessibility	–
Variation in the method of variation	–
Presence of historical series	Yes

dumps, etc.) was simultaneously put in relation to the presence of elements of worth: for example, a quarry in an area of landscape value, or near an architectural asset obviously constitutes a negative element, although this may not be the case elsewhere. Obviously, in this case, the construction of the indicator becomes even more complex.

The single indicators proposed will have to be tested in the field to define the calculation algorithm precisely, and validate the applicability of the indicators.

The work done lays the foundations for a methodological proposal for landscape indicator systems. In fact, the themes dealt with and referred to in the summary table have made it possible to allow for real problems associated with the use of territorial indicators, doing away with common methods of approach to the theme of landscape indicators, which often result in lists that have not been duly verified in operating conditions.

9.6 For an Evaluative Synthesis

The choice of the indicators is just the first step in the assessment, followed by the construction of a matrix to reach the results of the synthesis. The construction of the matrix is not the competence of this study, but there are various methods used in evaluative science. One particularly relevant problem is the attribution of "weighting factors" to the different aspects considered, resulting in the relative importance of each in relation to the others. Benchmarking techniques are used to consider policy targets in an explicit and transparent way (Paracchini et al. 2008). For example, one promising model of assessment is the ANP (Analytic Network Process), based on a participatory approach and sensitive to the heterogeneity of the values on the basis of the subject: the weight expressed by the different stakeholders becomes clear during the assessment and decision-making process (Bottero et al. 2008). This appears to be in line with the indications of the European Landscape Convention, dictating that the values attributed to landscape by populations and stakeholders must be taken into consideration. As mentioned above (in Chap. 1), the synthesis of the assessments expressed through the single indicators is in fact fundamentally a political rather than a technical question.

There are currently very few experiences in landscape assessment and monitoring that can be considered complete. Ten years have yet to pass since the SEA Directive (2001/42/EC), and even less if we consider its implementation in national legislation: the complete monitoring process, from the "ex ante" to the "ex post" phase, can be analysed in very few cases. While there are numerous examples of indicators useful for characterizing the state of the landscape in the "ex ante" phase, as we have seen, much less development has gone into indicators for the "in itinere" and "ex post" phase: this constitutes a prospect for future study.

One interesting case of long-term assessment is the study by Natural England, English Heritage and Defra on "*indicators of change*" (Haines-Young 2007, Baker 2009). "Countryside Quality Counts. Tracking Change in the Character of the English Landscape", as can be seen from the title, is a study which initially makes use of the accurate and homogeneous description of landscapes throughout the territory using the *Landscape Character Assessment* method, and concentrates on measuring the changes in two phases, 1990–1998 and 1998–2003 (with another update soon). With reference to some objective factors (mainly land use, that can be obtained from cartographical sources), first it is necessary to verify if the landscape is stable or changing, measuring the magnitude. But in order to assess if the change is positive or negative, every theme is compared with the *landscape vision* expressed both in current plans and policies for the territory, and by the stakeholders: the changes can be *Consistent with vision or Inconsistent with vision*. In the latter case there may therefore be a loss of value or the creation of new unexpected values. The final judgement on the change of the landscape characters can therefore be: *Maintained, Neglected, Enhancing, Diverging* (Table 9.10). The degrees of transformation attributed (based on the interpretation of the indicators), is therefore consolidated by the judgement of local experts.

Perhaps the most interesting part of this experience was not the individuation of the indicators (which, anything but banal in the method of measurement, concern themes such as agriculture, settlements, vegetation…) but the following phase, of interpretation. The results, in fact, were discussed also publicly online, presented to landscape professionals, analysing the concordance between expert opinions and those that resulted from the use of the indicators. The CQC method comes from a country where assessment is a constant, so much so that the monitoring has had time to mature, and it is interesting to note that the results do not merely apply to this monitoring activity,

Table 9.10 Matrix of the assessment of landscape changes proposed by Countryside Quality Counts project (Natural England et al. 2009, reworking)

	Consistent with vision	Inconsistent with vision
Stable	Maintained	Neglected
Changing	Enhancing	Diverging

but can be interpreted in processes for landscape policies and plans, with reference to the goals of the same, confirming the fact that any set of indicators becomes significant and can be interpreted only in a context of explicit values and goals.

This approach is confirmed in the European Council of Ministers Recommendation for the application of the European Landscape Convention (CoE 2008), in *Part II.2.1 Knowledge of the landscapes: identification, analysis, assessment:* "The term identification should not be interpreted simplistically nor be limited to an inventory but should be linked to the establishment of landscape quality objectives"; "Landscape knowledge should be developed according to an identification, description and assessment process, which includes: (…) recognition of characteristics and value systems based on analysis by experts or knowledge of the social perception of landscape (…)".

The clarification of the political goals appears to be fundamental also due to the qualitative nature of landscape indicators: the measurement of indicators cannot refer to scientifically established thresholds, but limits and targets established according to the acceptability of changes, on the basis of political and social sensitivity. In this, they differ from other environmental indicators and are quite similar to social indicators[4] (Bertrand et al. 2008).

Establishing the goals, establishing the thresholds and indicators to measure the direction of change means also considering the same indicators as criteria-guidelines for the protection, management and planning of landscape.

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[4] "In environmental research—especially in ecology—thresholds are often associated with limits which have certain system-inherent processes. In social and economic disciplines, if the notion of limit or critical limit is present, the concept of targets is often more appropriate, which are linked to political objectives and social acceptability. (…) Crucially, these limits are derived through deliberative processes and involve both social acceptability and political input, together with scientific understanding of how systems operate (be it socio-economic or environmental)" (Bertrand et al. 2008: 405–6).

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