3. Systems of urban and territorial indicators

The definition and scope of indicators still causes some confusion and they need to be distinguished from parameters and indexes. Parameters are upstream from the formulation of an indicator as they provide data to build the indicator. Indexes result from a collection of indicators combined mathematically. From this point of view, indexes can be seen as downstream of indicators. Nevertheless, an index can itself be used as an indicator, by simplifying the complex information contained in all its constituent parts (IISD, 2000).

In general terms, an indicator is derived from data — i.e. values that can be measured or observed — and can be defined as a value that provides information about a phenomenon. It is, therefore, a measure of its given state and evolution, which is able to summarise the characteristics of systems or highlight what is happening in a system (IISD, 2000).

An indicator is '...a statistic or parameter that, tracked over time, provides information on trends in the condition of a phenomenon and has significance extending beyond that associated with the properties of the statistics itself' (OECD, 1994).

In the past, the use of indicators was forced to be extremely simple, since it was derived from few data and was based on limited scientific knowledge. Their relevance in assessing the state of certain systems was not emphasised because it was assumed to be implicit or intuitive. When statistics was recognised as a science, the importance of indicators became crucial. The more data collection and availability increased, the more it became clear that indicators might be an effective tool to better understand and monitor complex systems. The main importance of an indicator, in fact, does not lie in the explicit value itself, but in the implicit information it contains. The concentration of carbon dioxide in the atmosphere is an example: despite the fact that it is only a measured value (a statistic), it can tell us about the use of energy, the depletion of natural resources, the diminishing capability of absorption of the forest, etc. As a result, the use of indicators spread widely, and some experts felt it necessary to distinguish between indexes and indicators. However, selecting the appropriate indicator is not a simple task. In fact, there are many parameters that can be measured, but only a few of them are able to translate complex relationships about phenomena in a simple way (EEA, 1999).

In order to be able to select an indicator, one must have a clear understanding of the system, and this is not always possible when dealing with environmental systems. Moreover, even when there is full knowledge of the system, there is still a gap between a 'theoretically sound indicator' and an 'operational indicator'. Indicators are generally built up by scientists, e.g. environmental experts, to be used by decision-makers, e.g. city managers, and represent an effective vehicle of knowledge between these two categories only when they are fully understandable to the latter. If the general public is also involved in the decision-making process, then good indicators help to understand and communicate environmental conditions. This gap between scientific knowledge on the one hand, and effectiveness on the other, is mostly linked to quality and quantity of available information. Particular effort should therefore be dedicated to the development of easily handled indicators, since potential users include a wide range of people from city managers, local administrators and planners, up to international bodies defining regional or global development strategies. Due to the complexity of the systems and to the quantity of data managed, the number of indicators should be reduced to the minimum. Furthermore, in order to include all the sectors that need to be considered is advisable to select a set of cross-sectoral indicators. The user can then handle more information with less effort.

The main, traditional usage of indicators is for monitoring purposes. However, indicators are often used for two other intertwined purposes: planning and communication. '…the overall quality of the sustainable process depends more on the indicators' ability to influence decisions than

on the pure scientific accuracy. Therefore setting up indicators schemes cannot be limited to the sheer production of information, but should be targeted at the indicators' potential to stimulate integrated decisions' (Bauler, 1998). As such, they should promote information exchange regarding the issue addressed (EEA, 1999). Thus, indicators should be easily understood, transparent and give reliable signals of the important trends in the actual situation to be compared across time (World Bank, 1997). In this context, the use of an indicator is linked to its potential to simplify. Different users have different understandings and needs as regards indicators and, thus, it is necessary to translate the real world in different ways. Indicators are a compromise between scientific accuracy and the demand for concise information (Verbruggen and Kuik, 1991).

3.1. Indicators' frameworks

Indicators have a synthetic meaning and they are developed for specific purposes. One of the first sets of indicators to be developed was based on economic indicators. In the post-war period, the existence of national accounting systems made possible the construction of indicators, including gross domestic product. They aimed to express the stage of development of a country in terms of its economic performance. Later, in the 1970s, it was recognised that economic indicators were not enough to give a picture of societal well-being and social indicators were introduced (Ingham, 1995).

With the growing awareness of the limits of environmental systems and pressures resulting from human activities, in terms of consumption and pollution, many international and national agencies have developed sets of environmental indicators. These indicators aim to 'reflect trends in the state of the environment and monitor the progress made in realising environmental policy targets' (EEA, 1999).

Indicator relevance is behind the development of multiple sets of indicators. There are a variety of sets of indicators produced at various levels. At the international level, there are two main agencies developing indicators: the Organisation for Economic Co-operation and Development (OECD) and the United Nations.

In 1990, following a request at the 1989 G7 Summit, a programme was initiated on environmental indicators. The Leading Indicators are based on the work undertaken by the National Bureau of Economic Research (NBER) of the United States that was published in 1987 (World Bank, 1997).

This programme led to the identification and definition of a core set of 72 environmental indicators based on policy relevance, analytical soundness and measurability. It promoted the actual measurement of 30 of these indicators in a number of countries, as well as the regular use of these indicators in OECD's analytical work on environmental performance reviews (OECD, 1994).The OECD has pioneered work on environmental indicators, which has set the basis for indicator development throughout the world (OECD, 1994). Besides the development of the indicators, this OECD programme implemented the pressure-state-response model (PSR) and thus, the agreement of a common terminology and conceptual framework (World Bank, 1997; Hill, 1997).

In Europe, the European Environment Agency, in connection with the EU's fifth environmental action programme (5EAP), has developed its own set of environmental indicators, based on the DPSIR model (driving forces, pressure, state, impact, response).

A purely economic view of development has been progressively abandoned; likewise an isolated assessment of the environmental system. Thus, the most recent trend on indicator development is moving towards the development of sustainability indicators. Within this set of integrated indicators, each one should reflect the interaction between the social, economic and social aspects, and thus measure the movement towards or away from sustainability, in terms of trends and directions, as stated by the Expert Group on the Urban Environment. Deriving from the Earth Summit in 1992, efforts were made to apply the concept of sustainable development at all levels, from global to local. In this context, a methodological framework and the development of sustainability indicators has been encouraged by several agencies. Based on the objectives stated in Chapter 40 of Agenda 21, the UN requires the development of indicators for sustainable development. Local Agenda 21 requires the development of local sustainability indicators. Within this

framework, the Sustainable Cities and Towns Campaign was launched in Europe. This campaign facilitates interaction between European cities and supports transfer of knowledge and exchange of experience in the field of urban sustainability and Local Agenda 21 in Europe. Thereby it helps implement the concept of sustainable development through the provision of central access to comprehensive and up-to-date information relevant to all those working in an urban context.

The UN sponsored the programme of the Commission on Sustainable Development (CSD) which developed a menu approach containing a set of 142 sustainability indicators. This indicator set was built on a modified PSR model, where the pressure indicators are replaced by driving force indicators within the model (DSR).

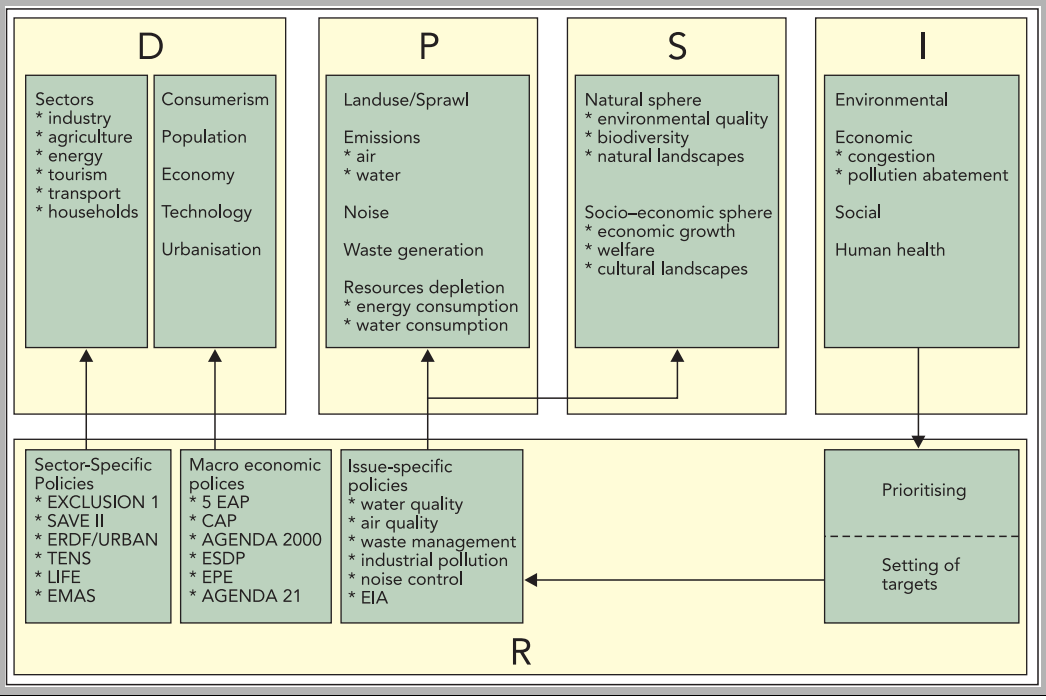
Also at UN level the urban indicators programme (UIP) of the United Nations Centre for Human Settlements (Habitat) was established. This programme started in 1988 as a joint Habitat/World Bank initiative in order to address the urgent global need to improve the urban knowledge base, by helping countries and cities to design, collect and apply policy-oriented indicators data. The UIP is a global framework to collect data based on indicators that will allow comparisons to be made between cities, countries and regions. It integrates a set of universal key indicators and a set of indicators developed locally as well as establishing a global network of local and national UIPs (UNCHS, 1997).

The World Bank, even if it is more a user than a developer of indicators, carried out the land quality indicators (LQI) programme in 1994, together with other organisations including FAO, UNDP, UNEP and CGIAR . This LQI programme seeks to develop a set of standardised indicators, focused on local and regional level, in order to better understand land degradation problems by integrating economic and environmental performance (World Bank, 1997).

At European level, the first step towards the development of an environmental indicator system was carried out by the EEA. A new indicator methodological framework was constructed: the driving forces, pressure, state, impact, response (DPSIR) model, which is a slightly extended version of the OECD model (PSR).

Box 3.1: The EEA DPSIR -model applied to urban issues

Driving forces — human activities such as production, consumption, transport, housing
Pressure — emission of pollutants, deposition of waste, extraction of natural resources, land consumption
State — effects of pressure on the physical media (quantity)
Impact — effects of pressure and of the quality of physical media on the state of ecosystems, public health and living conditions
Response — the societal responses to environmental problems



At regional and local level, a number of sets of indicators have been identified to fit each specific situation. On one hand, there is a demand for the existence of a set of indicators that could be applied in each context in order to perform comparisons. On the other hand, at a local level, the scale of the approach to sustainability requires more specific and detailed information.

The European common indicators — towards a local sustainability profile-project aims to overcome this problem by proposing a common set of sustainability indicators to be applied at local level. This set was designed to monitor and evaluate the progress towards sustainability achieved by local authorities. It integrates five core indicators and five additional indicators, which will be the basis of the implementation of a local sustainability profile. These indicators were proposed in the light of sustainable development, integrating, each one of them, social, economic and environmental dimensions (Expert Group on the Urban Environment, 2000).

This monitoring initiative follows a bottom-up approach, taking into account the principle of subsidiarity. It was developed by a topic-oriented working group of the Expert Group on the Urban Environment, with the support of DG Environment, European local authorities, Eurocities and the EEA. The final set of indicators was launched in February 2000 at the third European conference on sustainable cities and towns in Hannover and by that time it was ready to be adopted, on a voluntary basis, by European local authorities (Expert Group on the Urban Environment, 2000).

Box 3. 2: European common indicators — Towards a local sustainability profile

European Common Indicators — Towards a Local Sustainability Profile is an initiative of the European Commission (DG Environment), under the umbrella of the Expert Group on the Urban Environment. The work was carried out in a working group in close cooperation with the European Environment Agency (EEA), a group of local authorities and Eurocities during 1999. It analysed currently used indicator projects, evaluating their suitability for a Europe-wide scheme and their relevance to local sustainability, and making proposals fo r a common set of local sustainability indicators, to be used at the local level on a voluntary basis.
The European common indicators consist of a set of ten integrated indicators, reflecting the interactions between the different dimensions of sustainability. The use of these indicators is intended to be complementary to any local or national indicators. The indicators should not necessarily be used for comparing absolute measures between cities, but rather to measure movement towards or away from sustainability over time and for identifying trends and directions. In this sense, they are aimed at comparing 'progress made' rather than 'state of'.

Topics of indicators for the European common indicators

No	Core indicators (compulsory)	No	Additional indicators (voluntary)
1.	Citizen satisfaction with the local community	6.	Childrens journeys to and from scool
2.	Local contribution to global climatic change	7.	Sustainable management of the local authority
3.	Local mobility and passenger transportation	8.	Noise pollution
4.	Availability of local public green areas and local services	9.	Sustainable land use
		10.	Products promoting sustainability
5.	Quality of local outdoor air		

The monitoring initiative will provide objective and comparable information on cities' progress towards sustainability across Europe. It will serve as an evaluation tool for initiatives such as the European City Award Scheme and its successor, and will feed the database on good practice in urban management and sustainability, allowing for more objective identification of European good practice.
This set of indicators has to be seen as a proposal for a 'first generation'. Local authorities across Europe are encouraged to participate in the monitoring initiative and contribute to the further development of this set of voluntarily agreed indicators during the testing period that started in 2000 and is expected to be developed over a three-year period (more information at http://www.sustainable-cities.org/expert.html)

Nevertheless, regional and local specificities should be taken into account. The UN work expresses the need to develop urban indicators that reflect these particular circumstances. Conciliation of global and local expectations has to be made by adopting both a set of universal key indicators and a set of indicators developed locally (UNCHS, 1997). Within the framework of European common indicators these circumstances are also emphasised. The working group orientations given to local authorities in this initiative point out the importance of developing local and regional sets of indicators, 'European common indicators are intended to be complementary to any nationally or locally defined indicators and engaging in this initiative is not a substitute for actively continuing these other, equally important processes' (Expert Group on the Urban Environment, 2000).

Some cities have already developed local systems of sustainability indicators that reflect local specificities and seek the convergence of the many and varied sustainability indicators proposed by public and private institutions in Europe. The system proposed by the Catalan Network of Cities and Towns towards Sustainability is an example of a municipal sustainability initiative that takes into account local, regional and European levels. The network's panel of sustainability indicators is also connected to the European common indicators, since the most important have been included and, in some cases, expanded (Secretariat Technica de la Xarxa de Ciutads I pobles cap a la Sostenilitat, 2000).

The trend in the development of indicators is moving away from a larger to a very small number of highly aggregated values, through the construction of an index. Eurostat (2000) is coordinating work on the construction of an environmental pressure index (EPI), which will be aggregated from indicators within identified problem areas. At OECD, efforts have been made towards a unique index of urban sustainability, which is calculated by weighting the contribution of each indicator in the assessment of the progress towards sustainable development (Mega, 2000).

Recently, the 'ecological footprint' has been presented as one indicator able to deal with the complexity of sustainability. It aims at the integration of social, economic and environmental dimensions in a trans-generational way. The amount of space on the Earth that an individual uses in order to survive with existing technology is estimated, thus it measures the demand per capita on the bio-capacity of the Earth. The value is referred to the individual, which makes it comparable from place to place and over time. Despite its theoretical soundness, the way to make the concept operational is a still under debate. (Wackernagel and Rees in IISD, 2000).

Indicators are built for a specific purpose and their design should be able to address this purpose. For instance, the Urban audit main objective is to access 'urban quality of life'. Therefore, this dimension covers 21 domains, grouped according to defined criteria.

3.2. Use of indicators — potentials and constraints

Indicators are one of the most powerful tools that both scientists and policy-makers have at their disposal to better understand systems as complex as the urban ones. Nevertheless some points should always be borne in mind when developing an indicators' framework. Indicators represent components or processes of the real world systems. As a consequence, they are models and have all of their possibilities and limitations (Braat, 1991). They are built on parameters that have to be gathered in an adequate way to feed the indicator. In this context, three major issues associated with data gathering can be identified: standardisation of data collection, spatial scale and temporal scale.

Concerning the standardisation of data collection, social and economic indicators have overcome this constraint. For instance, gross national product (GNP) is measured the same way throughout the world facilitating comparison across countries. However, there is still a lack of standardisation in environmental data collection, which limits comparison between indicators. Particularly, notwithstanding the efforts in gathering information on land use, the corresponding indicators are of restricted use when a comparison has to be performed. Besides the standardisation of data collection, there is also a need for indicator standardisation. Indicators should be standardised to allow a cross-country comparison and should, at the same time, reflect the context for which they are designed. This implies that a compromise between standardisation and diversity should be obtained when designing a specific set of indicators. Such a compromise is more difficult to find when the scale decreases: at local scale the information is more differentiated than at the global one.

One advantage of the use of indicators is the possibility of geographical representation, associated with the generation of maps. Mapping, besides the matter of legend compatibility, also presents major issues associated with scale. Spatial scale and the minimum cartographic units of maps may affect the application and interpretation of indicators. The robustness of indicators to the spatial characteristics of the maps should be considered and embedded in their description to avoid comparisons of indicators derived from databases with

Box 3.3: Urban audit

The European Commission launched the terms of reference for the plot phase of the urban audit in June 1997. This pilot phase, which began in May 1998, was undertaken within the aegis of Article 10 of the ERDF Regulation, which enables the support of innovative measures, by the European Commission. The Directorate General for Regional Policy and Eurostat are responsible for managing the urban audit. Other directorates of the European Commission have advised on the choice of information to be included.
The overall purpose of the urban audit is to enable an assessment of the state of individual EU cities and to provide access to comparative data. It is foreseen that the process will facilitate the exchange of information amongst cities.

Fifty-eight cities were invited by the European Commission to participate in the urban audit during the pilot phase. These include several cities in each EU Member State. Paris and London have not been included because of their size.

The indicators of the urban audit cover five fields: socio-economic aspects, participation in civic life, education and training, environment, and culture and leisure. A comparison of the indicator scores will allow cities to judge their progress and to identify any specific difficulties.

The terms of reference for the urban audit pilot phase identified 33 'indicators' grouped under five headings. One criterion emphasised in the selection of indicators was the availability of data. During the pilot phase further consideration was given to refining more precisely the indicators so that, as far as possible, information could be collected on a comparable basis for the 58 cities. These considerations involved a review of existing relevant work; discussions amongst those involved in the urban audit pilot phase work including correspondents in each Member State and representatives from participating cities; and a detailed assessment of the practicality of obtaining information to build the 33 indicators mentioned in the terms of reference. As a result of this work the following refinements were made:

1. The indicators were regrouped into 21 domains reflecting aspects of urban 'quality of life'.

2. A list of indicators was defined within the 21 domains. For each indicator a 'standard' definition was given. Full details of the indicators and the standard definitions are provided in the urban audit manual.

3. Meta information was recorded for each indicator: the date to which it refers; any differences from the 'standard' definition; any differences from the spatial boundary to which the indicator applies; the data set used as source of information and its characteristics. This information is part of the urban audit manual.

4. Information was obtained for three points in time (1981,1991 and 1996). Assembly of time series information offered several advantages. Firstly, information on indicators at more than one point in time would provide evidence of the direction and magnitude of change. Secondly, some indicators, such as crime rates, are very sensitive to the precise recording procedures and thus direct comparisons may be invalid. In these instances time series information on the magnitude and direction of change may be more helpful to urban audit users. Thirdly, it is envisaged that the urban audit will be maintained and updated. The collection of historic information during the pilot phase helped identify the requirements for this, whilst incurring only marginal additional resources.

5. Where appropriate, comparable information at the national level was collected. This process helped in assessing if differences in indicator scores between the 58 cities were a consequence of national differences.

(More information on http://www.ereco.com/audit/index.html)

different technical specifications. For example, if a given indicator uses Corine land cover and Murbandy data, the results may be affected by the different minimum mapping unit of 1 (or 2) hectares (ha) in Murbandy and 25 ha in Corine.

It is also generally accepted that the relevance of an indicator depends on its periodicity. The temporal scale is, therefore, issue specific. For instance, is does not make sense to collect data of urban sprawl on a daily basis, but it does for carbon dioxide concentrations.

3.3. Relevance of spatial indicators

While urban sprawl became a major topic of environmental concern, recent analyses revealed that information on this issue was insufficient to provide an adequate understanding of urban dynamics. The main constraint consists in defining the limits of the system. The introduction of the concept of carrying capacity in line with a sustainability approach, further enlarged the dimensions of the problem, increasing its complexity.

In order to deal with environmental planning issues better and to support development strategies at all political levels, policy-making increasingly demands spatial and territorial information. If it is useful to know how many kilometres of road have been built, it is more useful to know which area it occupies, and even more useful to know which kind of land is consumed. Spatial information, as information in general, tends to be unmanageable if is not organised in a meaningful way. The development of spatially based indicators (SBI) is therefore a key issue for the integration of territorially based information into the land use planning process. For instance, land consumption is an indicator that is integrated in almost any

Box: 3.4 XARXA — System of local sustainability indicators

The XARXA network is an example of local scale development of sustainability indicators, in this case for the region of Catalonia. These indicators were defined through a consultation process within the 160 local bodies and boroughs that are members of the network. Differentiated information was used for the construction of these indicators now being applied in some cities of Catalonia.
A dual classification system was implemented: the pressure, state, response system combined with the model, flux, quality system.
In a pilot phase 30 indicators were selected and implemented in 11 boroughs of the network. The following indicators were tested:

4. Territorial mosaic
5. Urbanisation intensity of local economy
6. Urban structure: Urban land occupation
7. Urban structure: Proximity to basic urban services
8. Urban structure: Mobility of population
9. Urban structure: Streets with pedestrian priority
10. Planning sensitivity to the territory's ecological uniqueness
11. Protection of areas of natural interest
12. Prevention of environmental hazards
13. Citizen involvement in sustainability processes
14. Use of municipal collecting and storing system
15. Vitality of environmental associations in the borough
16. Municipal expenditure on the environment
17. Final energy consumption
18. Intensity of local energy use
19. Local renewable energy production
20. Reuse of municipal waste
21. Reuse of industrial waste
22. Waste production intensity of local economy
23. Consumption of municipality-supplied water
24. Water consumption intensity of local economy
25. Wastewater treatment
26. Reuse of treated water
27. Air emissions
28. Greenhouse gas emissions
29. Air quality
30. Population exposed to high levels of environmental noise
31. Evolution of groundwater quality
32. Ecological status of rivers (Ecostrimed)
33. Loss of vegetable biomass

Sustainability criteria
- Contribution to global sustainability
- Efficient use of ecological resources
- Appreciation and protection of biodiversity
- Citizen involvement in sustainability development
- Environment load capacity exceedance
- Use of internal resources
- Functional diversity of towns

indicator system, either in absolute value, referred to area, or per capita. Nevertheless, the value of land consumption in itself is relative, since it depends both on the value of the land that is consumed and on the value of the new land use.

Murbandy/Moland develops comparable databases to derive indicators in order to understand the evolution of urban areas and impacts on the surrounding environment. At the basis of its working plan lies the idea that, without a spatial approach, any urban indicator set aiming to address sustainability would be incomplete.

Territorial or spatial parameters are therefore used to develop sets of indicators with a degree of standardisation that allows comparisons within Europe. In practice, a core set of indicators specifically designed for one city might not work for another. 'A key question that has yet to be resolved is whether or not it is possible to develop a core set of urban sustainability indicators that could be used by all municipalities in a state, a country, or even internationally' (Maclaren, 1996). Murbandy/Moland demonstrates that this is possible to a certain extent. As stated by Bossel (1996): 'Sustainability can only be discussed in relation to a particular region, since it is directly related to its carrying capacity. Sustainability indicator sets are, hence, region-specific. They may have to include indicators in one region which would not be appropriate in another, although overall conclusions concerning the sustainability of each system could again be comparable'. Still, it is important to design core sets of indicators in order to facilitate

European and international comparisons (Opschoor and Reijnders, 1991). If deriving a good core set of indicators is a success, then city-specific ones can be added.

In practice, what makes the main difference between various sets of indicators aiming to report on urban sustainability is the spatial dimension. For this reason the geographic unit of analysis must be clearly specified, because shifting units can change the results (Sawicki and Flynn, 1996; Huang *et al.*, 1998). If a standard geographic unit for different urban systems can be defined, spatial referenced indicators allowing comparisons amongst the systems can also be derived. Still, this is not enough, if the data the indicators are based upon is not territorially differentiated (von Meyer, 1998). The technical framework for providing such a quality of information has never been developed on a large scale. As a consequence, 'good concepts and theoretical foundations for spatially relevant pressure indicators are lacking throughout the bulk of the international indicator literature' (Bittermann and Haberl, 1998).

Murbandy/Moland attempts to overcome these gaps and to offer a new point of view. The basic idea consists in the creation of a Europe-wide data set for urban areas, which was based on natural and artificial land cover characteristics. On the basis of such a database, indicators are developed and tested at various levels; from simple ones, solely based on spatial parameters, to more complex sustainable development indicators. Also, the latter ones are built up having as a reference point the spatial dimension, since the aim of this part of the project is to supply users with indicators based on a kind of information not obtainable elsewhere.