5. Land use database applications

The Murbandy/Moland project is a continuously evolving activity. To date, the territorial data sets have been completed and validated for 25 European areas and for six mega-cities outside Europe, and the assessment of the derived data is progressing rapidly. Moreover, several new areas - six European and one non-European - are currently being studied. The analysis of the data sets is therefore quite advanced, and allows several investigations to be performed. The work presented in this chapter is mainly aimed at showing both the potential of the database, and its capability to implement user-driven tasks.

The main target of the project itself consists of proposing a common methodology within the European Union (EU) for monitoring urban dynamics and supporting a sustainable planning process. In order to carry out sustainable land use planning and management it is necessary to identify problem typologies according to which indicators can be developed. The trends and features associated with urban growth that should be measured include:

- New urban areas built up on productive agricultural and environmentally sensitive areas;
- discontinuous urban growth;
- relation between residential needs and urban growth areas;
- availabilityof public facilities and green urban areas per capita;
- accessibility to collective transport networks and other services;
- exposureto natural hazards;
- social segregation associated with urban growth processes.

Addressing many of the above topics can be facilitated through the adoption of the Murbandy/Moland territorial database. Several statistics can be directly derived without further elaboration. Some examples are shown in Table 5.1. (a more complete table with the numeric values of land use classes for most of the cities has been added as Annex 2). More complex assessments can be carried out according to the needs of the specific users.

5.1. Preliminary results

The Murbandy/Moland database structure allows an easy and immediate extraction of basic land use data and indicators related to the classes of land cover and land use. Its GIS-based and ready-to-use configuration enables even a user with a minimal knowledge of GIS tools to handle it. A differentiated analysis of the urban uses, as for instance the proportion of residential areas services, industries and green urban areas is directly available. More advanced analyses can be carried out by combining several layers and ancillary data according to the detail of information needed. The analytical possibilities are thus endless and can be tailored according to user requirements.

5.1.1. Urban sprawl and land consumption

The population in Europe is almost steady. Nevertheless European cities are experiencing continuous growth. Murbandy/Moland allows harmonised analysis of cities' spraw1 to be carried out. With simple 'clicks' of the mouse it is possible to navigate in the GIS-based environment to individuate, within the study domain, the artificial areas and their evolution during different time periods. The phenomenon of sprawl is common to all cities independently of their geographical, economic or administrative characteristics. The analysis can be carried out at different levels. However it is possible to quantify the changes that have occurred in every single land use class since the beginning af the study.

The phenomenon of sprawl seems to be even more dramatic when, reversing the analytical approach, its immediate effects are assessed. In many cases the consumption of natural and agricultural area took place once urbanisation was already advanced (e.g. in the Ruhrgebiet, Germany), and the effect has been tremendous in all the areas under study, as shown by Milan, Dublin and Setúbal. Among the functions of natural and agricultural areas, the importance of biodiversity, hydrological and microclimatic regulation, and recreational and aesthetic values should be emphasised.

Statistics directly extracted from the Murbandy/Moland database. The sea area, when present, has not been taken into account during the computation.

Table 5.1

City	Total area: km²	Total urbanised area (class 1): km²		Total green urban area (class 1.4.1): km²		Urban sprawl: increase in artificial area (%) during the 40/50 years study period	Loss of natural and agricultural land due to sprawl vs. total area (%) during the 40/50 years study period
		1950s	1990s	1950s	1990s		
Algarve	781.5	32.2	119.1	0.2	0.7	270.4	11.4
Bilbao	169.6	27.4	61.4	0.7	1.9	124.2	20.6
Bratislava	462.7	40.8	123.3	1.1	2.1	202.6	18.1
Brussels	1 308.8	318.6	560.3	15.7	17.9	75.9	19.3
Copenhagen	665.0	242.7	386.1	9.3	16.0	59.1	19.4
Dublin	676.8	163.1	319.3	21.2	52.1	95.8	22.7
Dresden	1 256.7	231.1	314.1	52.1	44.0	36.0	7.3
Grenoble	193.4	31.1	91.4	4.1	5.1	193.5	31.2
Helsinki	1 041.5	135.0	326.0	13.3	29.3	191.0	25.6
Iraklion	29.8	9.0	21.7	0.1	0.1	139.7	41.3
Lyon	311.6	122.8	222.6	17.6	14.5	81.2	32.7
Marseille	328.3	93.5	150.2	9.5	4.6	60.7	17.6
Milan	325.2	114.5	233.4	4.3	16.6	103.8	37.0
Munich	797.8	246.7	357.0	20.8	30.9	44.7	14.3
Nicosia	75.9	24.8	52.0	0.7	1.2	109.6	36.6
Porto	197.5	51.3	121.5	2.3	5.2	136.8	35.7
Padua-Venice	515.5	69.7	188.9	4.4	9.7	171.0	23.1
Palermo	223.1	27.8	86.5	3.5	5.6	211.0	26.0
Prague	797.6	186.9	288.4	11.0	13.5	54.4	13.2
Ruhrgebiet	352.6	219.8	273.9	4.6	12.2	24.6	18.8
Setúbal	22.6	3.3	11.2	0.2	0.3	243.3	33.1
Sunderland	199.7	84.6	106.7	11.0	16.1	26.1	12.9
Tallinn	1 070.1	88.3	182.1	7.1	15.5	106.1	10.0
Vienna	841.8	249.7	341.1	14.8	19.5	36.6	11.5

Urban sprawl in Bratislava (Slovakia) from 1949 (left) to 1997. Only artificial surfaces (class 1 of the Murbandy/Moland legend) are depicted.

Figure 5.1

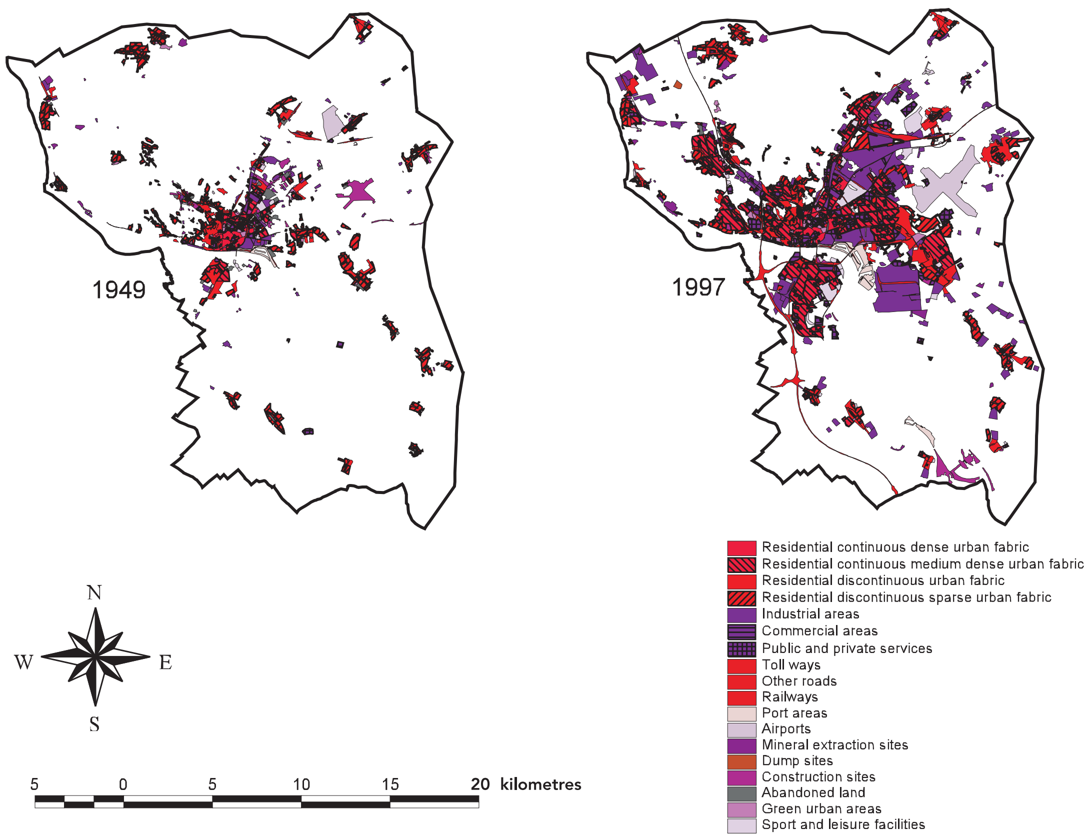


Figure 5.2 | Urban sprawl in Brussels (Belgium) from 1955 (left) to 1997. Only artificial surfaces (class 1 of the Murbandy/Moland legend) are depicted.

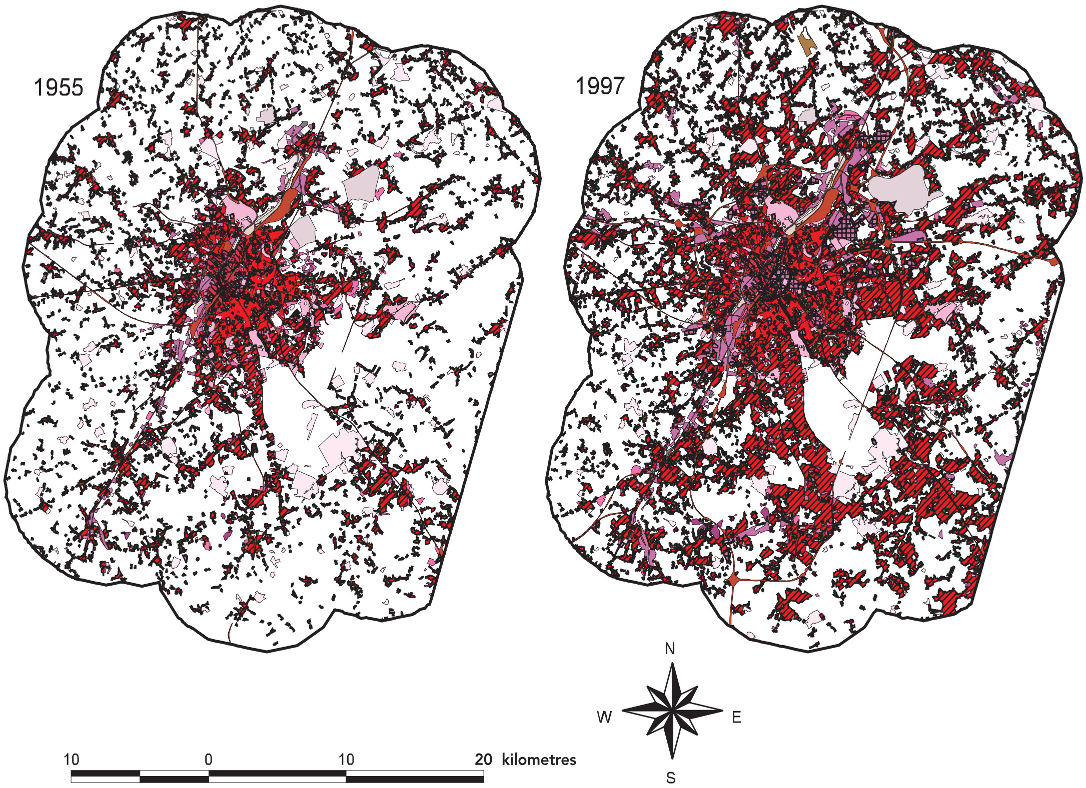
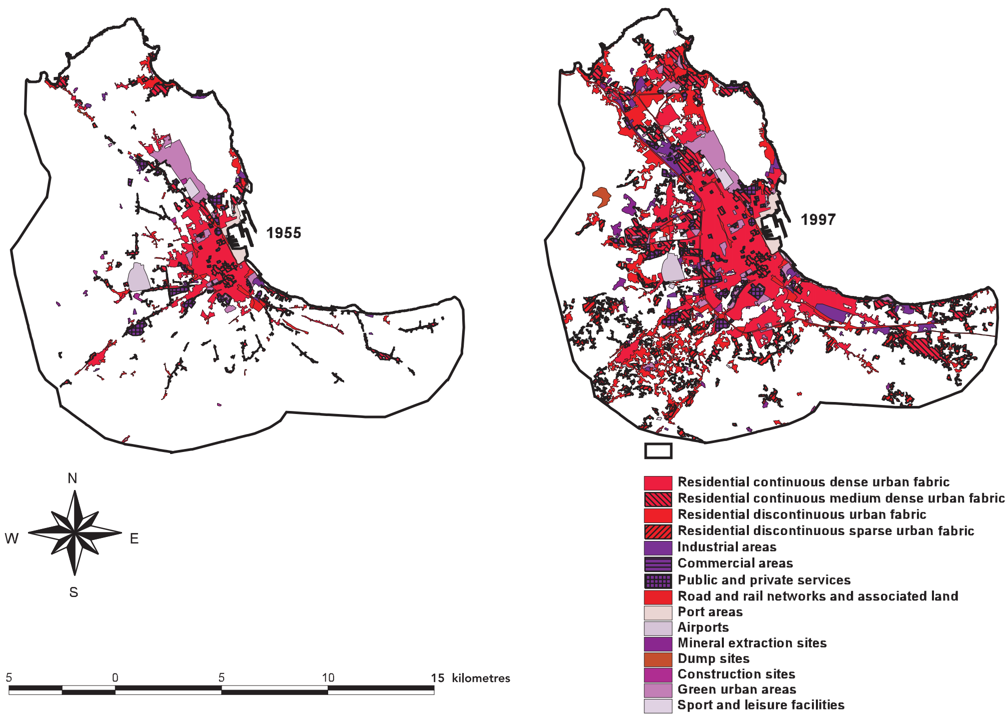
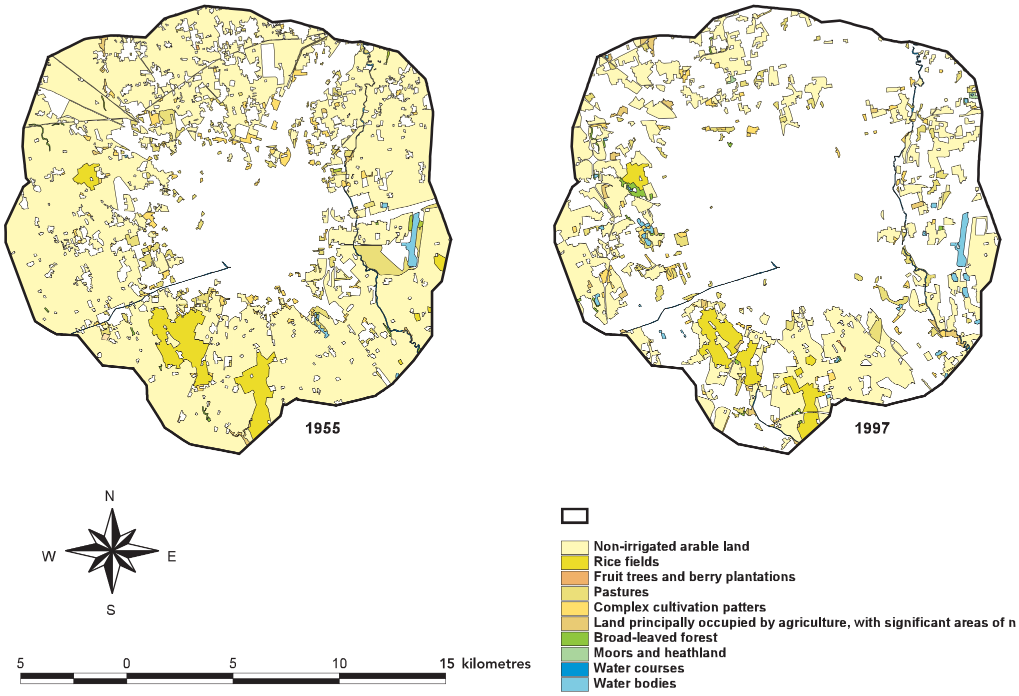


Figure 5.3 | Urban sprawl in Palermo (Italy) from 1955 (left) to 1997.
only artificial surfaces (class 1 of the Murbandy/Moland legend) are depicted.



Loss of natural and agricultural area in Milan (Italy) from 1956 (left) to 1998, only natural and agricultural areas are depicted. — Figure 5.4



Loss of natural and agricultural area in Dublin (Ireland) from 1956 (left) to 1998, only natural and agricultural areas are depicted. — Figure 5.5

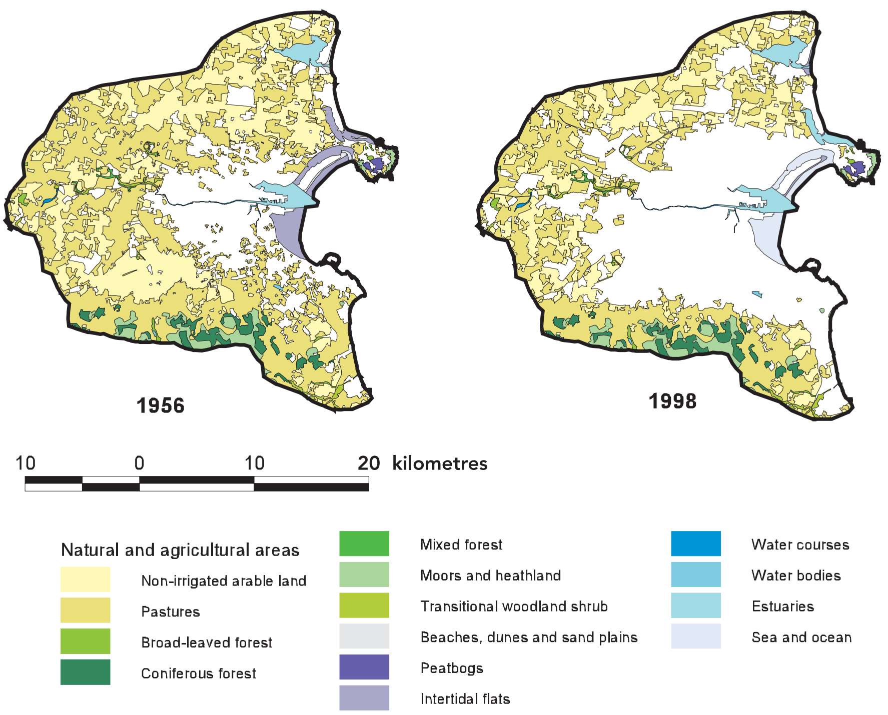
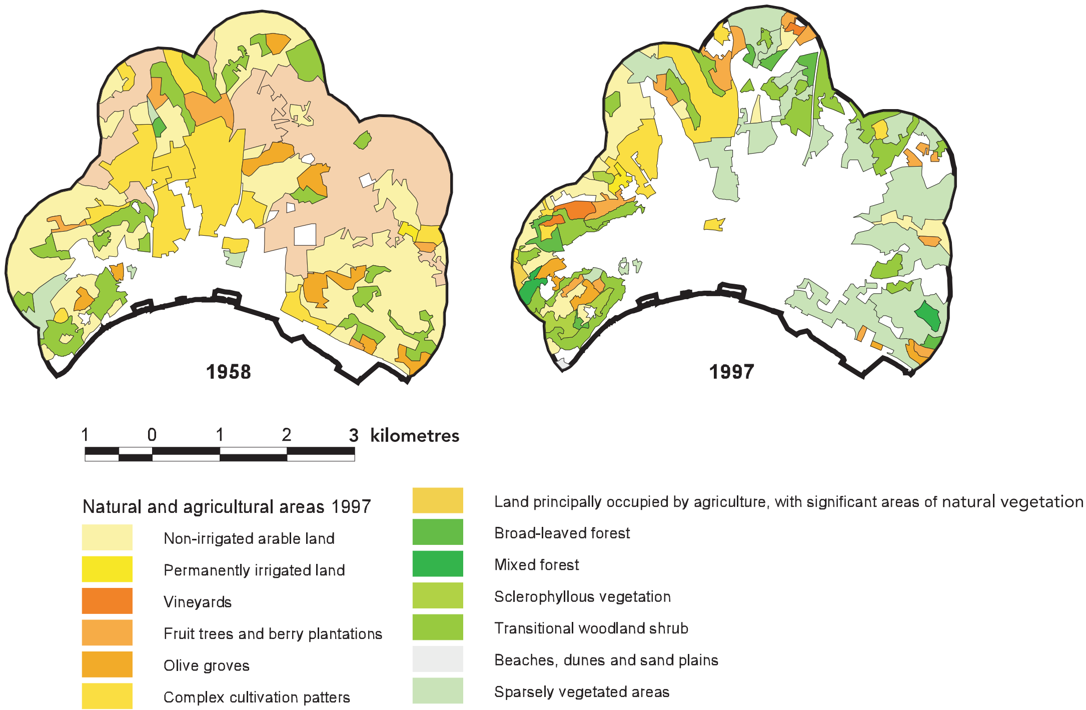


Figure 5.6 **Loss of natural and agricultural area in Setúbal (Portugal) from 1958 to 1997, only natural and agricultural areas are depicted.**



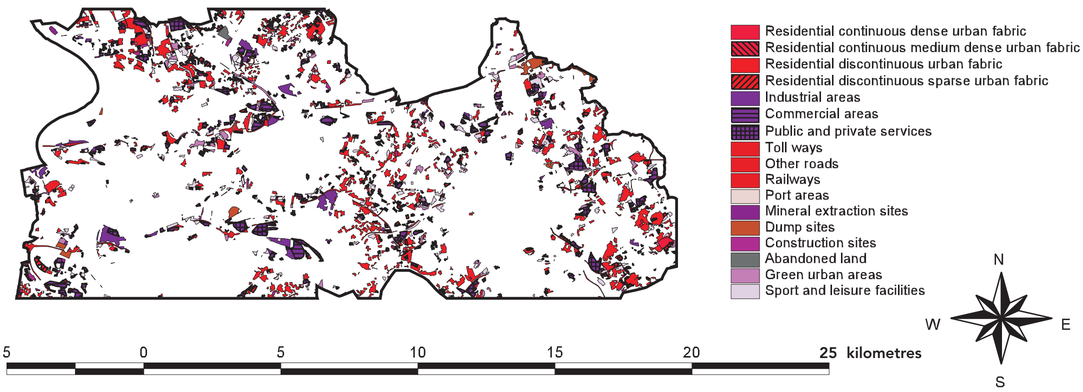
Land consumption by urban expansion affects the surrounding landscape, which is mainly formed by agriculture, forest and natural areas, represented in level 3 and 4 of the Murbandy/Moland legend. In the context of a intense urban development, natural areas have important environmental functions and increase the quality of life of the urban dwellers.

5.1.2. Transport network

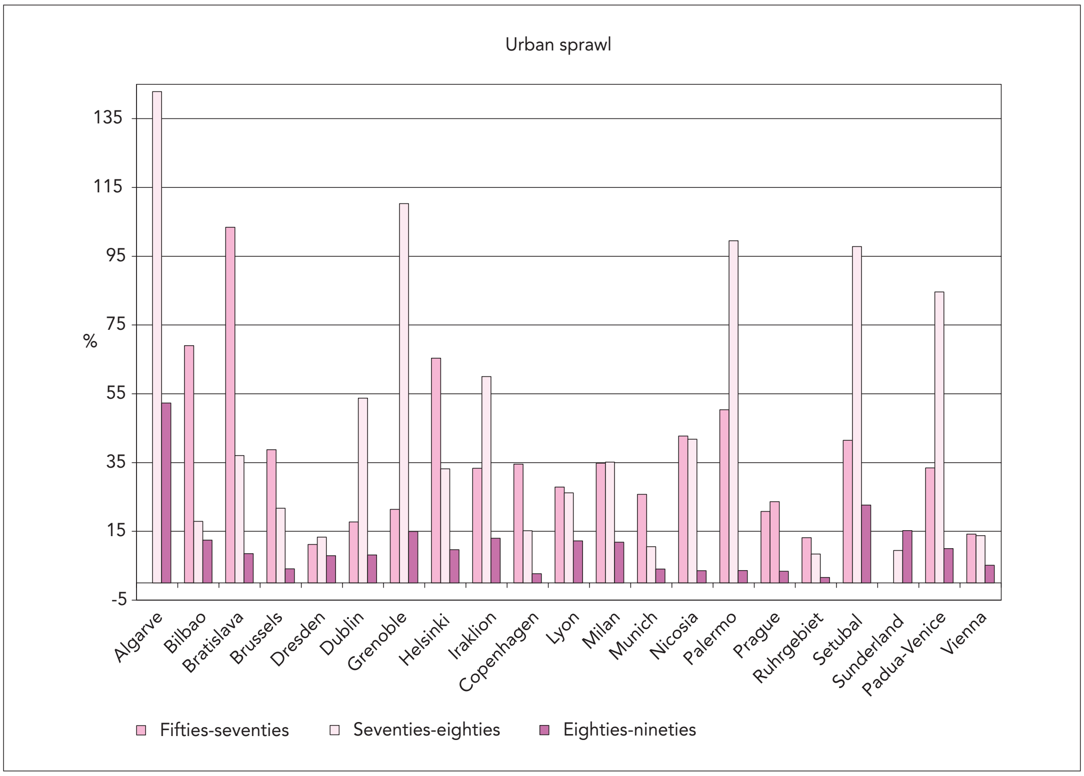
Transport corridors are major consumers of space. Since the Murbandy/Moland database also surveyed line features, it is possible to verify the densification of the transport network. It is also the case that length per capita has increased steadily over the last few decades.

The methodology is particularly useful for the carrying out both environmental impact assessment (EIA) and strategic environmental assessment (SEA). For instance, it is possible to work out the rate of surface waterproofing (impervious surface coverage) from linear transport infrastructure.

Figure 5.7 **Natural and agricultural land lost to development from 1952 to 1998 in the Ruhrgebiet area (Germany). The figure shows the different artificial land uses that have taken natural and agricultural areas during a 46 year period.**



The phenomenon of sprawl is dramatically common to all the areas studied. Figure 5.8



Urban sprawl during a 40-year period Figure 5.9

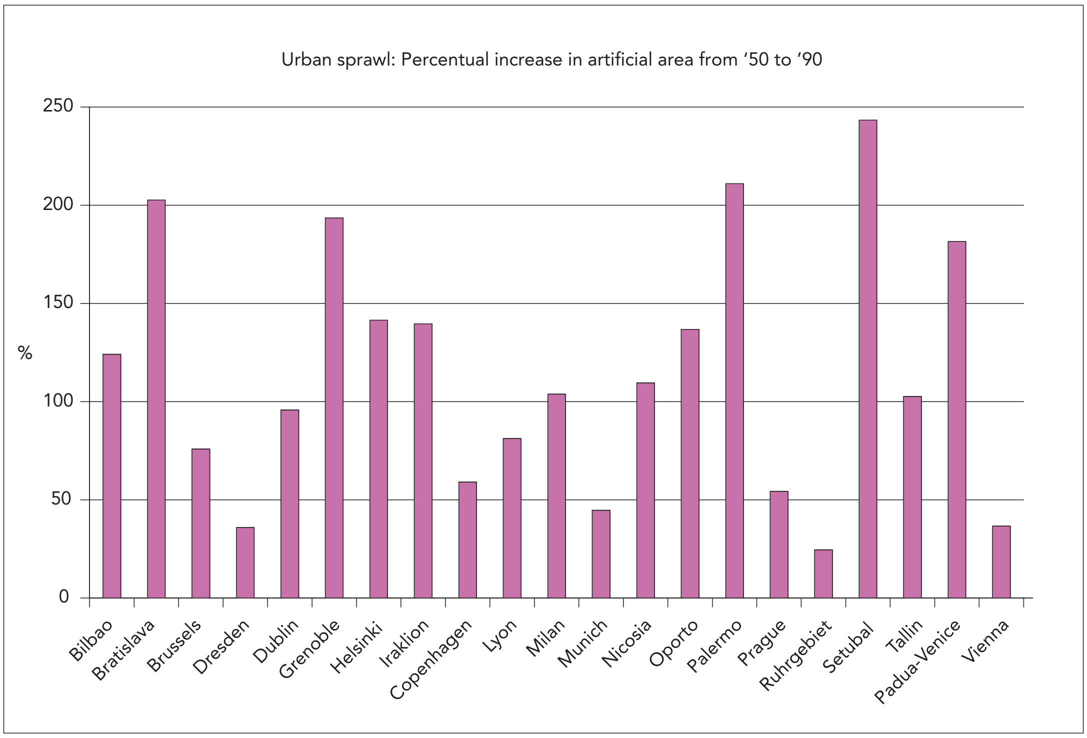


Figure 5.10	**Percentage of natural and agricultural land lost to urbanisation from the 1950s to 1990s. The loss in natural and agricultural areas due to city sprawl shows unsustainable trends for most of the cities investigated.**

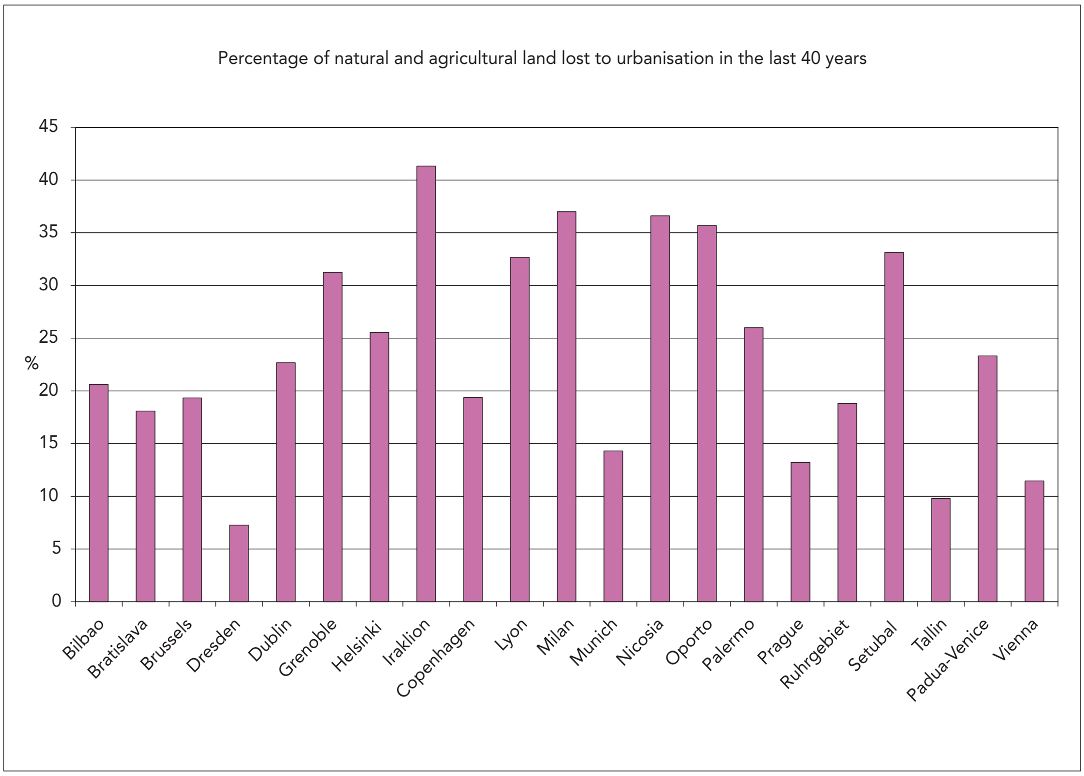
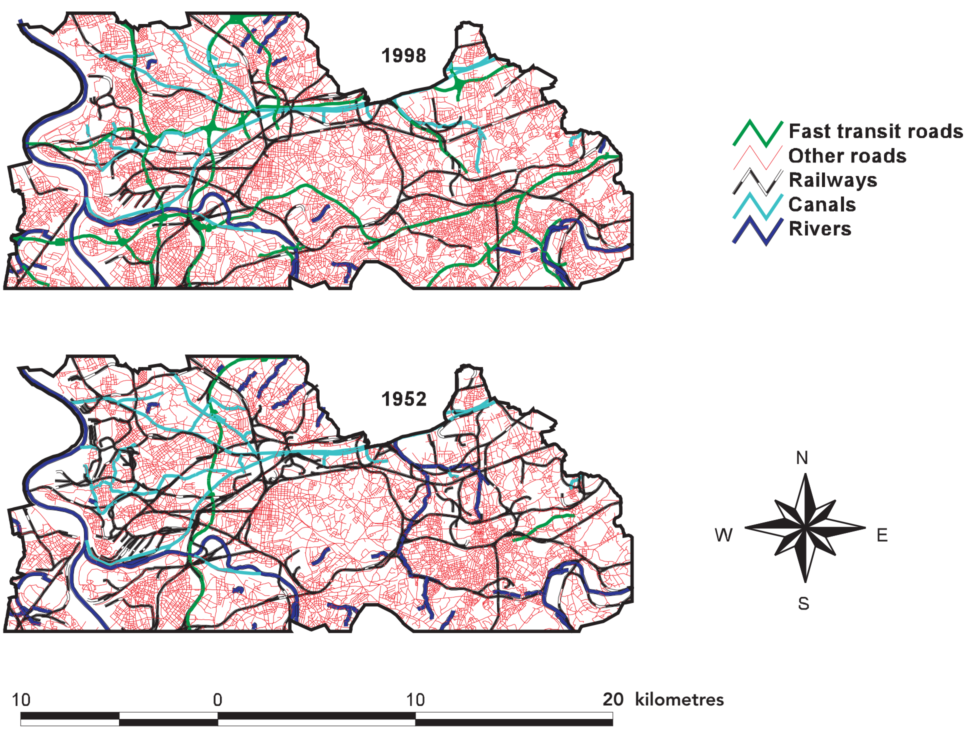
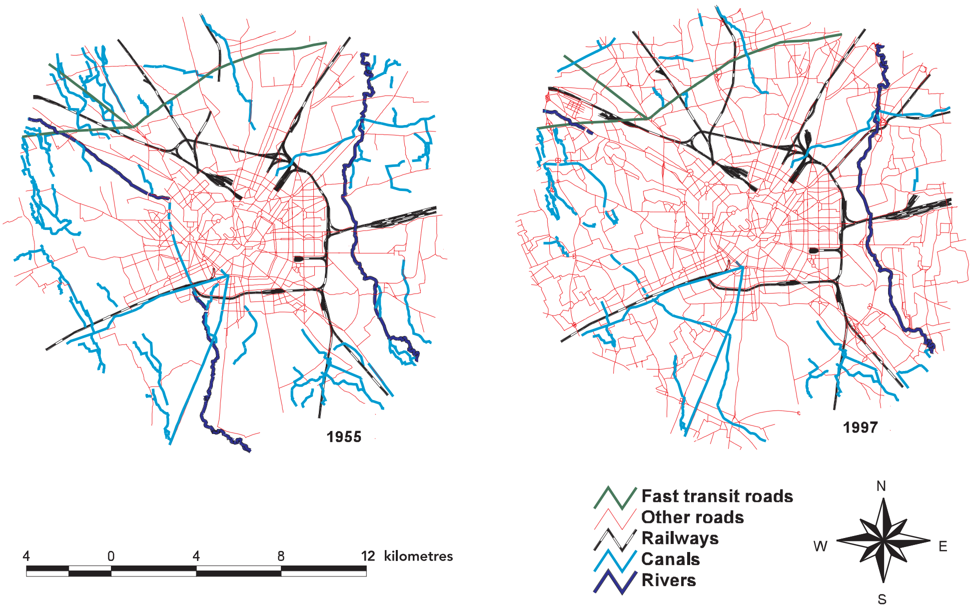


Figure 5.11	**Overall transport system evolution in the Ruhrgebiet area (Germany) from 1952 to 1998, including railways (black colour) and motorways (green colours)**



Transport network evolution in Milan (Italy) from 1955 to 1997.
Blue lines are canals and rivers; many of them were covered during the city development.

Figure 5.12



Transport network development in selected areas from the 1950s to the 1990s

Figure 5.13

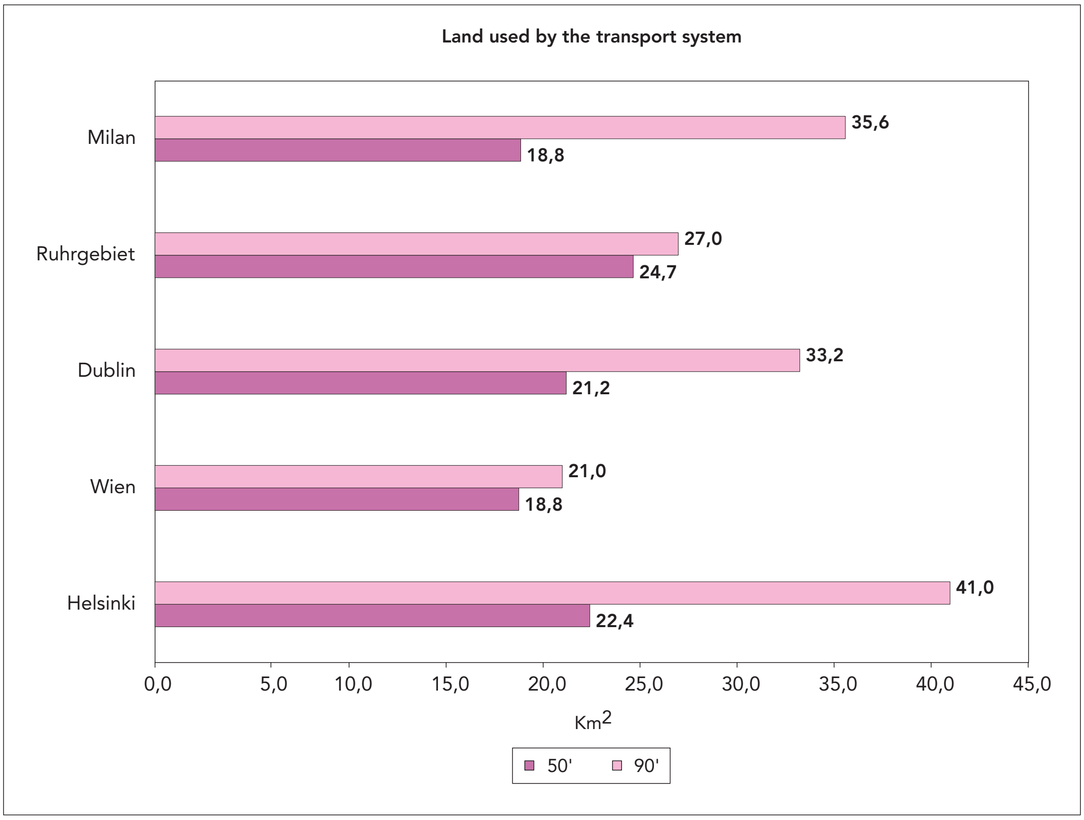


Figure 5.14

The ratio between road network length and residential area has remained almost steady over the last 40 years in Helsinki, Vienna and the Ruhrgebiet. In Dublin, however, the development of residential areas was not followed by an equivalent growth of roads.

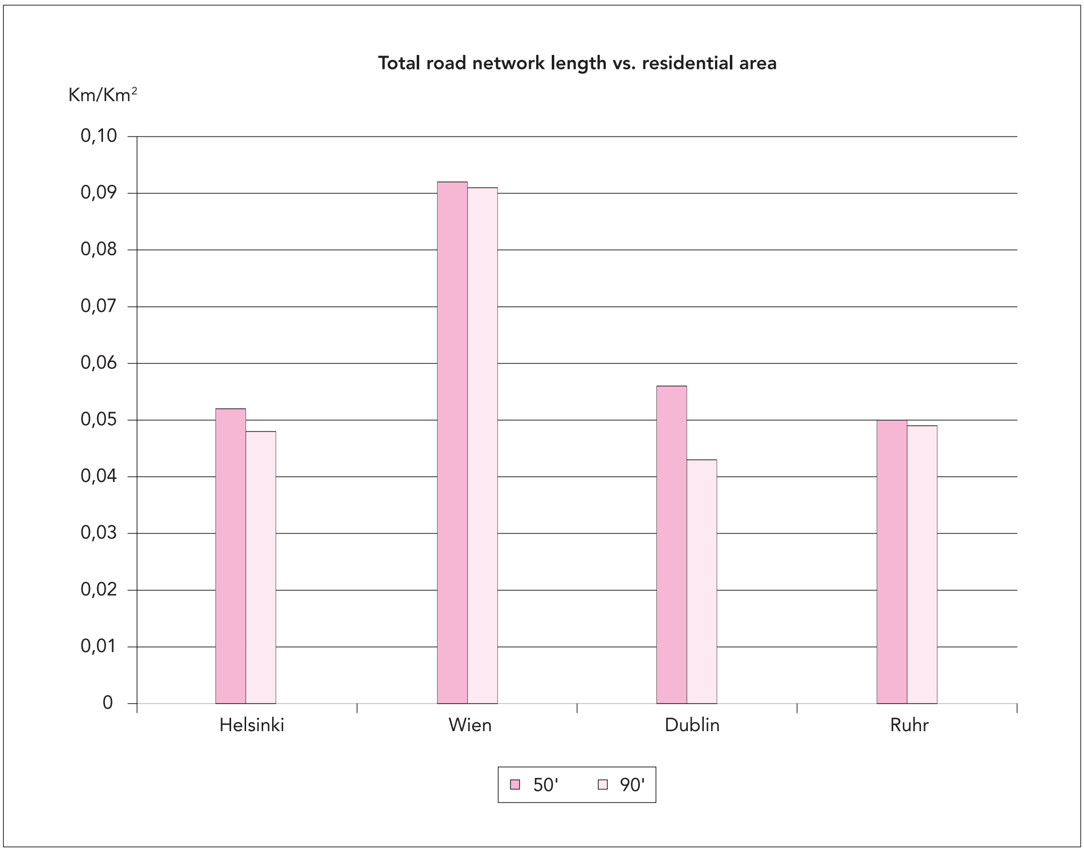
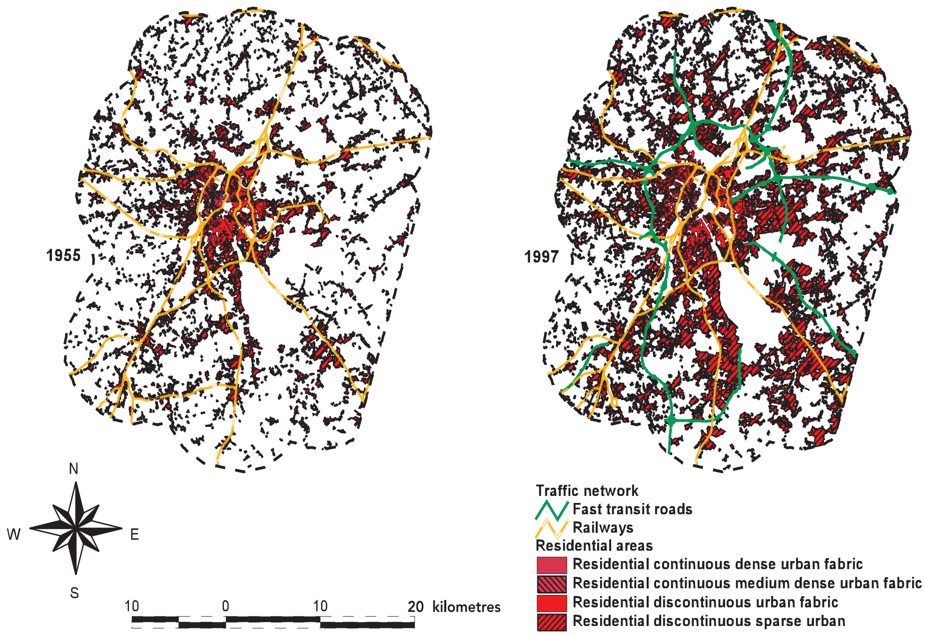


Figure 5.15

Correlation between the growth of residential area and the development of main transport features in Brussels from 1955 to 1997

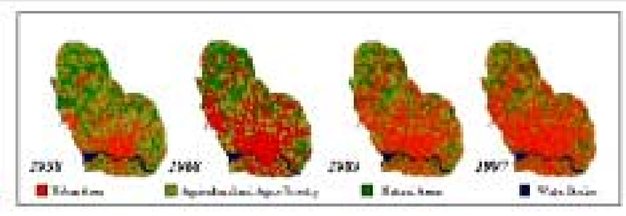


5.1.3. Artificial areas

Urban growth follows certain patterns, depending on a number of driving forces including land ownership structure. Three typologies of urban growth were considered: continuous (new developments taking place in continuity with previous urban areas); linear (urban growth along the existing road network); and discontinuous growth (not supported by existing urban areas or the road network).

Box 5.1: Urban growth typologies in Porto (Portugal)

Porto metropolitan area is following the general European trend, with the urban area augmenting increasing while population decreases in the city centre (Porto municipality). The Porto urban area has changed from a discontinuous growth typology towards a continuous typology. If in the sixties 1960s the urban development started in a disorganised way from the single rural property, afterwards but then the process turns became continuous while and the gaps are being progressively closed. The result is the disappearance of natural areas, which used to be dedicated to agriculture and forestry, facilitated by the decreasing economic importance of the agricultural sector.



Land use dynamics clearly show clearly a trend towards the increase of impervious areas, residential as well as industrial and commercial areas. However, the fraction of urban area occupied with residential areas is decreasing. This may lead to the conclusion that, even if during the last ten 10 years the population was stagnating (1 % growth rate), urban areas are increasing at a rate of 21 % rate, of which only 12 % is residential. The remaining urban area is mainly occupied with commercial and also public facilities.

Using the Murbandy/Moland database information on urban growth typologies and its their evolution identifying trends can be derived and relevant information for local urban planning provided.

Industrial and commercial areas

During the last four decades, the general trend throughout Europe has been the decrease of green areas pressured as a result ofby the construction of artificial areas. This phenomenon occurs mainly at the periphery of cities. On the other hand the analysis of cities' evolution shows an augmentation of the proportion of service areas.

Industrial and commercial units evolution in Lyon (France) from 1956 to 1997 Figure 5.16

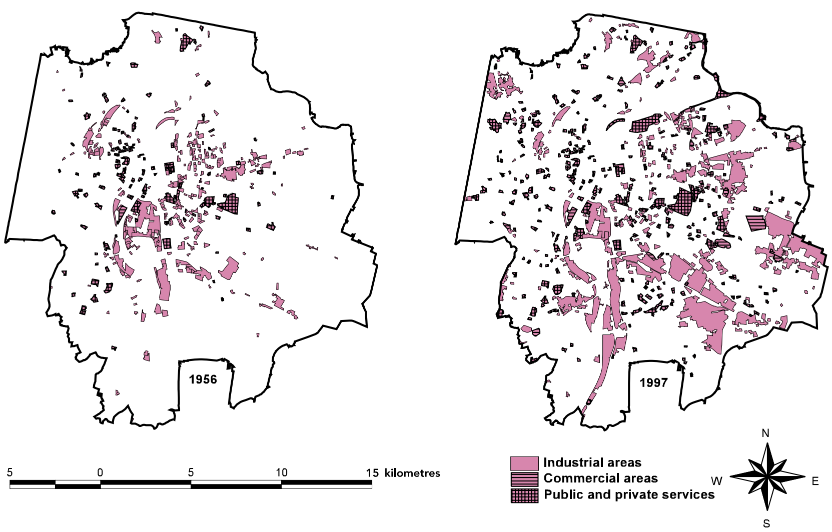


Figure 5.17 **Evolution of iIndustrial and commercial areas evolution in Sunderland (GB United Kingdom) from 1971 to 1996**

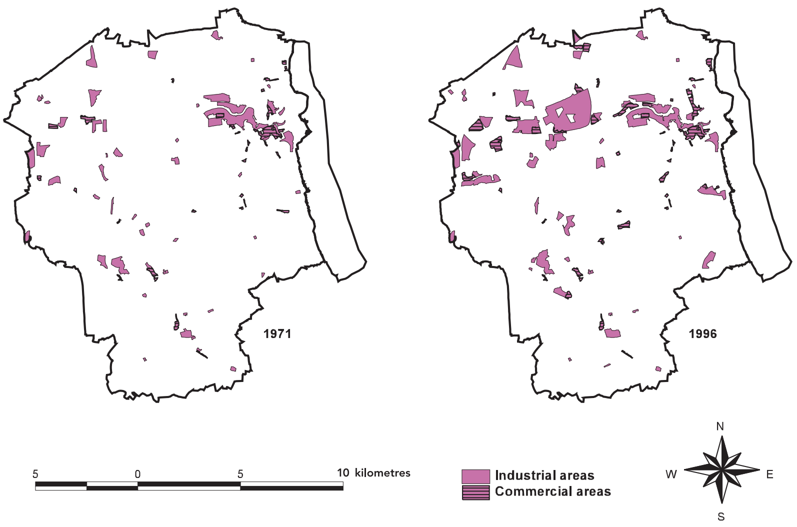
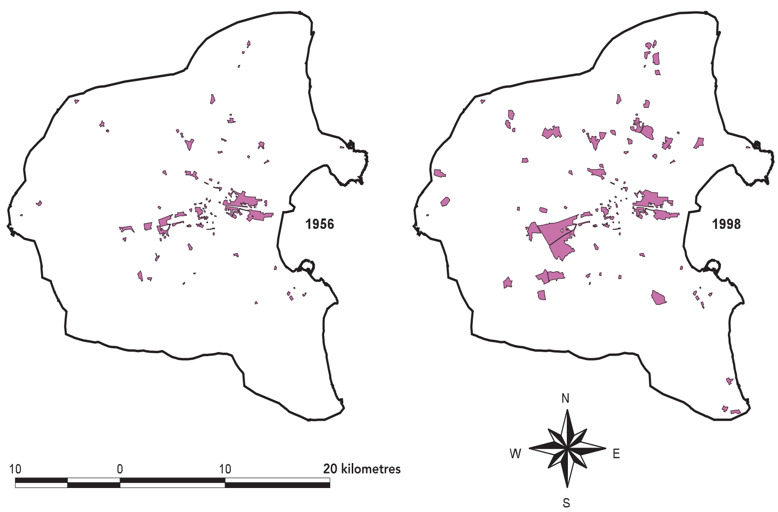


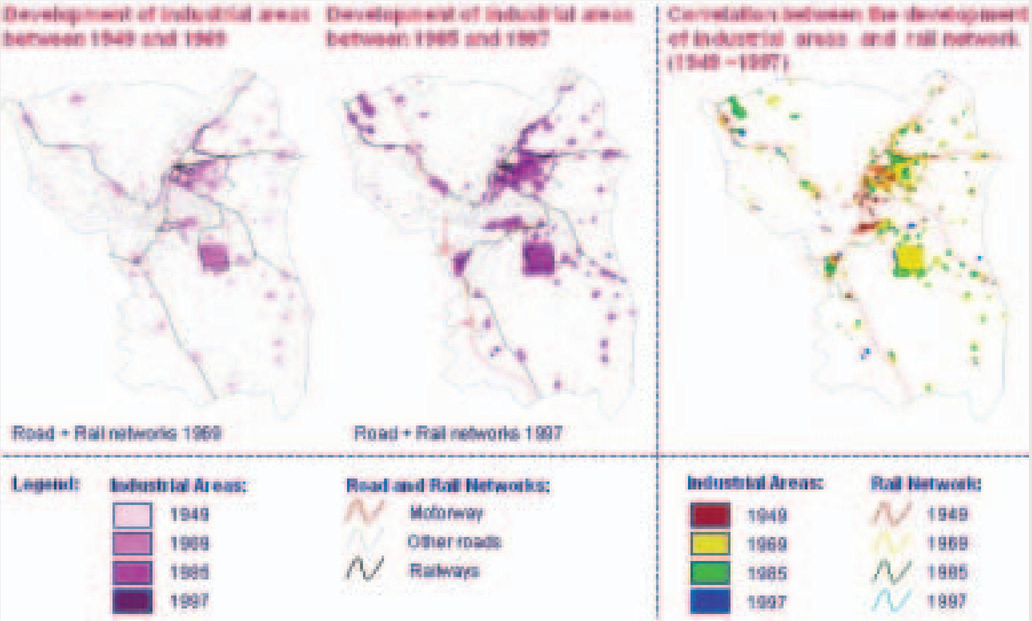
Figure 5.18 **Industrial areas evolution in Dublin (Ireland) from 1956 to 1998**



Since cities experience an increased demand for public facilities, as parks or transportation, the rate of growth for residential areas is smaller than that of the total urban areas. For instance, in Oporto, through the analysis of the Murbandy/Moland database enhanced with demographic data for each decade, it is possible to verify that even though the population is stagnating (1 % increase) the urban areas are increasing at a 21 % rate for the same period. Nevertheless only 12 % of the increases are of residential areas.

However, their increase does not always follows the same growth rate the overall artificial structure. In particular, the Murbandy/Moland database shows that for many cities the percentage increase in artificial area is bigger than the increase in green area. This particular aspect should be further investigated, since the proximity of green urban areas to residential units is considered an important indicator of urban sustainability. Section 5.2.1. of this report dedicates more emphasis to the potential support offered by the territorial database for tackling this issue.

Box 5.2: Development of industrial and commercial areas and public and private units over a 50-year period in Bratislava



Analysing the Moland database under industrial development, a clear relationship is visible between the industrial development and the railway network in the case of Bratislava. The analysis shows:

- the development of industrial areas between 1949 and 1969 as well as the road and rail networks of 1969;
- the development of industrial areas between 1985 and 1997 as well as the road and rail networks of 1997;
- the correlation between the development of industrial areas and rail networks during the period 1949–97.

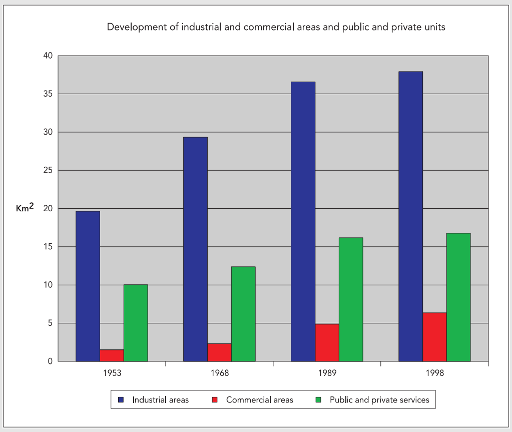
The results show that:

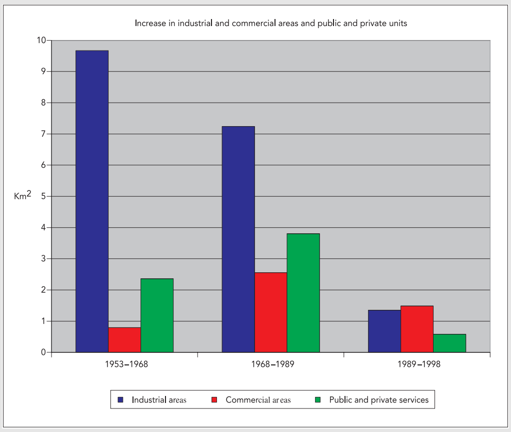
- the most important industrial areas of 1949 and 1969 are all very well connected to the rail network system;
- the growth of industrial areas over the years 1985 to 1997 is very closely linked to the further development of the rail networks; newly built industrial areas got a new rail connection.

Tourist infra-structure growth in the Algarve area (Portugal)

During the last 30 years Algarve (Portugal) has been transformed into a giant tourist resort that attracts more than 3 million tourists per year. Algarve is an attractive holiday resort for the Portuguese as well as for foreigners. Therefore the construction of tourism facilities is an ongoing process, even though in a different way from previously. Nowadays, big hotels on the beach and large apartment buildings are no longer buil, but instead golf courses and holiday villages spread along the Algarve coast.

The major land use changes have occurred in agricultural and natural areas. These areas were converted to artificial surfaces, mainly in residential areas. Figure 1 illustrates the shift of land uses from agricultural to residential areas. However, the Ria Formosa Nature Park is also suffering with this land use changes. The park is the major protected area in the region, occupying an area of 184 km^2 and it spreads along a strip of 60 km of shoreline — approximately half of the Portuguese south coast. The park has three different environmental units; marshland, dunes and shore, representing the largest continuous marshland area in Portugal. These multiple landscape units create a major diversity of habitats, which are the reason for its great wealth in terms of wild life. Due to its value, the park was proposed as a Man and the Biosphere Reserve by Unesco, which aims at the protection of the world's major ecosystems.

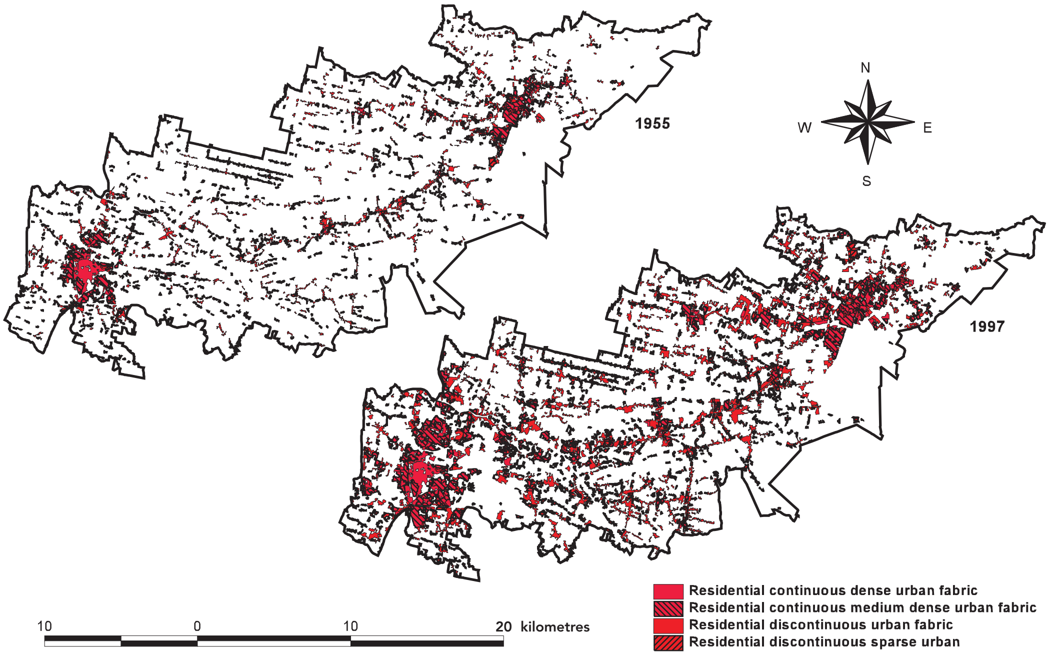




Residential areas

Figure 5.19

Growth in residential areas along the transport corridor Padua-Venice (Italy)



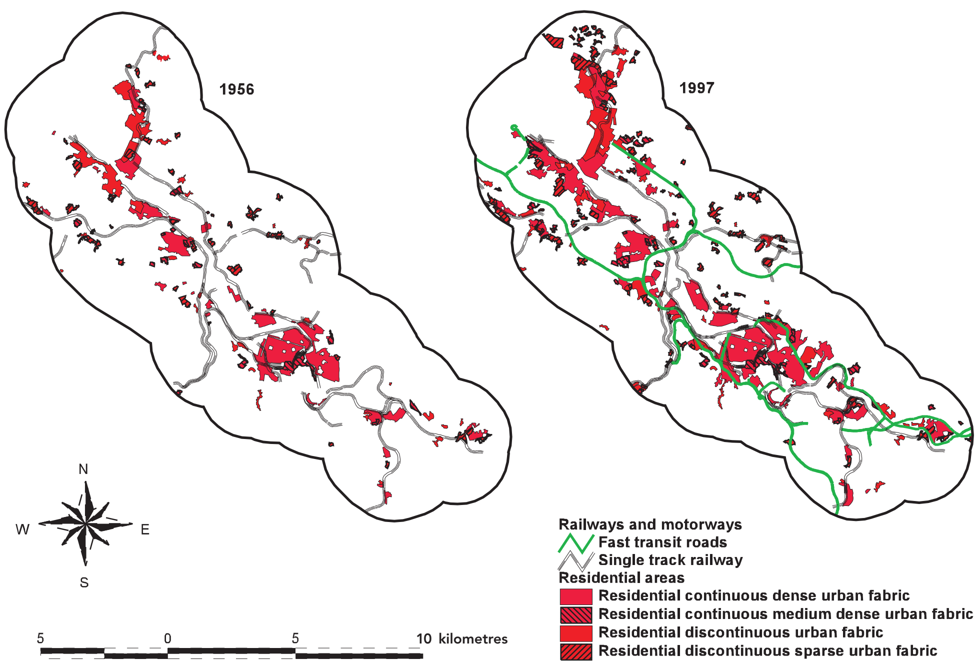
Green urban areas

Green urban areas are an essential feature for quality of life within the city. Murbandy/ Moland statistics show that in the urban context both green areas and parks are increasing in almost all the cities.

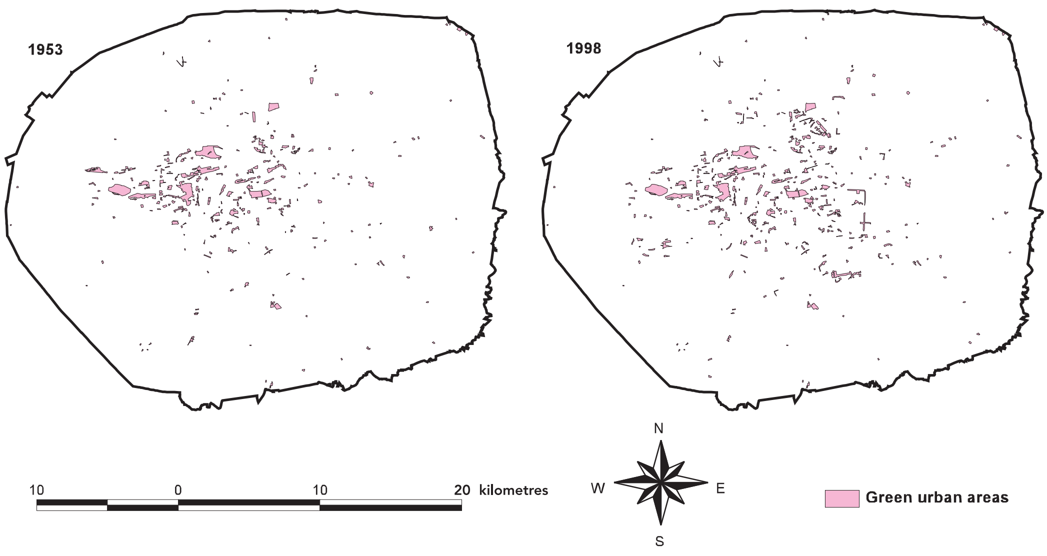
Another aspect to be considered is that the current increase in green urban areas cannot replace the loss of natural land. This negative trend, which leads cities away from sustainability, is clearly highlighted when we carry out the a comparative analysis of the two different land uses. The study of Porto, where the percentage of green urban area is also decreasing, emphasises this aspect.

Figure 5.20

Growth in residential area and traffic network in Bilbao (Spain) from 1956 to 1997



Green urban areas growth in Prague (Czech Republic) from1953 to 1998 — Figure 5.21



5.1.4. Combining socio-economic data

Urban evolution assessment generally requires very complex analyses combining different types of data and information. A territorial database is very well suited for this purpose, for instance associating the population density, as in the case of Vienna, to the residential areas identified by the Murbandy/Moland database. In this case-study, it has been possible to introduce a corrective factor: instead of being uniformly distributed over the overall area, the population has been re-distributed only in residential areas, ignoring those zones where the population number was obviously zero: wetlands, forests, etc. The map obtained has then been overlaid onto the population numbers of every administrative jurisdiction. The exact position of highly densely populated areas is immediately visible. It can be noticed that these areas do not always coincide with the most populated ones, according to administrative boundaries, and vice versa.

Correlation between the growth of residential and green urban areas in Lyon (France) from 1956 (left) to 1997 — Figure 5.22

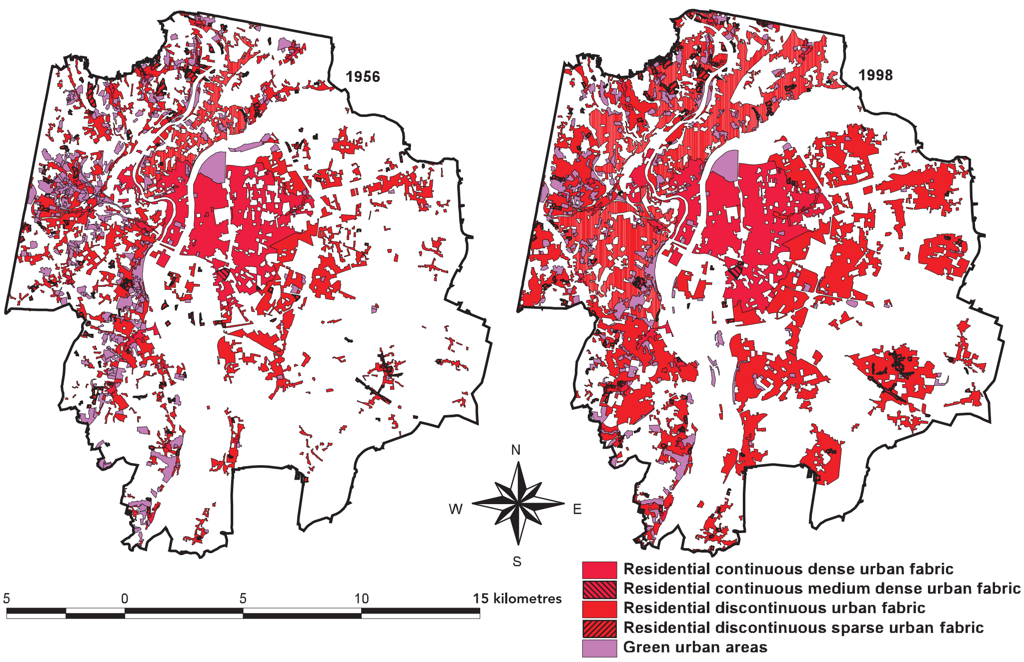
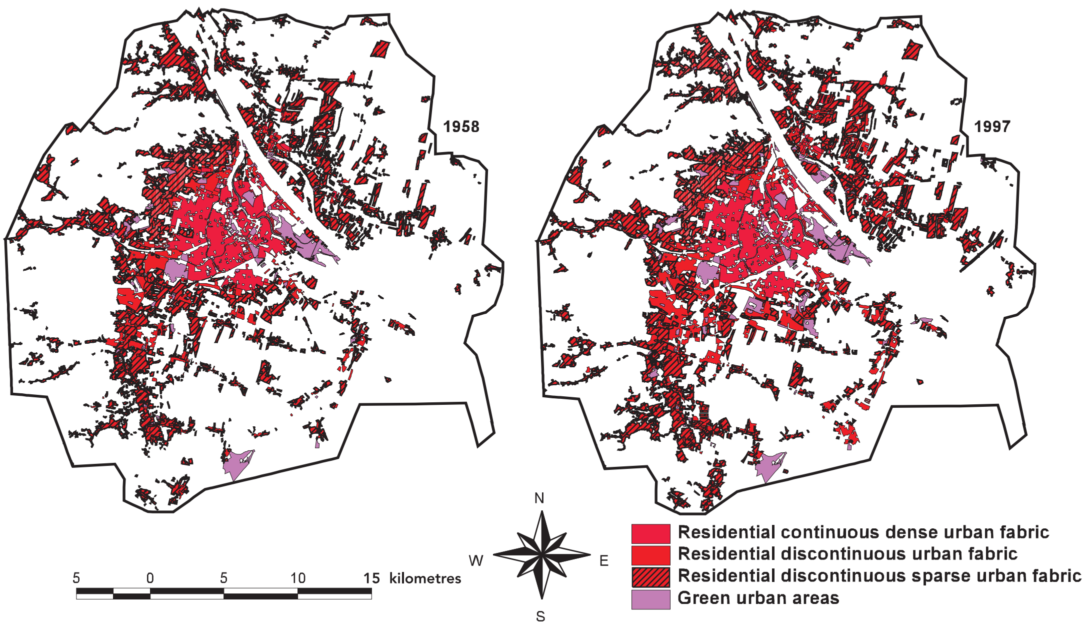
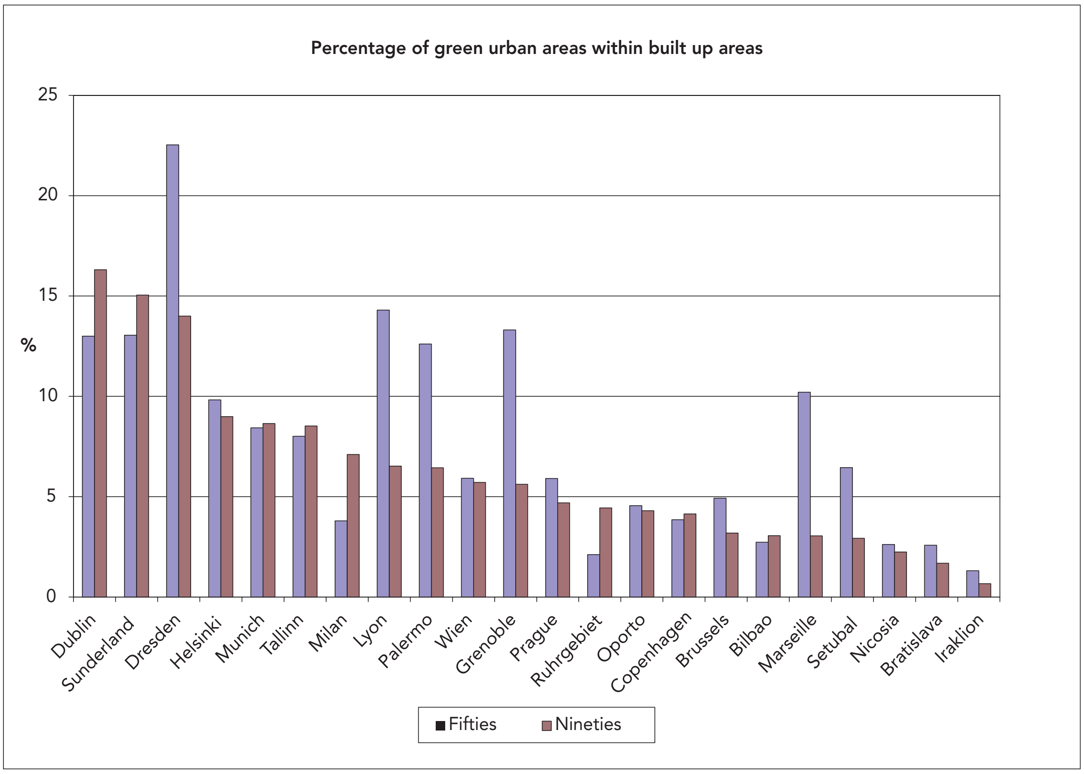


Figure 5.23 **Correlation between the growth of residential and green areas in Vienna (Austria) from 1958 (left) to 1997**

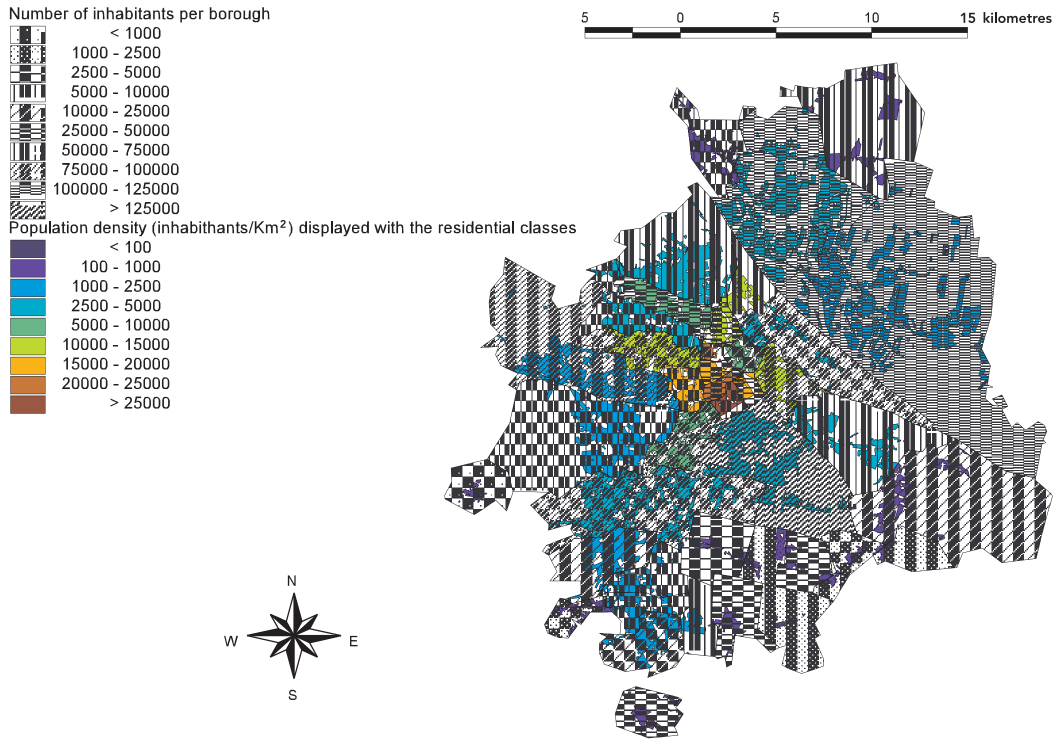


Among the broad spectrum of applications that can be derived from the database, the combination of territorial parameters and socio-economic data is perhaps the most interesting one, showing for example how the evolution of industrial and commercial sites can be associated with the movement of commuters during different time periods. Other features, such as the transport network evolution, can be added for cross-sectoral analyses.

Figure 5.24 **In many cases the percentage of green areas (parks and gardens) within the urban domains is decreasing.**



Population density in Vienna (Austria) | Figure 5.25



5.2. Supporting the European common indicators project

In 1991 the European Commission set up the Expert Group on the Urban Environment. The composition of the group was then modified in 1999, and currently its main objective is to provide specific advice and assistance on the development of European-level policy and instruments in fields of activity relating to the Communication 'Sustainable urban development in the European Union: A framework for action' (COM (98) 605). Its way of working has also been modified, and the group is now based on a small number of topic-oriented working groups. In 1999 one of these — the Working Group on Measuring, Monitoring and Evaluating Local Sustainability — started work on the project European common indicators — Towards a local sustainability profile. This aims at encouraging European local communities to use common indicators in order to measure their recorded progress towards sustainable local development. 'The launch of this new monitoring initiative at the Hannover Conference is, in my view, a milestone in the work towards sustainability at the local level' (Environment Commissioner Margot Wallstrom addressing the participants of the Hannover Conference, February 2000).

The Working Group on Measuring, Monitoring and Evaluating Local Sustainability proposes a set of local sustainability indicators for supporting better monitoring practices and enhancing comparability among cities.

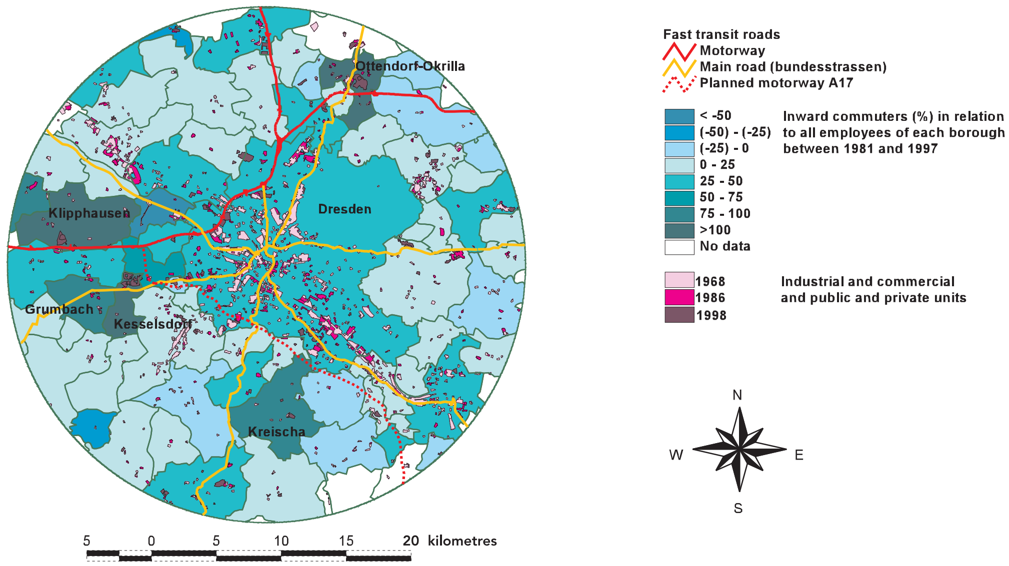
This section is dedicated to examples showing how the Murbandy/Moland database can contribute to computing such indicators. The methodological sheets for such indicators are presented in Annex 3.

5.2.1. Indicator A4: Availability of local public green areas and basic services

This indicator is defined as the citizen access to nearby public green areas and basic services. Local access is defined as living within a 500 metre (m) distance from the area/service.

Through the aid of a territorial database the indicator can be computed directly. A direct correlation between the position of residential areas and green areas is shown. A buffer of 500 m has been calculated around the green areas, to visualise the residential areas within that distance. By coupling population data to the position of residential areas the result of the indicator would be very precise.

Figure 5.26 **Relationship over time between commuters and industrial and commercial sites in Dresden (Germany)**



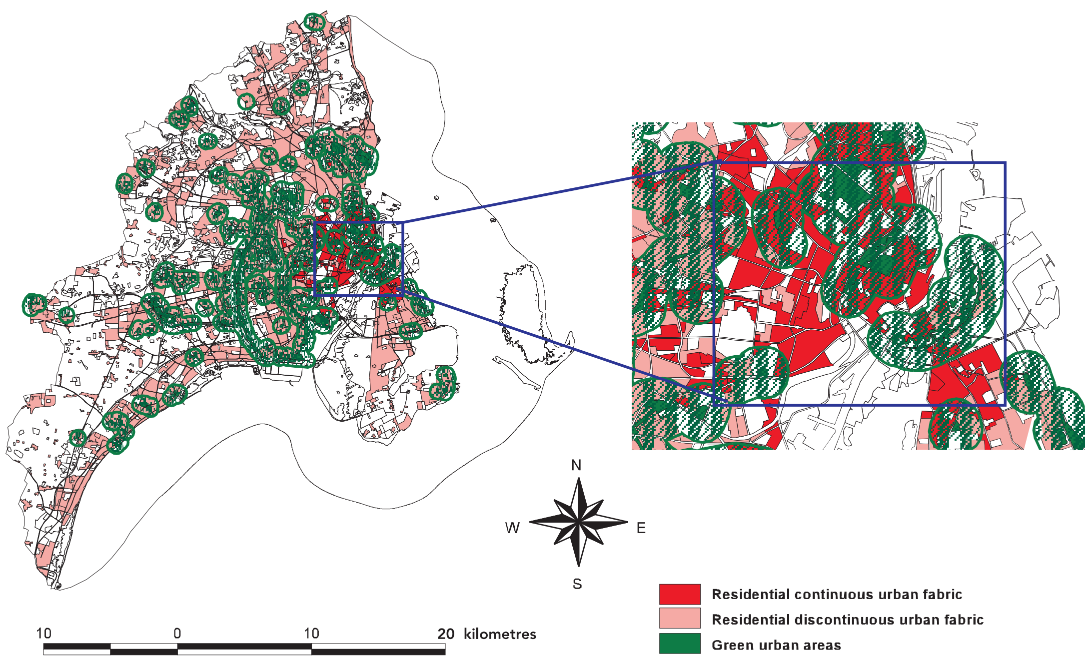
5.2.2. Indicator B8: Noise pollution

Within the framework of the Moland project an evolving set of environmental indicators is computed for assessing different aspects of the impact of transport networks on the surrounding area as part of the SEA methodology.

Some of these indicators are categorised as 'ecological' indicators and 'land use' indicators, others are categorised as 'perceptual' indicators. Potential noise impact, nearness to settlements, settlements touched and, visibility, are examples of perceptual indicators computed for example for railroads.

In particular the perceptual indicator 'potential noise impact' is used to estimate the potential noise impact of a transport link. It indicates how settlements are located with regard to the 65 dB (A) (4), 60 dB (A), 55 dB (A), 50 dB (A), and 35 dB (A) noise-

Figure 5.27 **City map of Copenhagen showing the residential areas (red colour), and the green urban areas with a 500 m belt around them**



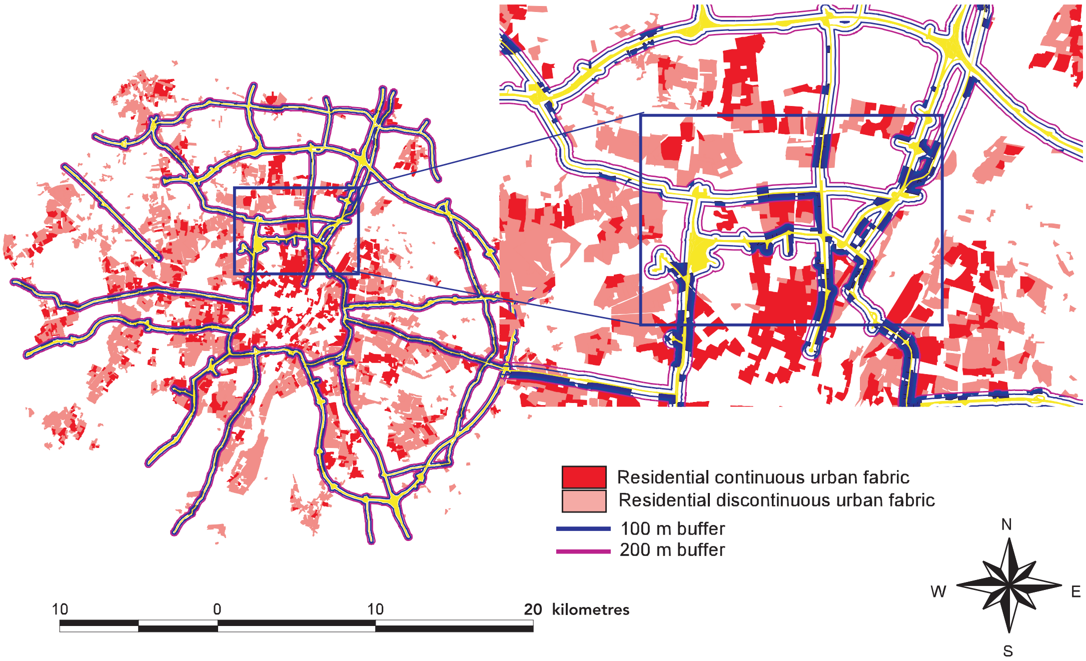
(4) dB(A) = international sound pressure level unit meaning 'decibel with an A frequency weighting' which reflects the sensitivity of the human ear

zones. The output from this indicator is a map showing the noise contours for the selected transport link (it could be road or railroads) in the study area.

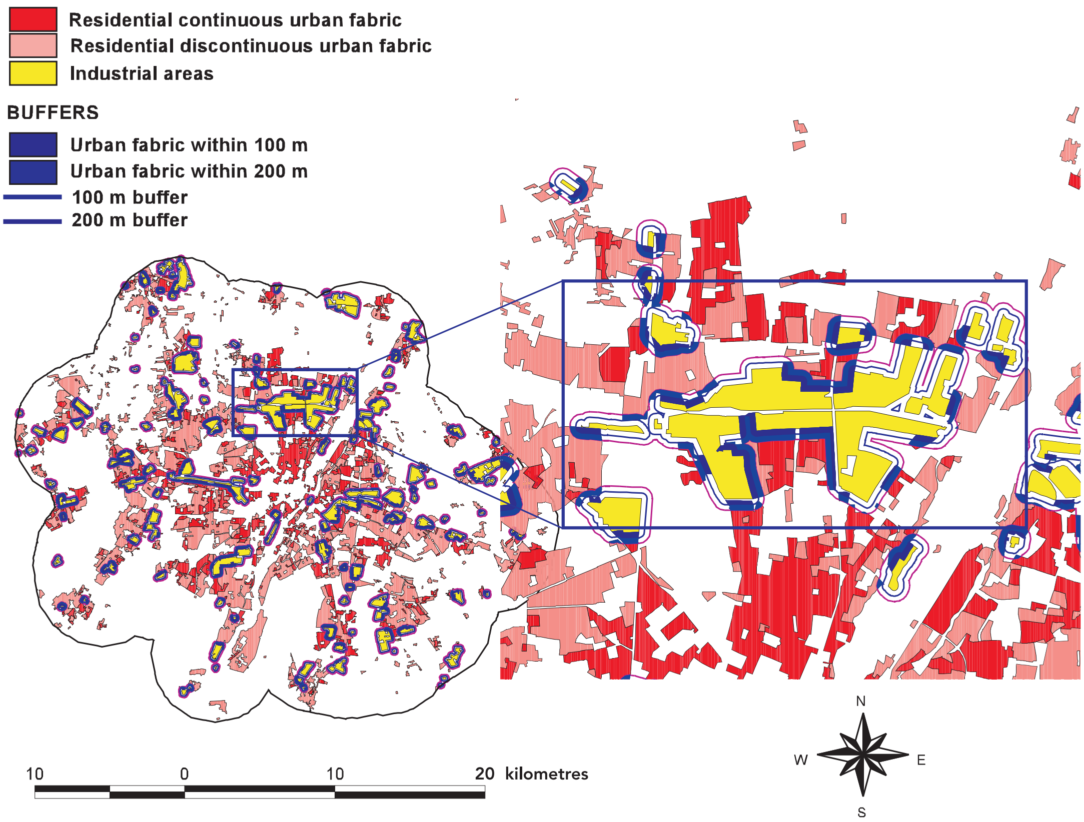
This methodology has been refined and simplified to provide support to the European common indicators project. Indicators B8 (noise pollution) is defined as the share of population exposed to long-term high level of harmful environmental noise.

Within the Murbandy/Moland project a buffer around noise sources (Figures 5.28 and 5.29) has been calculated. It is immediately possible to calculate the population living within that buffer, and therefore exposed to high levels of environmental noise.

Munich — population to harmful noise from motorways Figure 5.28



Munich — population exposed to harmful noise from industrial sources Figure 5.29

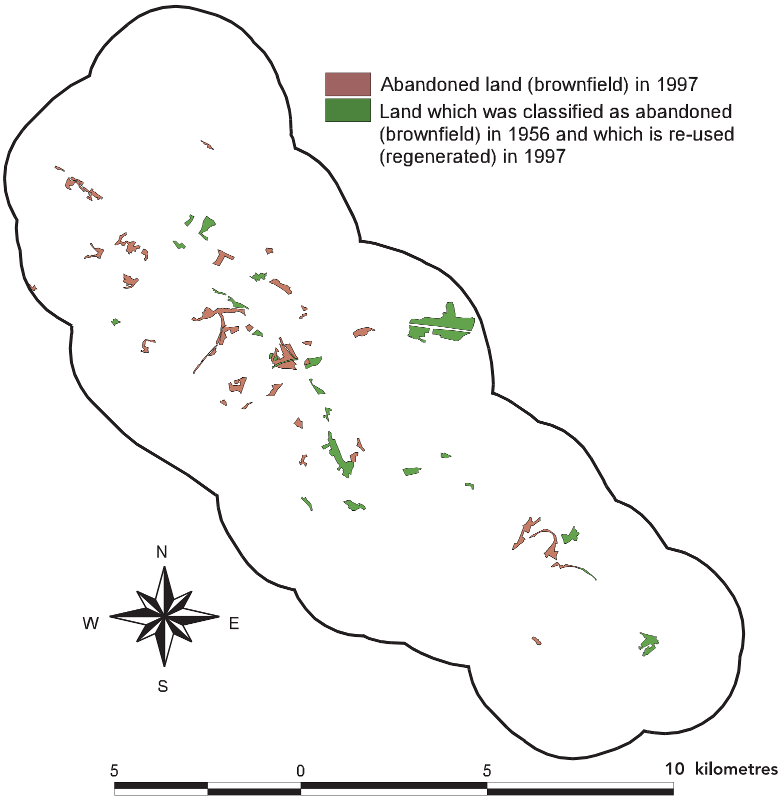


5.2.3. Indicator B9: Sustainable land use

This indicator represents sustainable development, restoration and protection of land and sites in the municipality.

A typical application of the Murbandy/ Moland databas57e for the computation of the above indicator is the identification of past brownfield sitess, and their current re-use those.

Figure 5.30 **City of Bilbao, Spain — brownfield development**



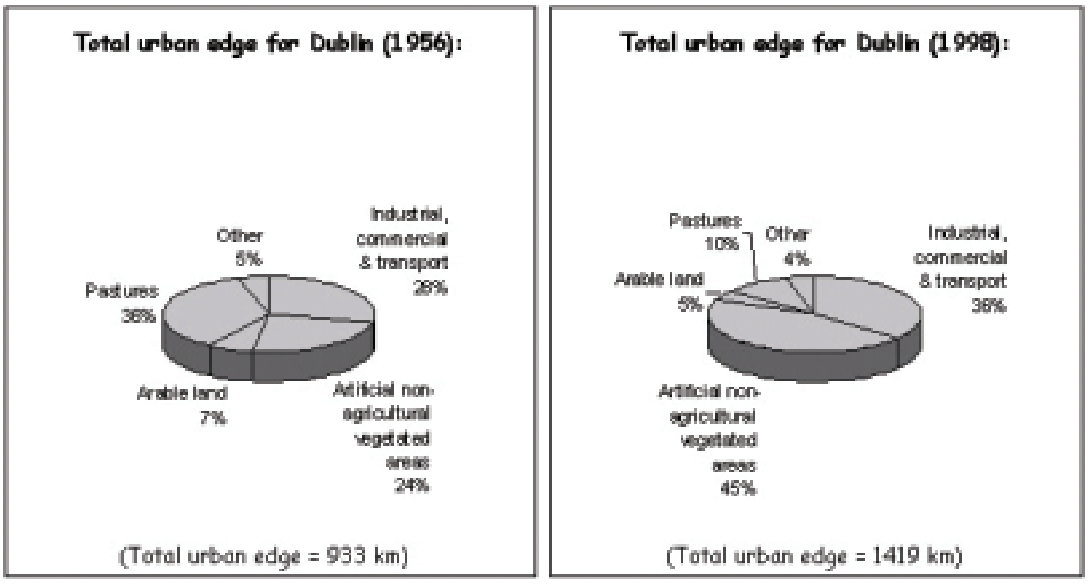
Note: The picture displays in brown colour the current — 1997 — brownfield sitess ('abandoned land'). The polygons with different colours represent land that was classified as 'abandoned' (= brownfield) in 1956, and that is now classified with a different land use typology. Every single coloured (except brown colour) polygon was brownfield in 1956. The legend shows the current land use class corresponding to each polygon.

5.3. Fragmentation of urban landscapes

Analysis of changes in the spatial structure or 'fragmentation' of urban landscapes can provide a deeper understanding of the impacts of past, current and future EU policies on urban environments, and can thus contribute to the formulation of policies and strategies aimed at promoting sustainable urban development. By analysing the fragmentation of urban landscapes, basic indicators related to the quality of life for citizens, as well as information on the impact of urbanisation on nature and biodiversity, can be derived. By presenting the results of the fragmentation analysis in the form of maps and tables it is visually possible to compare different cities, and different parts of the same city, in terms of their landscape fragmentation characteristics.

Landscape fragmentation can be quantified by analysing the properties and configuration of the spatial elements or 'patches' that make up the landscape. As part of the Murbandy/ Moland project, a methodology for quantifying and monitoring the fragmentation of urban landscapes is being applied to eight European cities — i.e. Bratislava, Dresden, Dublin, Helsinki, Milan, Munich, Prague and Vienna. In Murbandy/ Moland, changes in landscape fragmentation are measured using a landscape structural analysis software (Fragstats) that has been adapted for use with the Murbandy/Moland land use databases. The software takes as input a raster map of the land cover types in the area of interest, and computes various metrics that quantify different aspects of landscape fragmentation.

Urban edge analysis for Dublin Figure 5.31



One aspect of landscape fragmentation that is particularly important in urban environments is the composition of the 'total urban edge'. The total urban edge refers to the total length of the edge between the land use class 'urban fabric' and all other land use classes in the landscape. Analysis of the composition of the total urban edge is used to identify the land cover classes that are directly adjacent to urban fabric. This information can be used to derive indicators for comparing different cities in terms of, for example, the potential negative impacts of traffic corridors on residential areas. The change in the composition of the total urban edge in Dublin between the 1950s and 1998 shows a large increase in the amount of edge between 'urban fabric' and 'artificial non-agricultural vegetated areas' (i.e. mainly green urban areas). This indicates that much of the new urban fabric in Dublin has occurred adjacent to green urban areas, indicating more pleasant living conditions for citizens in these areas, but also the sprawl of residential functions.

'Edge-contrast' is a landscape fragmentation metric that reflects the degree of contrast between vegetated and non-vegetated surfaces: edges between vegetated and non-vegetated surfaces have high edge-contrast, while edges between vegetated and vegetated surfaces, or between non-vegetated and non-vegetated surfaces, have low edge-contrast. From the point of view of quality of life for citizens, areas of urban fabric that have high edge-contrast are generally more desirable than areas of urban fabric that have low edge-contrast. This is because living conditions are usually more pleasant for citizens who reside next to vegetated areas (e.g. forest, green urban areas), than for citizens who reside next to non-vegetated areas (e.g. industrial areas, transport corridors). On the other hand considering the overall urban area an increase in edge may depict a dissemination of residential areas, and the phenomenon of urban sprawl.

Fragmentation maps, presenting the change in the spatial distribution of edge-contrast for urban fabric in Dublin, from 1956 to 1998, show that most of the new urban areas in Dublin have a high edge-contrast (as shown by green in Figure 5.32). This means that most of the urban development in Dublin has occurred next to vegetated areas, indicating favourable living conditions for citizens. However, it is also clear that most of the urban development in north Dublin (i.e. north of the River Liffey) has a low edge-contrast (as shown by cyan and blue). This means that most of the new urban fabric in north Dublin has occurred next to non-vegetated areas, suggesting less favourable living conditions for citizens. In fact, these results reflect quite accurately the contrasting socio-economic situations of the two halves of Dublin, which has traditionally been divided between the less affluent north and the more affluent south. Thus, north Dublin has significant areas of low-cost housing (including high-rise apartment complexes) and industrial and commercial developments, while south Dublin is largely characterised by expensive residential properties, generally located in green leafy suburbs, with many nearby gardens, parks, and sport and recreation facilities, sprawling throughout the adjacent rural hinterland.

Figure 5.32 **Edge-contrast for urban fabric in Dublin**