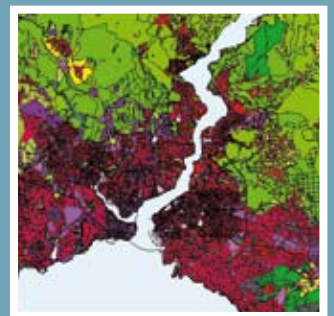


Urban sprawl in Europe

The ignored challenge

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Contents

Acknowledgements	4
1 Urban sprawl – a European challenge	5
1.1 Introduction	5
1.2 Why sprawl matters?.....	5
1.3 Why are cities sprawling?.....	6
1.4 Links to EU policies	7
1.5 Who should read this report?.....	7
2 The extent of urban sprawl in Europe	8
2.1 The European picture	8
2.2 Regional clusters of sprawling and compact cities	13
3 The drivers of urban sprawl.....	17
3.1 Clusters of drivers	17
3.2 Pathways to urban sprawl	20
4 The impacts of urban sprawl.....	28
4.1 Environmental impacts	28
4.2 Socio-economic impacts	35
5 Responses to urban sprawl.....	38
5.1 Initiatives to counter sprawl	38
5.2 The European spatial development perspective	39
5.3 Current barriers to addressing urban sprawl	39
5.4 Policy coherence and effectiveness	40
5.5 Local urban and regional management.....	44
5.6 By way of conclusion – combat against urban sprawl	45
Annex: Data and methodological approach.....	49
A The challenge of scales.....	49
B Definition of urban areas.....	49
C Assessing urban sprawl at the European level: Corine land cover.....	51
D Assessing urban sprawl at regional and local levels: MOLAND	51
References and further reading	53
Further electronic resources	56

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1 Urban sprawl – a European challenge

1.1 Introduction

Europe is a fascinating and diverse continent, one of the most urbanised on earth. Today, approximately 75 % of the European population live in urban areas, while still enjoying access to extensive natural or semi-natural landscapes. With its stunning urban landscapes, historical cities and cultural treasures, Europe remains one of the world's most desirable and healthy places to live. Moreover, it is the most frequently visited world-travel destination.

The urban future of Europe, however, is a matter of great concern. More than a quarter of the European Union's territory has now been directly affected by urban land use; by 2020, approximately 80 % of Europeans will be living in urban areas, while in seven countries the proportion will be 90 % or more. As a result, the various demands for land in and around cities are becoming increasingly acute. On a daily basis, we all witness rapid, visible and conflicting changes in land use which are shaping landscapes in cities and around them as never before.

Today, society's collective reliance on land and nature for food, raw materials and waste absorption results in a resource demand without precedent in history. In Europe, our consumption patterns are completely different from what they were twenty years ago. Transport, new types of housing, communication, tourism and leisure have emerged as major components of household consumption.

As most of the population live in urban areas, agricultural land uses and their functions in the countryside have consequently evolved. Today, they ensure both the feeding of the city populations and maintenance of a diminishing rural population. Coasts are being urbanised at an accelerating rate, and resident communities are being transformed in order to accommodate these new economies. As a result, our coasts are becoming increasingly intertwined with the hinterland and more dependent on tourism and secondary homes (EEA, 2006).

In this modified landscape, a powerful force is at work: cities are spreading, minimising the time and distances between and in-and-out of the cities. This expansion is occurring in a scattered way throughout Europe's countryside: its name is urban sprawl. Furthermore, it is now rightly regarded as one of the major common challenges facing urban Europe today.

1.2 Why sprawl matters?

Sprawl threatens the very culture of Europe, as it creates environmental, social and economic impacts for both the cities and countryside of Europe. Moreover, it seriously undermines efforts to meet the global challenge of climate change.

Urban sprawl is synonymous with unplanned incremental urban development, characterised by a low density mix of land uses on the urban fringe (Box 1). Classically, urban sprawl is a US phenomenon associated with the rapid low-density outward expansion of US cities, stemming back to the early part of the 20th century. It was fuelled by the rapid growth of private car ownership and the preference for detached houses with gardens.

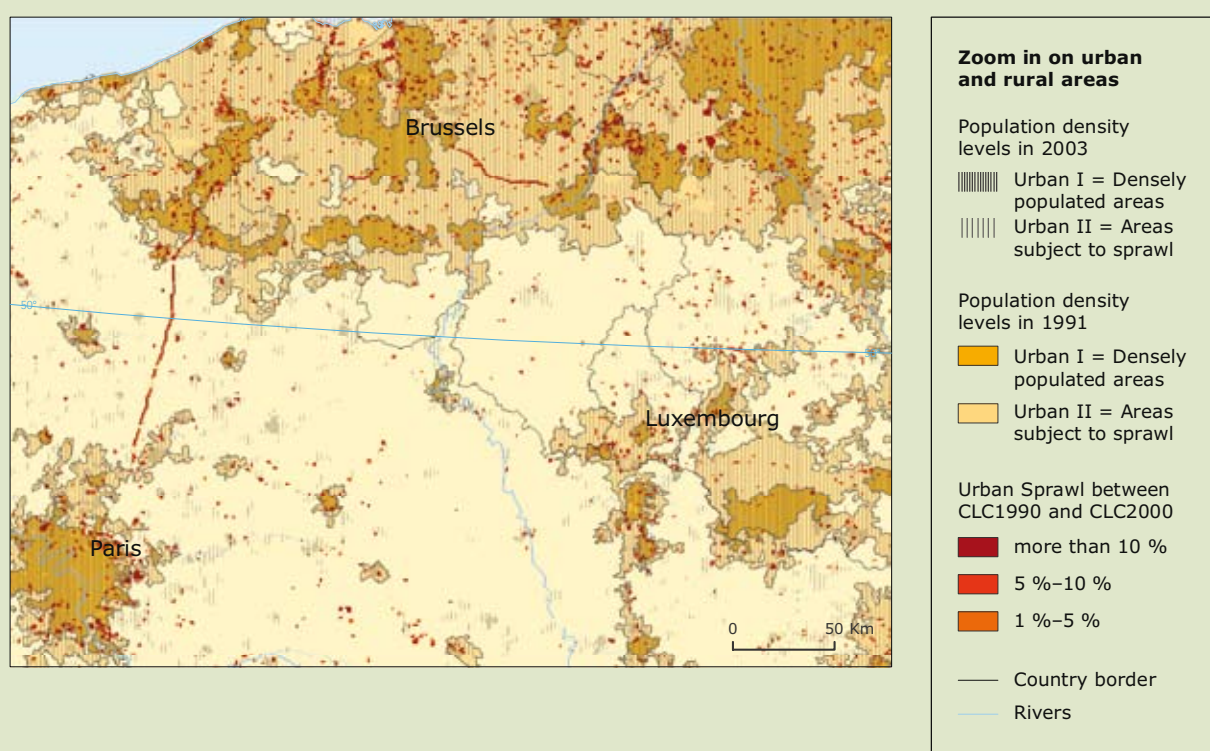
In Europe, cities have traditionally been much more compact, developing a dense historical core shaped before the emergence of modern transport systems. Compared to most American cities, their European counterparts still remain in many cases compact. However, European cities were more compact and less sprawled in the mid 1950s than they are today, and urban sprawl is now a common phenomenon throughout Europe. Moreover, there is no apparent slowing in these trends. The urban areas particularly at risk are in the southern, eastern and central parts of Europe are particularly at risk.

The sprawling nature of Europe's cities is critically important because of the major impacts that are evident in increased energy, land and soil consumption. These impacts threaten both the natural and rural environments, raising greenhouse

Box 1 Urban sprawl – definition

Urban sprawl is commonly used to describe physically expanding urban areas. The European Environment Agency (EEA) has described sprawl as the physical pattern of low-density expansion of large urban areas, under market conditions, mainly into the surrounding agricultural areas. Sprawl is the leading edge of urban growth and implies little planning control of land subdivision. Development is patchy, scattered and strung out, with a tendency for discontinuity. It leap-frogs over areas, leaving agricultural enclaves. Sprawling cities are the opposite of compact cities – full of empty spaces that indicate the inefficiencies in development and highlight the consequences of uncontrolled growth.

The map of northeast France, Belgium, Luxembourg and northwest Germany illustrates the definition of urban sprawl, and shows the urban areas overlaid with population density. It is clear that low density populated areas extend far beyond the centres of cities, with new urban areas spreading along the Paris-Brussels axis adjacent to the TGV high-speed railway (an effect of the 'beetroot' train stations).



Note: Due to changes in the Eurostat methodology the two datasets (1991 and 2003) differ.

Source: EEA (based on EEA and Eurostat data).

gas emissions that cause climate change, and elevated air and noise pollution levels which often exceed the agreed human safety limits. Thus, urban sprawl produces many adverse impacts that have direct effects on the quality of life for people living in cities.

1.3 Why are cities sprawling?

Historically, the growth of cities has been driven by increasing urban population. However, in Europe today, even where there is little or no population

pressure, a variety of factors are still driving sprawl. These are rooted in the desire to realise new lifestyles in suburban environments, outside the inner city.

Global socio-economic forces are interacting with more localised environmental and spatial constraints to generate the common characteristics of urban sprawl evident throughout Europe today. At the same time, sprawl has accelerated in response to improved transportation links and enhanced personal mobility. This has made it possible either to live increasingly farther away

from city centres, while retaining all the advantages of a city location, or enabled people to live in one city and work in another.

The mix of forces include both micro and macro socio-economic trends such as the means of transportation, the price of land, individual housing preferences, demographic trends, cultural traditions and constraints, the attractiveness of existing urban areas, and, not least, the application of land use planning policies at both local and regional scales.

Overall, evidence suggests that where unplanned, decentralised development dominates, sprawl will occur in a mechanistic way. Conversely, where growth around the periphery of the city is coordinated by strong urban policy, more compact forms of urban development can be secured.

1.4 Links to EU policies

In essence, through the realisation of the 'internal market', Europe's new prosperity and economic development has put pressure on cities. The role and contribution of cities to Europe's economic growth, jobs and competitiveness, while also delivering social and environmental goals, has been addressed extensively by the EU institutions together with the regional and local authorities (European Commission, 2005). Sustainable urban development appears prominently in many European policy commitments, not least EU regional policy.

To this end substantial EU Cohesion and Structural Funds budget transfers to Member States provide powerful drivers of macro-economic change to support EU integration. However, analysis shows that they can also create inadvertent socio-economic effects that have promoted the development of sprawl. The coordination of land use policies and Structural and Cohesion Funds investments remains key to support the containment of urban sprawl, which is complicated by the fact that EU intervention in many other, if not all, policy domains, impact on or are impacted by urban development.

One illustration of the extent of these interrelationships is the EU commitment to sustainable development and policies to tackle climate change: how can we ensure that the growth of urban greenhouse gas emissions due to the dominance of car transport in the EU's sprawling cities does not threaten to undermine EU Kyoto commitments to reduce greenhouse gas emissions by 2020?

Overall, the EU has an obligation in relation to the wide range of environmental, social and economic impacts of urban sprawl to define a clear and substantial responsibility, and a mandate to take an active lead in the development of new initiatives to counter the impacts of sprawl.

1.5 Who should read this report?

This report is targeted at all those actively involved in the management of Europe's urban areas. The aim is to inform about the impacts of urban sprawl in Europe today and that without concerted action by all agencies to address the underlying causes, the economic social and environmental future of our cities and regions can be compromised.

Subsequent chapters of this report describe the patterns of urban sprawl that have emerged throughout Europe during the post war period (Chapter 2), which are related to the global social and economic trends that form the fundamental drivers of sprawl (Chapter 3). Chapter 4 reviews the evidence of the impacts of urban sprawl, and concludes that the sprawling city creates major and severe impacts in relation to a variety of environmental, social and economic issues affecting not only the city and its region but also the surrounding rural areas. Finally, Chapter 5 examines the principles that could underpin the framework for action at EU level to combat urban sprawl. This would include increased policy coherence built around measures to secure policy integration via close coordination between policies in different domains, better cooperation between different levels of administration, as well as policy definition according to the principles of sustainable development.

2 The extent of urban sprawl in Europe

2.1 The European picture

The process of urbanisation in Europe has evolved as a clear cycle of change during the post-war period from urbanisation to suburbanisation

to de-urbanisation and, most recently, to re-urbanisation. Historically, the growth of cities was fundamentally linked to increasing population. In contrast, urban sprawl is a more recent phenomenon and is no longer tied to population

Map 1 Urban expansion in Europe (1990–2000)



Source: EEA, 2005.

growth as mentioned in Chapter 1. Rather a variety of other powerful factors drive the development of the modern city, including individual housing preferences, increased mobility, commercial investment decisions, and the coherence and effectiveness of land use policies at all levels.

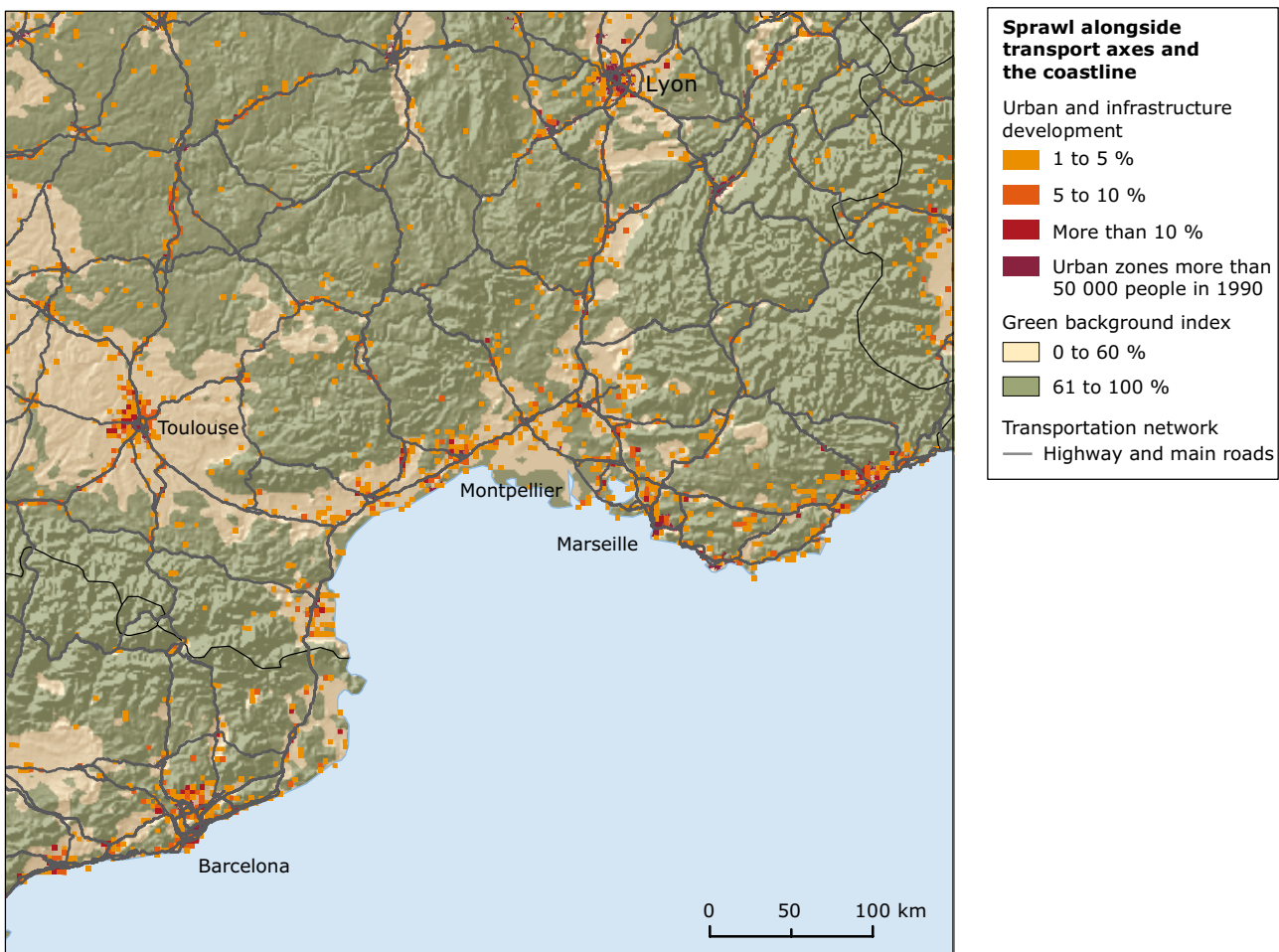
All available evidence demonstrates conclusively that urban sprawl has accompanied the growth of urban areas across Europe over the past 50 years. This is shown from a recent European perspective (Map 1). The areas with the most visible impacts of urban sprawl are in countries or regions with high population density and economic activity (Belgium, the Netherlands, southern and western Germany, northern Italy, the Paris region) and/or rapid economic growth (Ireland, Portugal, eastern Germany, the Madrid region). Sprawl is particularly evident where countries or regions have benefited from EU regional policies. New development patterns can also be observed, around smaller towns or in the countryside, along transportation

corridors, and along many parts of the coast usually connected to river valleys. The latter is exemplified by the so-called 'inverse T' of urban sprawl along the Rhône valley down to the Mediterranean coast (Map 2).

Hot spots of urban sprawl are also common along already highly populated coastal strips, such as in the case of Spain where the artificial areas may cover up to 50 % of the total land area (Map 3). This is doubly worrying given the known vulnerability of coastal ecosystems and because the Mediterranean region is classified as one of 34 biodiversity hotspots in the world.

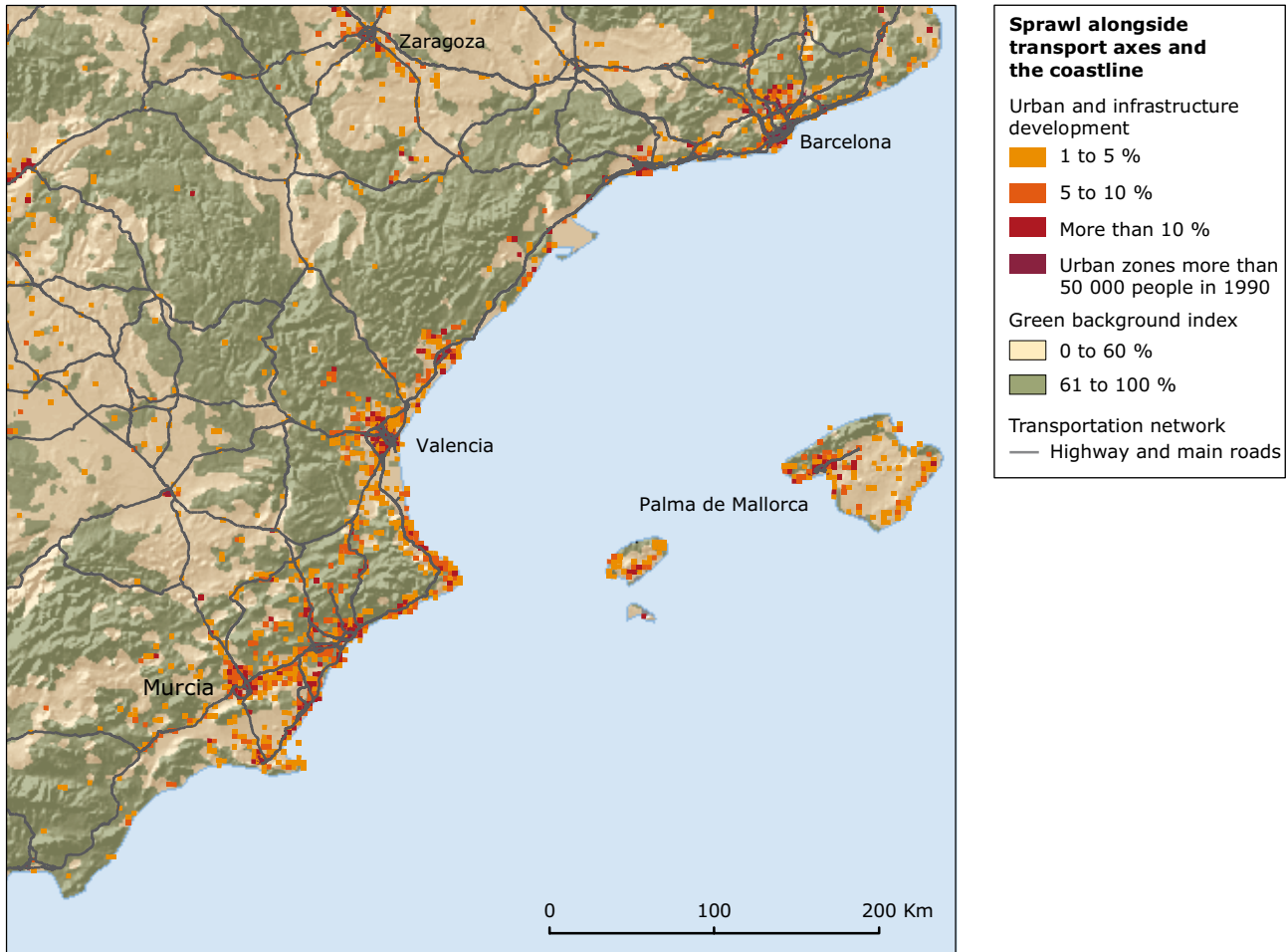
Sprawl may also follow from the expected rapid economic development in many parts of the new Member States, as internal economic dynamism, greater access to EU markets, and Cohesion Fund and Structural Funds investments drive economies. The 2004 accession is too recent to permit full understanding of the potential impacts of urban

Map 2 Urban sprawl along the Rhône corridor: south of France (1990–2000)



Source: EEA.

Map 3 Urban sprawl on the Mediterranean coast: southeast Spain (1990–2000)



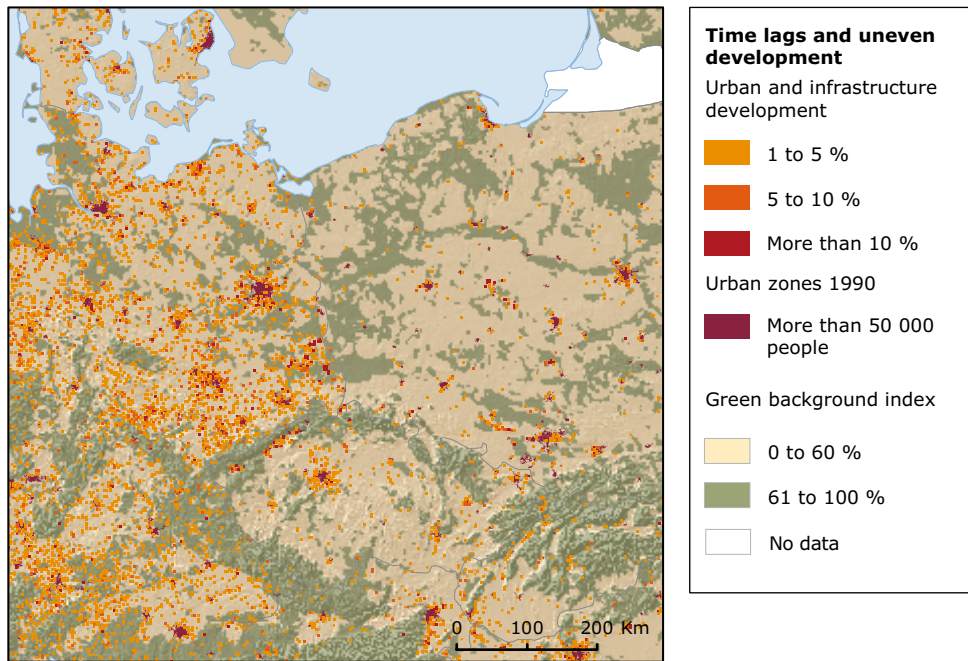
Source: EEA.

sprawl driven by this economic expansion, but some insights can be provided by comparisons between eastern Germany and Poland for the period 1990–2000. East Germany benefited from large monetary transfers from West Germany after unification in 1990, making it one of the most rapidly developing regions in Europe. In contrast, just to the east, in Poland, where EU membership is more recent, there was less development during the period 1990–2000 and the differences in the levels of urban sprawl between Germany and Poland are quite marked (Map 4). This contrast is accentuated by the region history.

As already said, the growth of built-up areas in Europe reached its peak in 1950s–1960s (MOLAND), when the average annual growth rate reached 3.3 % (Figure 1). In subsequent decades the main wave of urban growth has moved farther away from the city centres allowing urban sprawl to extend the urban footprint into the adjacent countryside (Antrop, M.,

2004; Sallez & Burgi, 2004; Prud'homme & Nicot, 2004; Couch *et al.*, 2005).

Indeed during the ten year period 1990–2000 the growth of urban areas and associated infrastructure throughout Europe consumed more than 8 000 km² (a 5.4 % increase during the period), equivalent to complete coverage of the entire territory of the state of Luxembourg. This is equivalent to the consumption of 0.25 % of the combined area of agriculture, forest and natural land. These changes may seem small. However, urban sprawl is concentrated in particular areas which tend to be where the rate of urban growth was already high during the 1970s and 1980s. Moreover, they run alongside the emerging problems of rural depopulation. On a straight extrapolation, a 0.6 % annual increase in urban areas, although apparently small, would lead to a doubling of the amount of urban area in little over a century (EEA, 2005). This needs careful consideration as

Map 4 Urban sprawl in Germany, Poland and Czech Republic (1990–2000)

Source: EEA, 2005.

we look ahead to the type of Europe we would like to see in the next 50–100 years, taking into account possible climate change and the many impacts and adaptation challenges it would pose (see Chapter 4, Section 4.1.4).

Historical trends, since the mid-1950s, show that European cities have expanded on average by 78 %, whereas the population has grown by only 33 %. A major consequence of this trend is that European cities have become much less compact. The dense enclosed quarters of the compact city have been replaced by free standing apartment blocks, semi-detached and detached houses. In half of the urban areas studied in the Moland project, more than 90 % of all residential areas built after the mid-1950s were low density areas, with less than 80 % of the land surface covered by buildings, roads and other structures (Figure 2). Only in 5 of the 24 cities, all in southern or central parts of Europe, were more than 50 % of new housing areas (built since the mid-1950s) densely built-up.

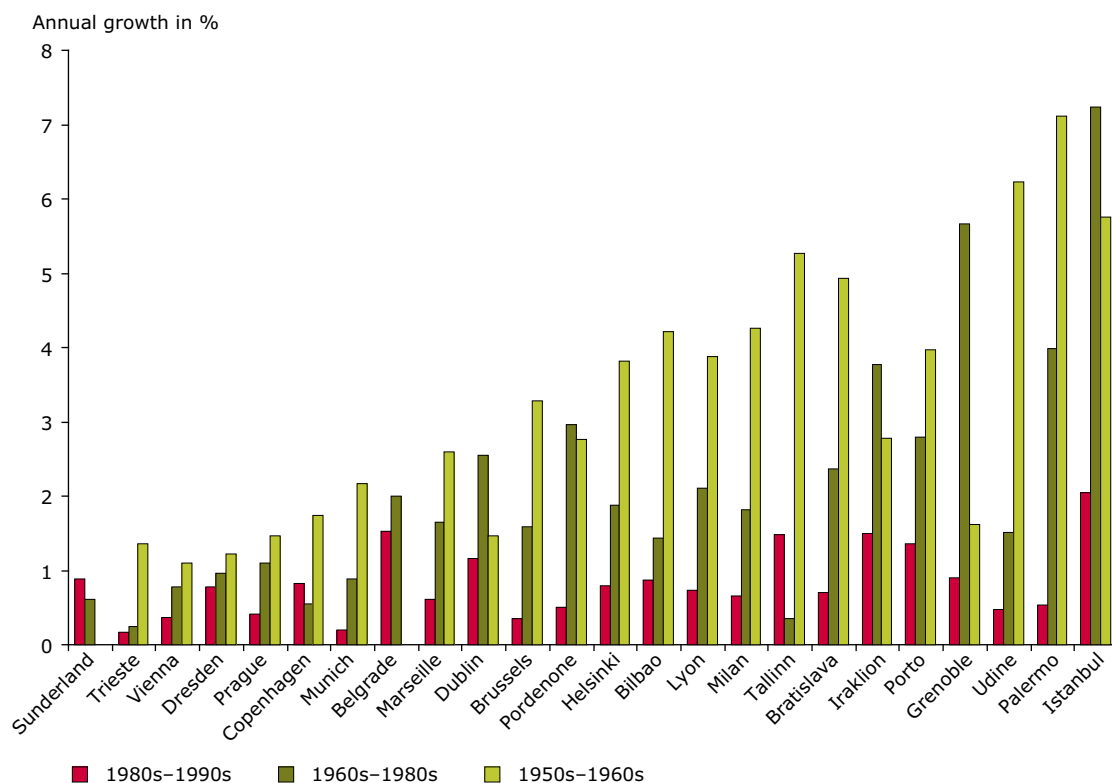
Trends towards new low density environments are also evident in the space consumed per person in the cities of Europe during the past 50 years which has more than doubled. In particular, over the past 20 years the extent of built-up areas in many western and eastern European countries has increased by 20 % while the population has increased by only 6 % (Figure 3).

Sprawl is greater, and in many cases significantly greater, than would be expected on the basis of population growth alone (MOLAND). Only in Munich and Bilbao has population grown more rapidly than in the built-up area. Palermo with 50 % growth in population generated more than 200 % growth in the built-up area (Figure 4).

Although the population is decreasing in many regions of Europe (Map 5 — blue tone), urban areas are still growing in those areas, notably Spain, Portugal and some parts of Italy (Map 5 — dark blue tone). Conversely, moderate increases of population accompanied by a large expansion of urban areas can be observed in Spain, Portugal, Ireland and the Netherlands. Major gains of population (> 10 %, through immigration) can only be observed in western Germany, where the average annual expansion of built-up areas is 47 000 ha/year, growth equivalent over 5 years to the area of Greater Copenhagen.

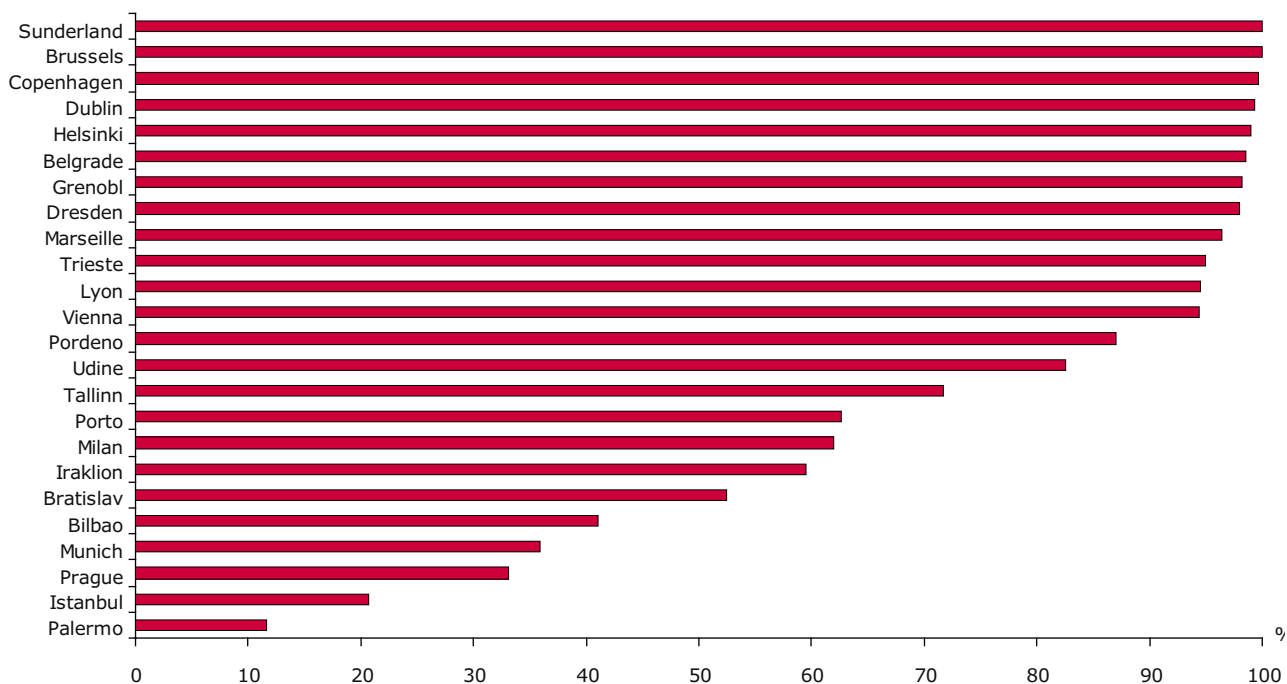
European cities are also remarkably diverse in respect of urban residential densities (Figure 5). Generally, there is a tendency for residential densities to fall towards the north and west of Europe, and the five urban areas with residential densities of at least 10 000 inhabitants/km² are all located in southern or southeastern Europe. There is no tendency, however, for urban sprawl to vary with the density of cities, as irrespective of urban

Figure 1 Annual growth of built-up areas from the mid-1950s to the late 1990s, selected European cities



Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

Figure 2 Low density residential areas as a proportion of all residential areas built after the mid-1950s, selected European cities



Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

residential density, sprawl is equally evident in the vast majority of the cities examined.

2.2 Regional clusters of sprawling and compact cities

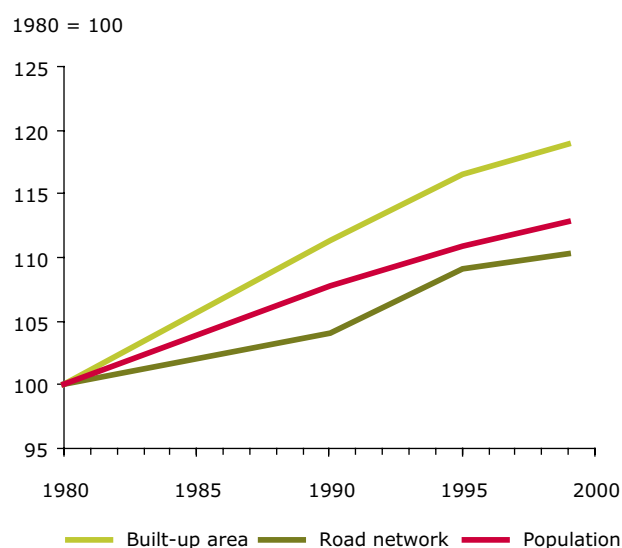
An assessment of the most sprawled and most compact urban areas in Europe can be realised based on the following indicators:

- Growth of built-up areas (1950s–1990s)
- Share of dense residential areas of all residential areas (1990s)
- Share of low density residential areas of all new residential areas (mid-1950s onwards)
- Residential density (1990s)
- The change in growth rates for population and built-up areas (1950s–1990s)
- Available built-up area per person (1990s).

Such indicator analysis for selected cities in Europe, undertaken as part of the MOLAND project, shows the most compact city, Bilbao, is three times denser than the most sprawled city, Udine. Generally the analysis demonstrates certain clustering of cities according to the degree of sprawl or compactness that appear to be more pronounced in certain regions of Europe rather than others (Table 1).

Southern European cities have a long urban tradition in which the urbanisation process has been

Figure 3 Built-up area, road network and population increases, selected EEA countries



Note: Countries covered are: Belgium, Czech Republic, Denmark, France, Germany, Latvia, Lithuania, the Netherlands, Poland, Slovakia and Spain.

Source: EEA, 2002.

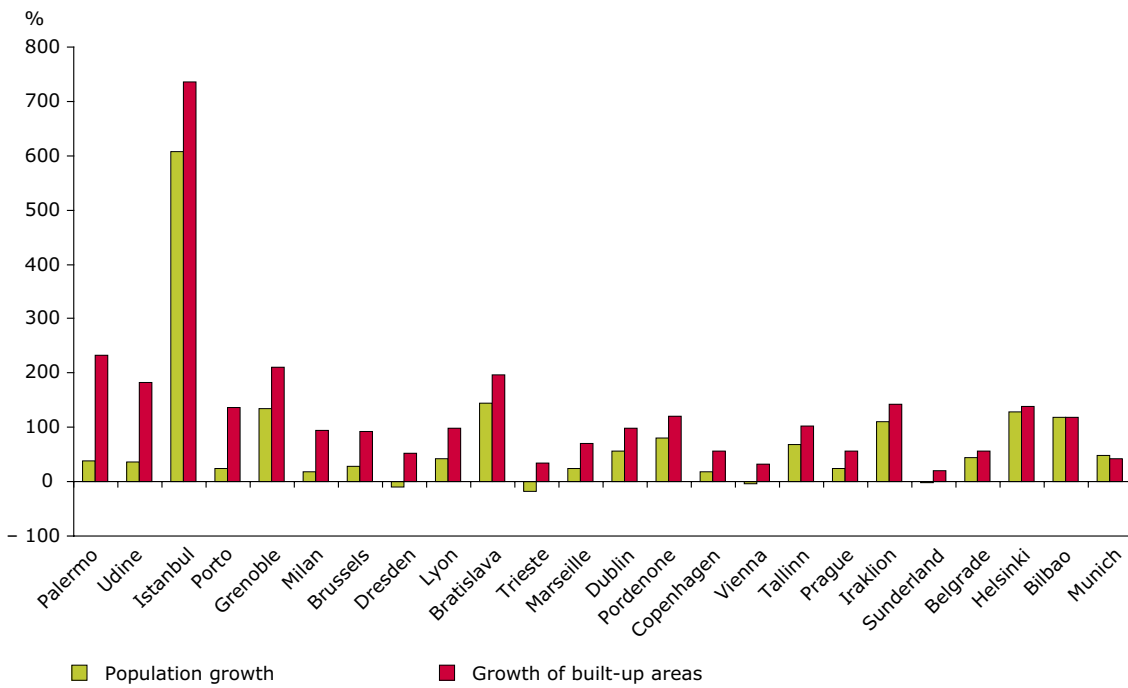
slower, with fewer periods of rapid growth and the cities have been very compact. In recent decades, however, urban sprawl has started to develop at unprecedented rates, and it is most probable that unless land use planning and zoning restrictions are

Table 1 Distribution of Europe's sprawling and compact cities

	Southern European cities	Eastern and central European cities	Northern and western European cities
Sprawled Compact		Udine	
		Pordenone	
		Dresden	Helsinki
			Copenhagen
			Dublin
			Brussels
			Grenoble
	Marseille	Trieste	Sunderland
	Porto	Vienna	Lyon
		Bratislava	Tallinn
	Belgrade		
	Prague		
	Munich		
	Iraklion		
	Palermo		
	Milan		
	Bilbao		

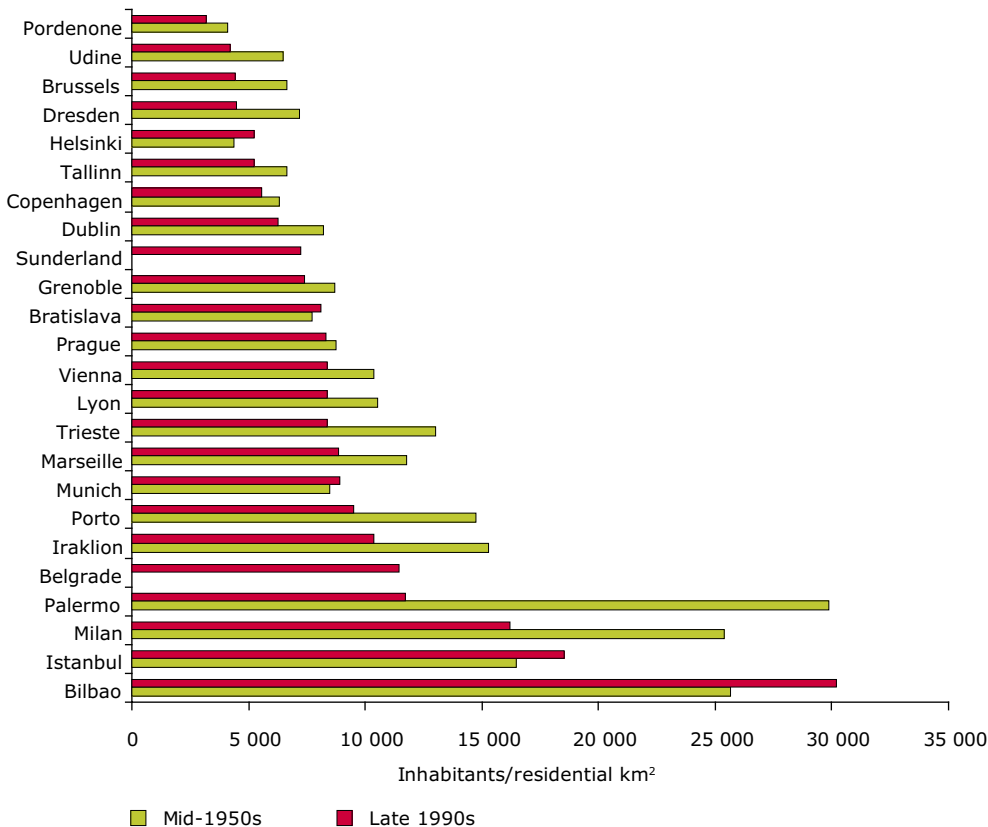
Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

Figure 4 Population growth and the growth of built-up areas (mid-1950s to late 1990s), selected European cities

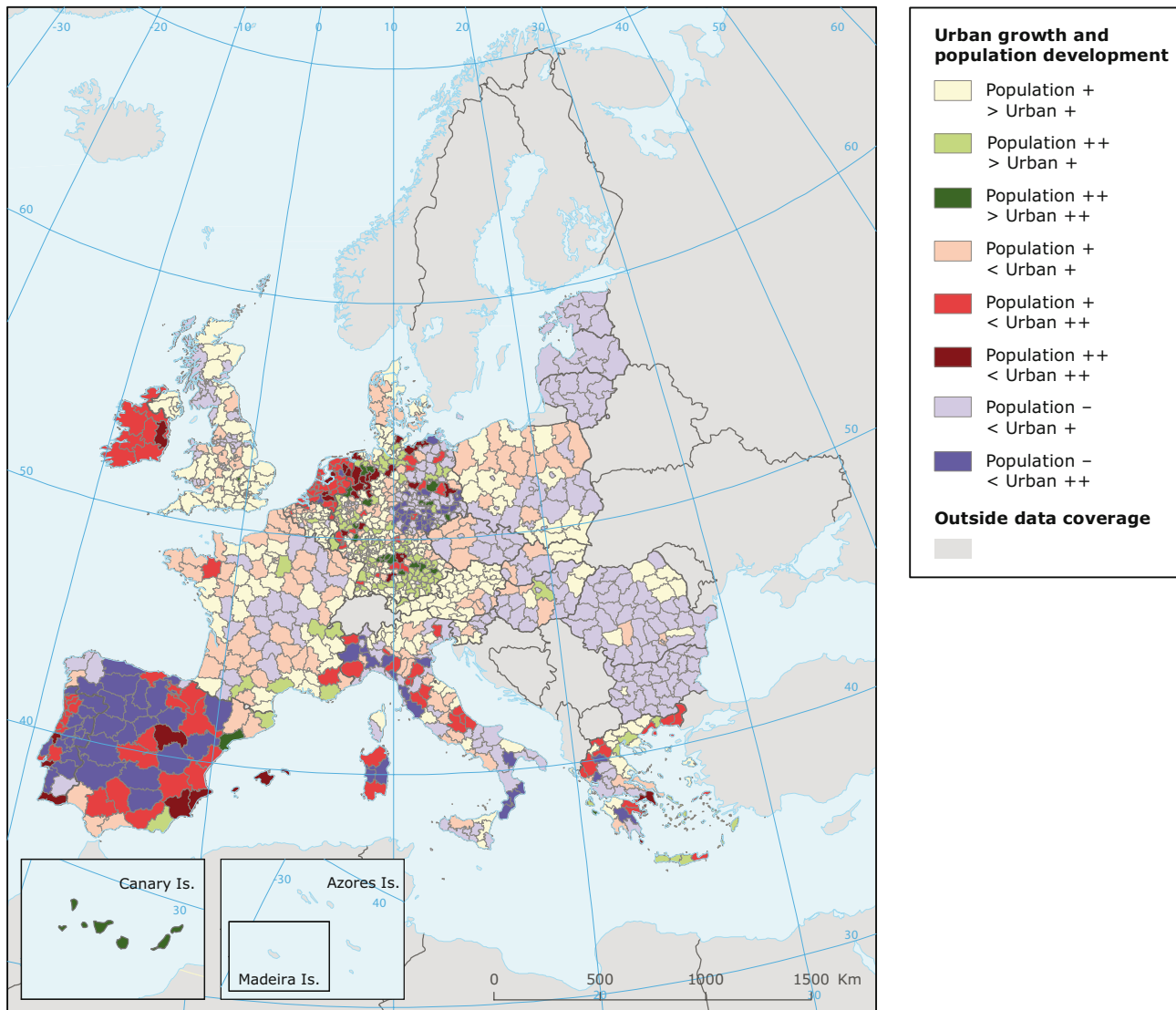


Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

Figure 5 Residential density in mid-1950s and late 1990s (measured by inhabitants/residential km²), selected European cities



Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

Map 5 Urban growth and population development in Europe (1990–2000)

Source: By courtesy of ESPON, 2006; GeoVille Information Systems (based on EEA and Eurostat data).

more rigorously applied the gap between northern and southern cities will rapidly narrow (Blue Plan, 2005; Munoz, 2003; Dura-Guimera, 2003). Bilbao lies in a class of its own in respect of density and compactness, much of which can be attributed to its location, adjacent to the sea and bordered on two sides by mountains. Nonetheless it is apparent that physical constraints cannot provide the entire explanation of its success, and credit should also be given to the active local planning regime and its well developed transport system.

Clusters of compact cities are also evident in the former socialist countries of central and eastern Europe. The compact urban form and high densities mainly reflect the strong centralised planning regimes and substantial reliance on public transport

that prevailed during the communist era (Ott, 2001; Nuisl and Rink, 2005). Today, these cities are facing the same threats of rapid urban sprawl as the southern European cities as the land market is liberated, housing preferences evolve, improving economic prospects create new pressures for low density urban expansion, and less restrictive planning controls prevail. Dresden is an exception amongst ex-socialist cities with a much less compact structure due to the unique circumstances of its wartime experience and subsequent reconstruction.

In northern Italy, small and medium sized cities are also special cases as the whole region has experienced very strong urban sprawl in the past decades and the process continues. The most sprawled cities in the study, Udine and Pordenone,

are relatively small cities in the Venezia-Friuli-Giulia region. In smaller cities, in general, densities are lower as the population pressure is lower and in many cases the planning regulations are more permissive allowing more low density building than in large cities.

In general cities in northern and western Europe have less of an urban tradition, and have been more strongly influenced by traditions in which the planning ideal has supported spacious, less compact, garden suburbs (Hall, 2002). This has resulted in much lower densities and more suburban development, particularly as individual housing preferences in north and west European cities have also favoured semi-detached and detached houses.

Along the coastal regions of Europe major population growth is accommodated by continuous sprawling development. During the period 1990–2000, urbanisation of the coast grew approximately 30 % faster than inland areas, with the highest rates of increase (20–35 %) in the coastal zones of Portugal, Ireland and Spain. Many

of the mountainous regions of Europe are also under threat from urban impacts, especially where transport routes provide good communications with adjacent lowland regional centres.

All the evidence presented in this section demonstrates that throughout Europe urban areas have expanded considerably more rapidly than the growth of population during the post-war decades. There is no apparent slowing down in these trends. Particularly at risk are the urban areas of the southern, eastern and central parts of Europe where the urban structure has historically been very compact but which in the past few decades have started to grow rapidly outwards.

For these reasons, it is apparent that new policies and tools are necessary to control and channel urban expansion so that urban areas can develop in a more sustainable manner. However, in order to define which sustainable urban planning strategies should be adopted, it is essential in the first place to fully understand the socio-economic drivers that provide the motors of sprawl. This is the focus of the next chapter.

3 The drivers of urban sprawl

3.1 Clusters of drivers

Sustainable urban planning strategies to combat urban sprawl can only be effectively specified when the forces driving urban sprawl are fully understood. Further general analysis shows that residential sprawl and the development of economic activities, in turn linked to the development of transport networks, are intrinsic causes of expanding cities. This is largely a consequence of increasing passenger and freight transport demand throughout Europe, as well as relatively high increases in the price of already urbanised land. The attractiveness of living in the centre of cities has fallen, while the quality of life associated with more 'rural areas' including city suburbs, being closer to nature, has increased. These factors present a planning challenge for small municipalities attempting to maintain their populations and attract small and medium-sized enterprises.

The extremely low price of agricultural land (in most cases good agricultural land) compared to already urbanised land (e.g. brownfield sites) or former industrial sites, is also an important factor underlying urban sprawl. In many development projects, the cost of agricultural land acquisition is relatively low. Thus, it enables greater profits to be made compared to those from already urban land or former industrial waste land, even in cases where no remediation is needed (non-polluted sites). This factor is particularly important in the economic heart of Europe stretching from the United Kingdom down through the Benelux countries, Germany and France (also known as the Pentagon zone). The trend of good agricultural land being deliberately and artificially maintained at a low value is reinforced by the broad use of expropriation tools. A direct side effect of these combined tools — low value, future use not taken into account, and expropriation — is clearly demonstrated by the development of villages near cities for residential or business purposes.

3.1.1 Macro-economic factors

Global economic growth is one of the most powerful drivers of urban sprawl. Globalisation

of the economy is today fundamentally interrelated with the development of information and communication technologies (ICT). Both phenomena are beginning to have profound impacts on the spatial distribution of population and employment. Overall, it is likely that ICT will drive urban development towards an even more sprawled future (Audriac, 2005).

Drivers of urban sprawl

Macro-economic factors

- Economic growth
- Globalisation
- European integration

Micro-economic factors

- Rising living standards
- Price of land
- Availability of cheap agricultural land
- Competition between municipalities

Demographic factors

- Population growth
- Increase in household formation

Housing preferences

- More space per person
- Housing preferences

Inner city problems

- Poor air quality
- Noise
- Small apartments
- Unsafe environments
- Social problems
- Lack of green open space
- Poor quality of schools

Transportation

- Private car ownership
- Availability of roads
- Low cost of fuel
- Poor public transport

Regulatory frameworks

- Weak land use planning
- Poor enforcement of existing plans
- Lack of horizontal and vertical coordination and collaboration

EU integration also has far-reaching impacts upon the economies of European cities. In this context, barriers to trade between Member States have been substantially removed and an important feature of this trend is the emergence of the 'super regions' which transcend national boundaries. Furthermore, integration tends to support the development of capital cities, and erode the competitive position of smaller cities and towns. All regions of the EU are intended to benefit from economic growth generated in the new integrated Europe; however, the reality is that new patterns of economic advantage and disadvantage are emerging, as EU action is only one factor amongst many influencing trends in local economies.

EU integration supports investment in longer-distance transport networks to facilitate improved accessibility and mobility. The proposed Trans-European Transport Networks (TEN-T) will greatly influence the future spatial development of urban areas across Europe especially in the EU-10 where natural areas are more prevalent than in the EU-15. In particular, the TEN transportation network is designed to solve some of the existing accessibility problems between EU-15 and the new Member States. However, given the powerful influence that new transport links have in generating development it is vital that current TEN plans fully address all possible impacts of the new infrastructure provision on urban sprawl and on the natural environment.

EU Structural and Cohesion Funds investments throughout Europe can either drive sprawl or support its containment. Investment in new motorways and other road connections readily attracts new development along the line of the improved transport links, frequently exacerbating urban sprawl, as will be seen later in the case study of Dresden-Prague. Alternatively, Structural Funds interventions can be channelled to the redevelopment of deteriorating inner cities making them more attractive for housing and other public and private investments, thereby assisting in the development of more compact cities.

Global competition is also driving efforts to secure economies of scale in the distribution and consumption of goods that have driven changes in the retail sector over the past decades. In the 1950s, most shops were small and located in the middle of residential areas, and the majority of the population did their shopping on foot. Today, major out-of-town shopping centres are the dominant form of retail provision, which together with the surrounding parking areas occupy vast areas of land only accessible by car.

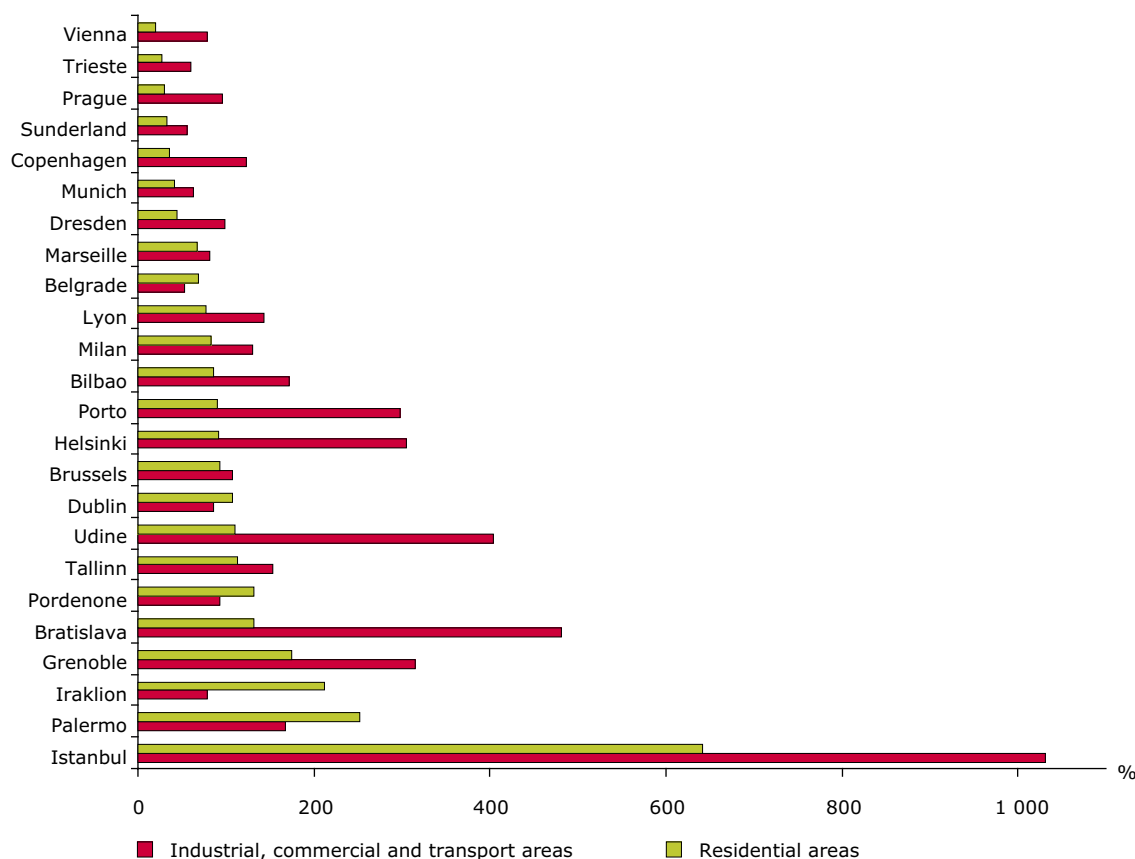
The inter-linkages between residential and industrial/commercial/transport areas in urban development are also critical to the promotion of sprawl. In some cases residential areas promote the development of associated commercial areas. More often new transport links and nodes, and commercial and industrial development facilitate the development of new residential areas in their vicinity. Whatever the relationship it is notable that in most cities industrial, commercial and transport areas are prime motors of sprawl that have outpaced the growth rates of residential areas with on average, growth rates of 100 % above those of residential areas.

The rapid development of transport networks over the past 45 years has impacted particularly strongly outside the historic city centres and these new networks today occupy significantly more space than previous networks. Furthermore, industrial, commercial and transport areas occupy between 25 % and 50 % of all built-up land, and on average one third of urban land is used for these purposes (Figure 6).

In distributional terms, analysis of these land uses shows that in the core of cities the growth of housing and commercial areas are of similar magnitudes, whereas in the immediate vicinity outside the core, the pressures for housing development are generally greater (Figure 7). For all land uses, new development predominantly takes the form of diffuse sprawl, and most new services, other than commercial, and recreation activities are developed outside the core of the city.

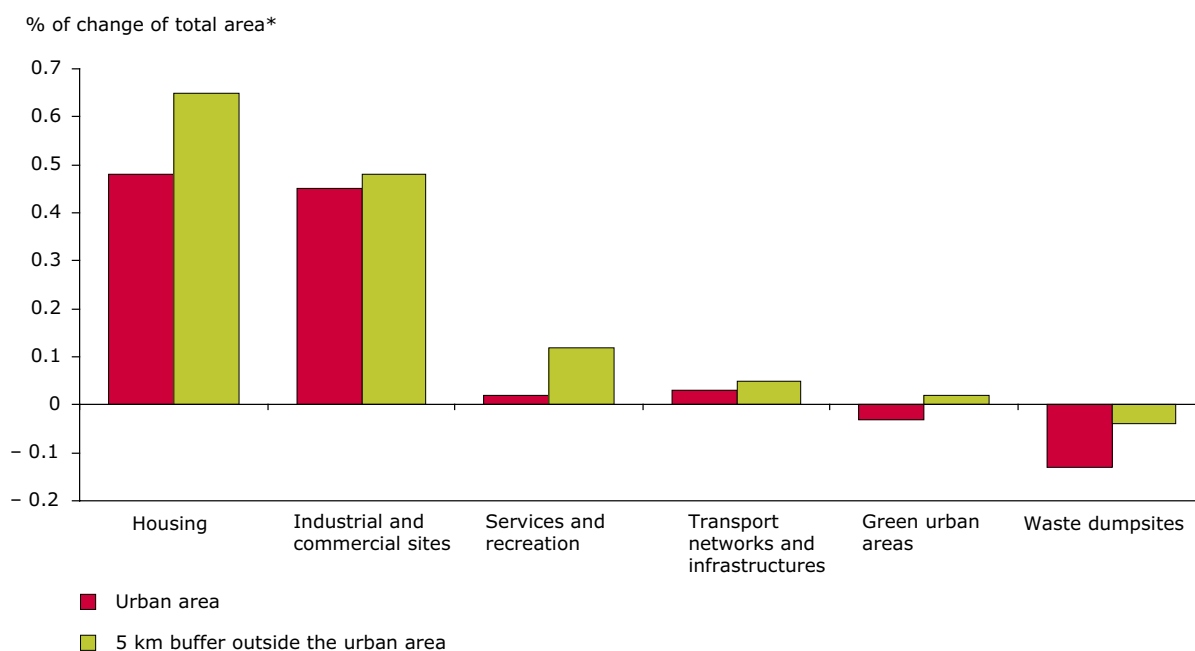
New transport investment, in particular motorway construction, can be a powerful stimulant for new development and sprawl, including shopping centres and residential areas. Land use and transport are inter-dependent in complex ways as development influences mobility patterns. New suburban development without adequate public transportation typically increases the demand for private car use. In contrast the construction of new light rail systems has a tendency to increase housing densities around access points (Handy, 2005). Households make choices between residential areas taking into account the price of housing and the price of commuting between the work place and home. When travel costs fall below a certain threshold and income reaches a certain level the rate of sprawl quickens, and unsurprisingly sprawl is more common in regions where incomes are high and commuting costs are low (Wu, 2006).

Figure 6 Growth rates of residential areas and industrial, commercial and transport areas from the mid-1950s to the end 1990s, selected European cities



Source: MOLAND (JRC) and Kasanko *et al.*, 2006

Figure 7 Functional changes for urban areas greater than 50 000 inhabitants (1990–2000)



Note: * EU-25 except Cyprus, Finland, Malta and Sweden, but with Bulgaria and Romania.

Source: EEA.

3.1.2 *Micro-economic factors*

From the perspective of land economics, high land prices in the core of the city force developers to seek lower prices in the more peripheral areas. The price of agricultural land is universally much lower than the price of land zoned for housing or the development of services. Agricultural land therefore becomes a highly attractive target for investors and developers. Although planning permission for non-agricultural development increases the value of agricultural land substantially, its price still remains at much lower levels than land in the core urban areas.

Municipalities and public development agencies have a crucial role in the process of conversion of agricultural or natural land to space for housing or commercial development. Throughout the EU, countries they have the responsibility for land use zoning. Competition among municipalities for new income generating jobs and services is great, and many municipalities can be tempted to relax controls on the development of agricultural land and even offer tax benefits to commercial and industrial enterprises to invest in the municipality. Competition of this nature between municipalities fuels urban sprawl.

3.1.3 *Social factors*

As the evidence presented in Chapter 2 indicates, population growth no longer determines the outward expansion of built-up areas.

Other demographic factors may however increasingly have impacts on urban sprawl. Families with small children are most likely to move to suburban areas and to rural areas outside the city. In contrast the elderly and single are least likely to move out of cities. As the trend towards an increasingly ageing population and smaller households continues, it may be anticipated that some slowing down of the movement from cities to suburbs will occur in the coming decades (Couch & Karecha, 2006).

More and more people in Europe regard a new house, ideally a semi-detached or detached house in the suburban/rural areas outside the city, as the prime investment to be made in their lifetimes. Many wealthier households also actively seek a good investment opportunity. Properties on the peripheries of cities are considered to be better investments because land prices are generally lower than in the core, and the value of property is expected to rise more rapidly outside the urban core (Couch & Karecha, 2006; Wu, 2006). Similar considerations

apply in respect of the purchase of second homes, which are not only seen as good investments but also provide additional opportunities for recreation outside the city. The persistence of the suburban ideal underpins the apparently ever increasing demand for houses in the sprawled suburbs and peripheral urban areas, and forms a vital stimulus to urban sprawl.

In contrast to the apparent attractions of the suburbs, the many negative aspects of the inner city cores, including poor environment, social problems and safety issues, create powerful drivers of urban sprawl. City cores are perceived by many as more polluted, noisy and unsafe than the suburbs. The built-up environment is also considered unattractive because of poor urban planning, with areas lacking green open space and sports facilities. Unemployment, poverty, single parent households, drug abuse and minorities with integration problems are also often identified with inner-city areas. These negative environmental factors drive many families with small children out of the city.

As families move out of the city, social segregation begins to intensify. Municipal tax revenues are lowered, and can become insufficient to maintain services such as schools and hospitals. The quality of schools plays a crucial role as parents try to secure the best education for their children. In the inner city a downward cycle of deprivation can readily become established as more and more of the population attempt to move out, reinforcing the problems of those that must remain (Burton, 2000; Couch and Karecha, 2006).

3.2 Pathways to urban sprawl

Deeper understanding of the relationships between the trends that drive urban sprawl, and the specific national, regional and local considerations that fashion the development of the cities and regions of Europe, is essential to redress the adverse effects of sprawl. The prime aim of the following case studies is to permit an assessment of the relative importance and impact of the various forces driving sprawl set against the range of contrasting development outcomes described.

The case studies consistently emphasise the commonality of the key drivers of urban development in terms of economic development, allied in some cases with population growth. Urban development is characterised in terms of a low density space extensive mix of residential, commercial, transport and associated land uses in the urban fringe. However, the case studies

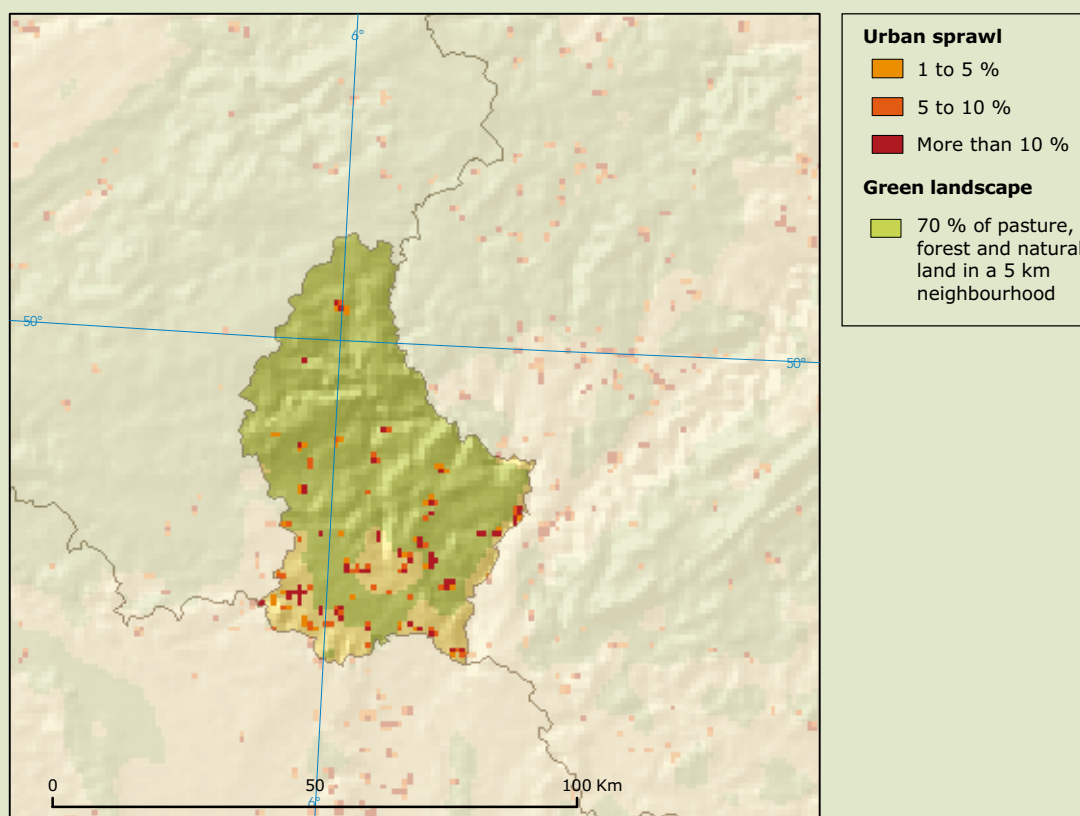
also clearly demonstrate city sprawls, the extent to which effective planning strategies control development and how they are applied influence the degree of urban sprawl. Where unplanned, decentralised development dominates, sprawl will occur. Conversely, where growth around the periphery of the city is coordinated by strong urban policy perspectives, more compact forms of urban development will be secured.

The next chapter reviews the multiple, severe and interconnected impacts of urban sprawl in order to fully understand the impacts of sprawl and why it is important for cities not to sprawl. The full range of impacts of sprawl are considered including impacts in respect of environmental resources, natural and protected areas, rural environments, the quality of urban life and health, as well as socio-economic impacts.

Box 2 Luxembourg: new urban traditions, high income and immigration

The expansion of urban areas is the most important land use change in Luxembourg. These changes are mainly concentrated around the existing urban centres of the city of Luxembourg and the old industrial southwest. In both cases the main contributor to this trend is the development of new service industries including financial and EU institutions. The pressure for new residential growth reflects efforts made to attract new inhabitants from the countries bordering Luxembourg and the influx of a growing working population with their families. It also reflects the high income levels in Luxembourg which makes it possible for most inhabitants to live in detached houses. Furthermore, short distances and a relatively small population make commuting a feasible option without excessive congestion.

Map Urban sprawl in Luxembourg driven by socio-economic changes (1990–2000)



Source: EEA.

Box 3 Dublin metropolitan area: rapidly growing economy and population

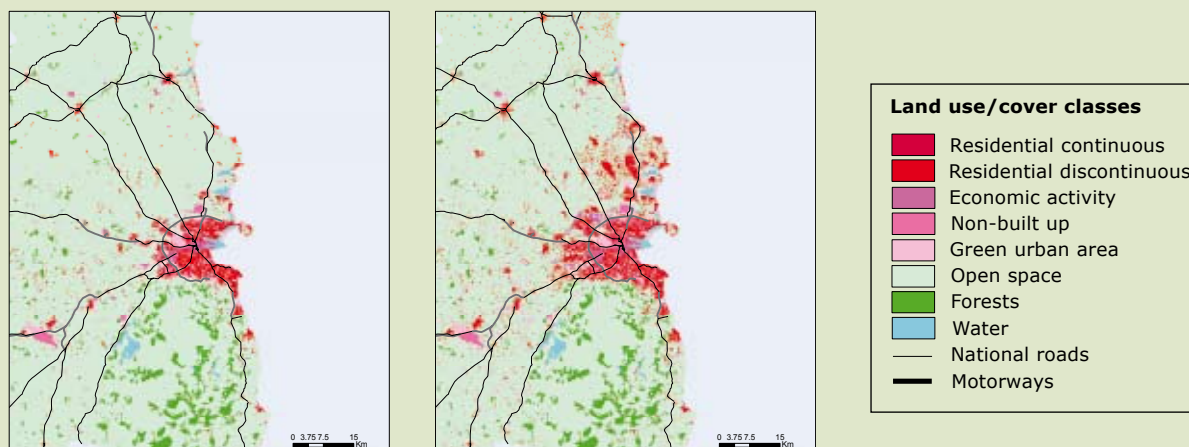
Dublin is a relatively small city by European and international standards. However, it dominates the urban pattern of Ireland in terms of demography, employment and enterprise (Bannon, 2000). The Greater Dublin metropolitan area population was 1 535 000 in 2002, 40 % of the total Irish population. The National Spatial Strategy (2002) suggests that by 2020 the Greater Dublin area population will be in the range of 1.9–2.2 million. The strong growth of the Greater Dublin is a result of the region's role both within Ireland and as a European capital city. Consequently, the Greater Dublin area will need to accommodate 403 000–480 000 additional inhabitants by the year 2020.

Population growth and economic development, as well as house type and price, are predicted to be the main drivers of land use change in the Greater Dublin area during the coming decades. High house prices in Dublin are a significant push factor driving the population towards the rural fringes of the city where it is cheaper to buy or build a house. Another push factor is the small size of apartments in the city centre, forcing families with children needing more space to move out of the city where houses prices are lower and housing more affordable. Personal housing preferences also play an important role as rural living is the Irish housing ideal (Michell, 2004). This preference is realised in single-family houses in open countryside with the benefits of the proximity to the capital or other urban areas. The realisation of this ideal is greatly facilitated by the planning regime which imposes few constraints on the conversion of agricultural areas to low-density housing areas.

Urban–rural migration in the Greater Dublin area has led to the growth of rural towns and villages at the expense of the City of Dublin. The growth of residential areas appears to follow the line of road and rail transport, suggesting a preference for rural living but with the benefits of proximity to urban areas including employment. Another push factor is the transport system in Dublin. Commuting times are long and the lack of orbital roads and rail networks means that to get from one side of the city to the other necessitates a journey through the centre. Often it is quicker to commute from outside Dublin to the centre rather than from one side to the other (Gkartziou and Scott, 2005).

The regional MOLAND model was applied to the Greater Dublin metropolitan region consisting of the following 9 counties: Dublin Co., Kildare, Laois, Longford, Lough, Meath, Offaly, West Meath and Wicklow. According to the 2025 scenario, the outward expansion of residential areas in the Greater Dublin area is estimated to increase by 110 % over the forecast period. In the same period commercial areas will more than double while industrial areas will grow slightly more modestly. The main development axis is to the north from the Greater Dublin area along the seashore as well as inland. To the south little new residential, or industrial or commercial development will take place because of the physical constraints of upland areas. The 2025 scenario also suggests the development of Dublin City to the northwest along the line of the Dublin-Belfast corridor. This development will encourage Dublin City to develop from a mono-centric to poly-centric relationship with the neighbouring cities of Dundalk, Newry and Drogheda. The Greater Dublin Metropolitan area needs land use guidance and zoning as well as new infrastructure if it is going to achieve a more sustainable form of development over the period to 2025.

Map Dublin 1990 and modelled scenario for 2025



Source: MOLAND (JRC).

Box 4 Portugal and Spain: threats to the coasts of Europe

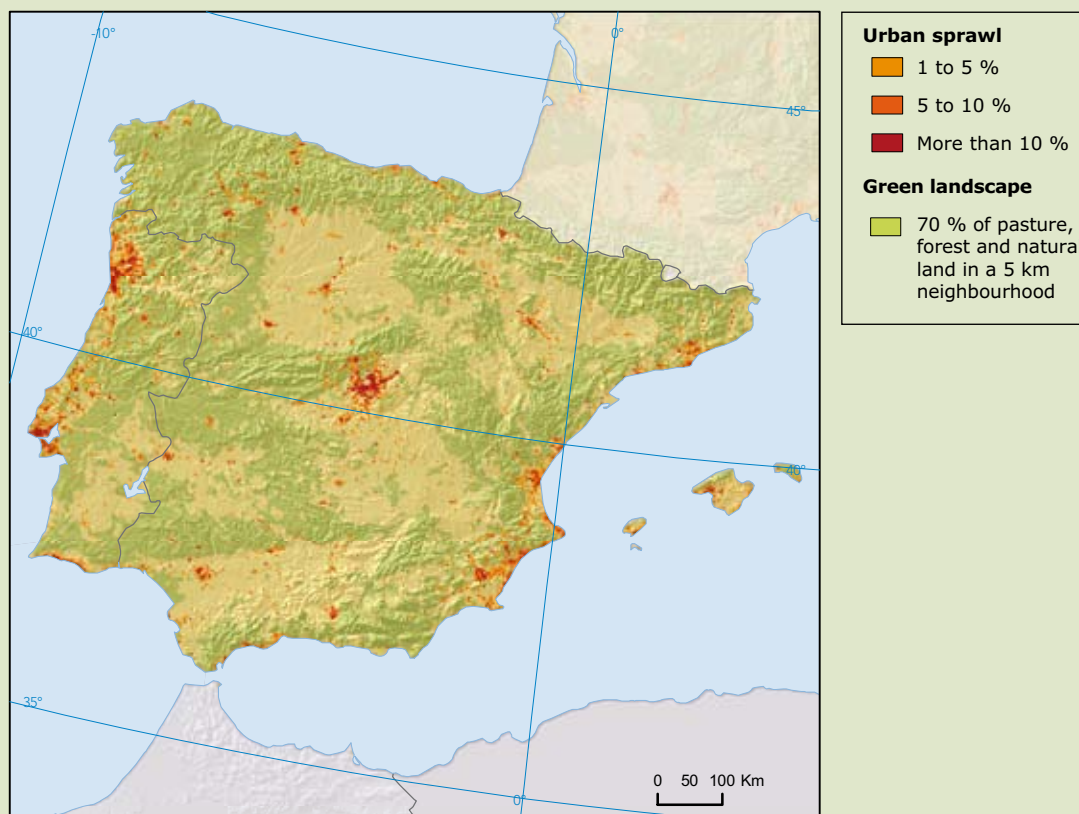
Coastal urbanisation and urban sprawl in coastal zones is no longer necessarily induced and supported by the main coastal cities. By its nature, urban land use along the coasts has become suburban. This new phenomenon, which challenges the state of the environment and sustainability of the coastal areas, is recognised by coastal managers across Europe (CPMR, 2005).

The predominant pattern of residential urbanisation is diffuse settlements adjacent to or disconnected from concentrated urban centres. Residential sprawl is on average responsible for more than 45 % of coastal zone land transformation into artificial surfaces. There is an increasing demand for investment in coastal residences due to tourism and leisure from northern Europe. In addition, there is also domestic demand from the inland population, e.g. the retired. In the past 10 years residential expansion has spread to the coasts of other regional seas, for example the Atlantic coast of Portugal.

Portugal has experienced some of the most rapid increases in urban development in the EU, focused around major cities and the coast. Portugal's urban development is concentrated around the two metropolitan areas of Lisbon and Porto, along the coastline from Lisbon/Setubal to Porto/Viana do Castelo, and more recently along the Algarve coast. In 2000, 50 % of continental Portugal's urban areas were located within 13 km of the coastline, an area which accounts for only 13 % of the total land area. Given the persistently high urban pressures along the coastline, these zones are subject to special development and legal measures.

In Spain, economic growth and tourism has resulted in an increased number of households and second homes particularly along the Mediterranean coast. Illustrative of this phenomenon are the Costa del Sol and Costa Brava which developed significantly during the 1950s and 1960s due to the demand for high quality holidays. This led to the combined development of accommodation, infrastructure and leisure facilities, such as golf courses and marinas. This development is still very intensive today.

Map Polarised urban sprawl around major cities and the coast of Portugal and Spain (1990–2000)



Source: EEA.

Box 5 Madrid region: rapidly growing economy and weak planning framework

The Madrid region is considered to be one of the EU hotspots in urban development in the EU (EEA, 2005). Urbanised land in Madrid grew by 50 % in the 1990s, compared with a national rate of 25 %, and an EU Figure of 5.4 % (Fernández-Galiano, 2006; EEA, 2005). The extraordinary urban development in Madrid region is the result of a number of drivers other than population growth, as the population of the Madrid Autonomous Community had a growth rate of only 5.16 % during the period. There is no single explanation for the intense growth of Madrid in the last few years, rather a number of inter-linked socio-economic factors have produced enormous pressures. The first factor is demand for first and second homes. 513 000 new houses were built in the region in the 1990s (López de Lucio, 2003) even though the population increase for the same period was only 240 000. This housing demand is supported by the current favourable economic situation in Spain combined with low mortgage interest rates across the Euro-zone. Other factors driving the decentralisation process include increased mobility based on a substantially improved transport network, including new toll motorways, three motorway rings around the city, and new and improved metropolitan and train connections. Today both Guadalajara and Toledo can be considered an integral part of the Madrid region due to improved accessibility in the Madrid region, Conversely, in the new low-density residential areas on the periphery of the city new mobility needs are being generated and transport improvements are a priority. The overall effect of the above is a tremendous increase in house prices. More and more people must go further out from the centre to find affordable housing, forcing an ever-growing number of people to commute by car. These socio-economic drivers have promoted an intense decentralisation process in the Madrid region involving both population and economic activity, with a number of territorial impacts, population and employment redistribution, very high rates of housing growth, and the appearance of new urban hubs served by large, decentralised shopping and entertainment malls (López de Lucio, 2003). Today Madrid is a sprawled region, a process that has occurred within the context of a weak spatial planning framework (Munoz, 2003; López de Lucio, 2003; Fernández-Galiano, 2006). The problem of planning is common to a large number of European urban regions, in which the regulatory capacity of municipalities cannot match the enormous forces reshaping the territory (Fernández-Galiano, 2006).

Future development paths: scenarios

Three land use scenarios identified for the region of Madrid describe alternative development paths that form the basis for decisions facing the city planners in delivering a more sustainable Madrid. The alternatives include urban regional development paths based on the idea of competitiveness and free market forces (business-as-usual and scattered scenarios), contrasting with a development path where competitiveness is sought in a more environmentally and socially sustainable way through integrated planning and engagement with stakeholders (compact development scenario). These scenarios are represented as follows:

Business-as-usual: This scenario represents a continuation of very rapid economic growth with low to moderate population growth. The scenario extrapolates the same characteristics and trends identified in the 10 year period 1990–2000.

Compact development: This is an environmental scenario, and is based on an assumption of a 40 % decrease in demand for urban land as compared with the 'business-as-usual' scenario. In this case a more compact development style prevails, representing a departure for current trends. It is probably the least realistic scenario of the three identified.

Scattered development: This is a market-led development scenario with greater environmental impacts than the 'business-as-usual' scenario. The scenario is based on more rapid population growth than the business-as-usual case, and assumes a 10 % increase in demand for urban land compared to the 'business-as-usual' scenario. Growth is mainly concentrated in a number of peripheral nodes and the city moves towards a sprawled development style.

The three scenarios show divergent patterns of land use for 2020. However, the business-as-usual scenario shares some common features with the scattered development scenario, as both create severe impacts in terms of additional land consumption and the generation of new commuter movements relying on the private car, as well as other environmental impacts. Overall, urban sprawl is profoundly modifying Madrid in an unsustainable way, and it is clear that the sustainable development of the Madrid region can only be attained by the compact development scenario provided spatial regulation measures are implemented in the short to medium term.

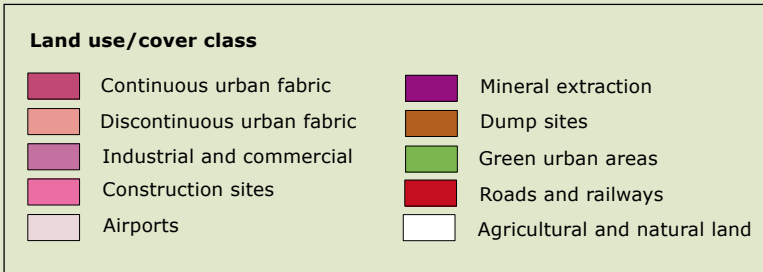
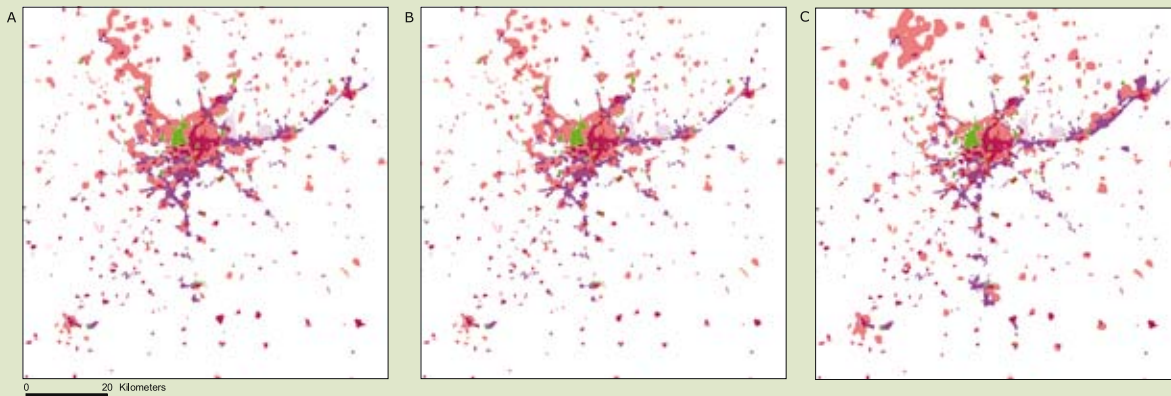
Box 5 (cont.)

Map Development scenarios for the Madrid region 2020

A: Business-as-usual

B: Compact development

C: Scattered development



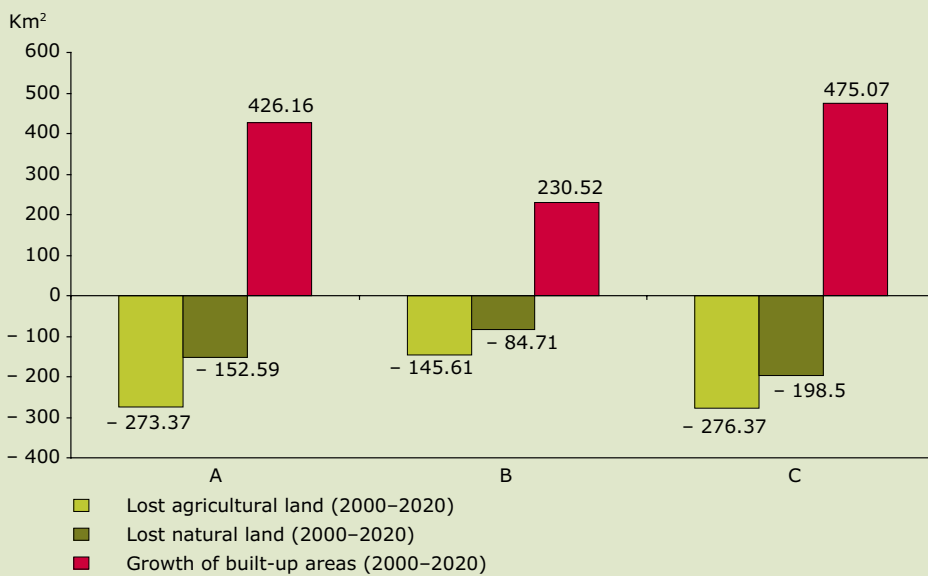
Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

Figure Land use changes for the Madrid region 2020

A: Business-as-usual

B: Compact development

C: Scattered development



Source: MOLAND (JRC).

Box 6 Istanbul: European megacity on two continents

Istanbul is a large city at the very edge of Europe, and has a long and turbulent history at the crossroads of European and Asian cultures. Istanbul has always been among the largest cities in the world. At the turn of the 21st century there were approximately 10 million people living in Istanbul, 15 % of the Turkish population. This figure is estimated to grow by 2.5 million people by 2015 based on high birth rates and continuing migration from the countryside. In the past 50 years the growth of Istanbul has been stunning. The built-up area has expanded by 600 % and the population has grown even more, from approximately 1 million to 10 million. Istanbul has always been and still is a very densely populated city. The fact that it is divided by the Straits of Bosphorus has created very specific land use development dynamics.

Rapid growth has created numerous problems, such as traffic congestion, pollution (both air and water), unemployment and other social problems, large areas of unregulated housing (50–70 % according to Blue Plan, 2005) and squatter settlements, infrastructure which is lagging behind both the expansion of the city and increasingly restrictive environmental standards (Çağdaş & Berköz, 1996; Erkip, 2000).

What will Istanbul physically look like in 2020? Population growth will remain a key driving force shaping the Istanbul of 2020. Growth of 25 % means 2.5 million new inhabitants, equivalent to the total population of Rome. It is also likely that with the modernisation of the economy and the changes brought by preparations for EU membership, the general standard of living will rise. The improved economic situation will lead to changing housing preferences, with increasing movement out of the city centre to the peripheral parts. (Ergun, 2004; Dökmeçi *et al.*, 1996). The new suburbs are typically more spacious, with dominance of larger detached and semi-detached houses, gardens etc. which particularly attract families (Dökmeçi & Berköz, 2000). Even the phenomenon of gated cities, which are inhabited by the richest strata and guarded 24 hours a day with full commercial and recreational services have spread to the environs of Istanbul. There are almost 300 gated cities in the immediate vicinity of Istanbul metropolitan municipality (Blue plan, 2005). As a consequence of these developments the population density has dropped. The future of the squatter settlements is an unknown factor, although it is likely that rising living standards (Türkoğlu, 1997) and pressures from the EU will push the authorities to provide proper housing and services to the squatter settlements. The provision of improved housing for these areas will require the accommodation of the same number of people in apartments with at least double or triple the land take.

Residential housing occupies only a part of urban space. Approximately one third is used for commerce, industries and transport purposes. These land use classes tend to grow at a much quicker pace than residential areas when the economy is expanding (Kasanko *et al.*, 2006). As Istanbul will remain the engine of the Turkish economy and will inevitably attract a lot of foreign investment after joining the EU, it is certain that commercial and service related areas will grow very rapidly (Çağdaş & Berköz, 1996) and that new business and office areas will be built to accommodate the growth. The globalisation of the economy and rapid technological development will also create pressures for increases in commercial land. Attempts to alleviate major problems of traffic and congestion will require further space for new transport infrastructure. The Marmaray project linking the European and Asian parts of Istanbul via an underwater railway tunnel and linked to 76 km of combined tube and railway along the coastline will have a drastic impact on future land use in Istanbul.

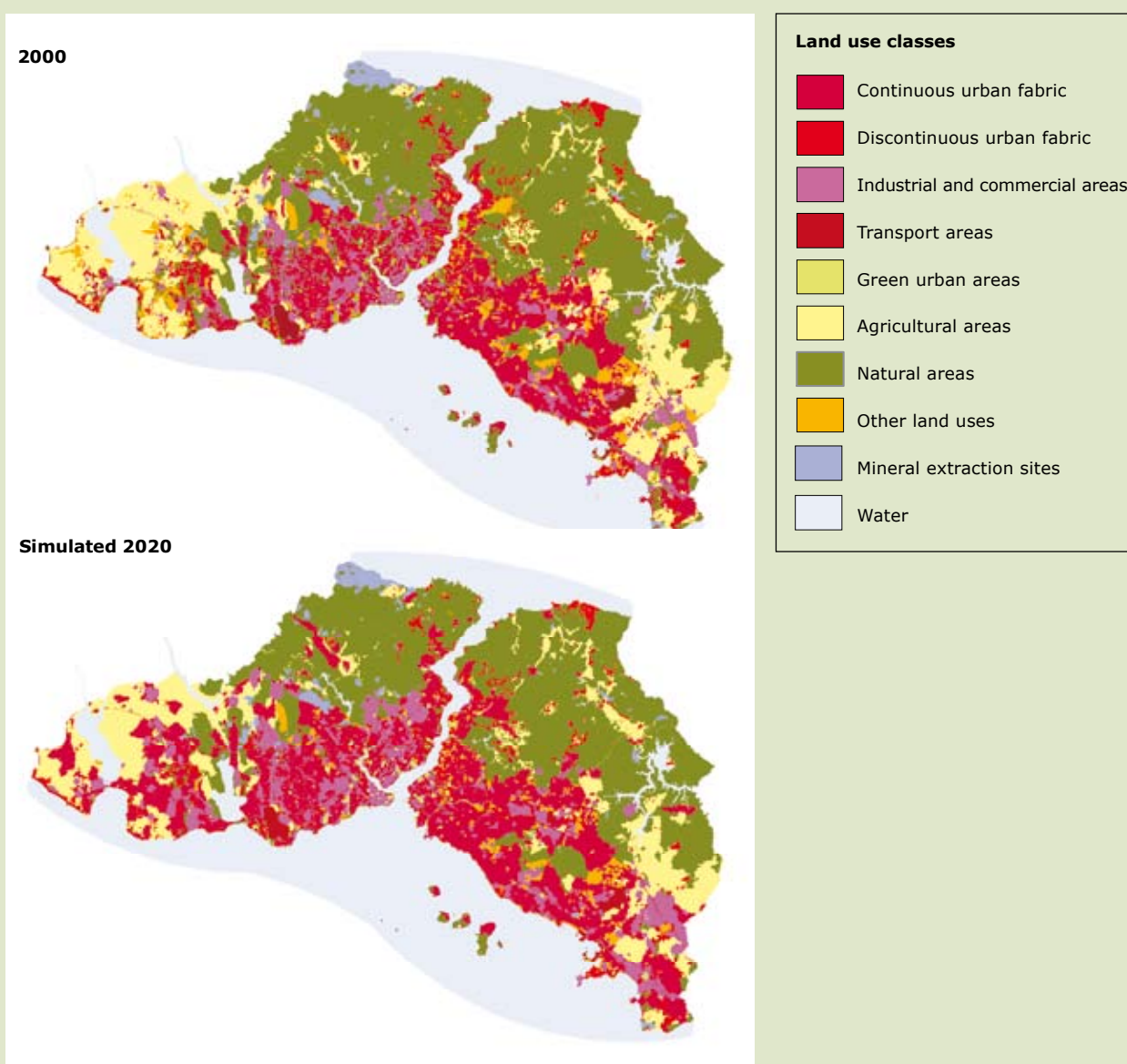
Future development paths: scenarios

The land use scenario for the year 2020 follows the main trends from 1988 to 2000 with slightly smaller growth expectations. The estimated population growth of 2.5 million inhabitants is comparable to the growth from 1988 to 2000. The simulation was made using the MOLAND model (Barredo *et al.*, 2003; Barredo *et al.*, 2004).

Three clear development tendencies are evident (see Map). First, the filling in of available land within previously built-up areas on both the European and Anatolian sides of Istanbul. Second, the growth along the coastline both westwards and eastwards. This is particularly noticeable on the western side of the European part of Istanbul where large new residential areas are built in the Bükükçekmece area between the two lakes near the coastline. The future Marmaray rail link on the Anatolian side will support the development of the areas close to the coast on the eastern part of the study area. Third, the conservation of the forest area north of Istanbul where there is relatively little new residential development occurring.

Box 6 (cont.)

From an environmental point of view the future developments presented in these simulations are acceptable. Making the urban structure denser and channelling growth along the major transport axes reduces environmental impact, and retains large parts of the natural and agricultural areas in the vicinity of Istanbul. However, it should be emphasised that there are many drivers including housing preferences and land price, which are exerting pressure for less dense future development. Achieving more compact urban development and controlled growth necessitates political agreement on planning and zoning objectives and means of implementing them as well as the control of unauthorised developments.

Map Istanbul 2000 and 2020

Source: MOLAND (JRC) and Kasanko *et al.*, 2006.

4 The impacts of urban sprawl

'Four out of five European citizens live in urban areas and their quality of life is directly influenced by the state of the urban environment' (European Commission, 2006).

Urban development has impacts far beyond the land consumed directly by construction and infrastructure and its immediate surroundings. Economic development and the marginalisation of land by consequent urban development generates the need for new transport infrastructures to link them together, which in turn produces more congestion, and additional costs to society (SACTRA, 1995).

These developments, supported in part by EU budget transfers, have given a powerful economic boost to many disadvantaged regions or regions undergoing restructuring throughout Europe. Some of the most visible impacts, evident in urban sprawl, are apparent in countries or regions with rapid economic growth (Ireland, Portugal, eastern Germany, the Madrid region), regions that have also benefited most from EU regional policies.

New Member States, where little urban sprawl has been detected, may follow the same path of urban development in the coming decades. The environmental impacts will be greater as these areas still possess large amounts of natural landscape. In particular, transport needs are set to grow rapidly in the context of the enlarged EU and the new EU neighbourhood policy. Preliminary analysis indicates that these developments will impact directly on valuable areas of natural landscape.

Experience shows, moreover, that many environmental problems generated by the expansion of our cities create economic and social implications for the city. Urban sprawl and the demise of local shopping and social infrastructures affect many cities with negative effects on the urban economy, as mentioned earlier. Furthermore, environmentally degraded urban areas are less likely to attract new enterprise and services, posing a significant impediment to further local investment. This in turn causes reallocation and the further exacerbation of urban sprawl. Environmental degradation also

tends to reduce house prices in the urban core leading to concentrations of socially underprivileged groups, aggravating social exclusion (Austrian EU Presidency, 2006).

The drivers of sprawl and their impacts are fully interconnected and essential to the concept of sustainable development and the associated ecosystems view of the functioning of the city and its surrounding areas. Both concepts inform the analysis of the impacts of urban sprawl in this chapter of the report. The interconnectedness of impacts poses some of the greatest challenges for the design of effective policy solutions to combat the problems of sprawl. However, active urban renewal and redevelopment policies in many urban areas are successfully reversing the deconcentration of urban centres and the decay of central city districts (Working group, 2004).

4.1 Environmental impacts

4.1.1 Natural resources and energy

Urban development involves the substantial consumption of numerous natural resources. The consumption of land and soil are of particular concern as they are mostly non-renewable resources. In contrast to changes in agricultural land use, the development of farmland for new housing or roads tends to be permanent and reversible only at very high costs.

Over the past 20 years, as described in Chapter 2, low density suburban development in the periphery of Europe's cities has become the norm, and the expansion of urban areas in many eastern and western European countries has increased by over three times the growth of population (see Chapter 2, Figures 3 and 4). The problem of the rapid consumption of scarce land resources is graphically illustrated in the widespread sprawl of cities well beyond their boundaries (Figure 8).

Urban sprawl has also produced increased demands for raw materials typically produced in

remote locations and requiring transportation. The consumption of concrete in Spain, for example, has increased by 120 % since 1996, reaching a level of 51.5 million tons in 2005. This increased demand reflects major expansion of construction activity in Spain, mainly along the coast and around major cities, where urban sprawl has become endemic. Associated environmental conflicts include the expansion of quarries adjacent to nature reserves and the over-extraction of gravel from river beds.

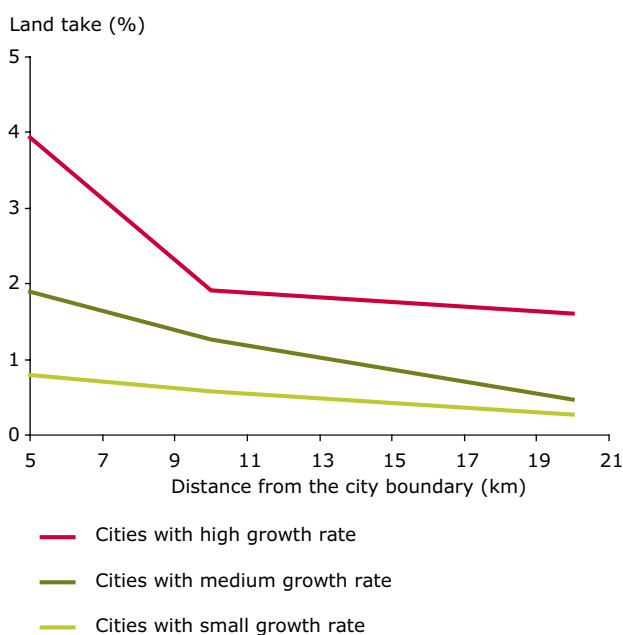
Urban sprawl and the development of urban land also dramatically transform the properties of soil, reducing its capacity to perform its essential functions. These impacts are evident in the extent of compaction of soil leading to impairment of soil functions; loss of water permeability (soil sealing) which dramatically decreases; loss of soil biodiversity, and reductions of the capacity for the soil to act as a carbon sink. In Germany, for example, it is estimated that 52 % of the soil in built-up areas is sealed (or the equivalent of 15 m² per second over a decade). Regions such as Mediterranean coastal areas have experienced 10 % increase in soil sealing during the 1990s. In addition, rainwater which falls on sealed areas is heavily polluted by tire abrasion, dust and high concentrations of heavy metals, which when washed into rivers degrade the hydrological system.

Land use change also alters water/land-surface characteristics which, in turn, modify surface and

groundwater interactions (discharge/recharge points), to the point that a majority of the small watersheds affected by urban sprawl show hydrological impairment. If the capacity of certain territories to maintain the ecological and human benefits from ground water diminishes, this could lead to conflicts due to competition for the resource. These conditions generally generate strong migratory flows of people looking for places offering a better quality of life (Delgado, J., 2004). Areas in the southern part of Europe, where desertification processes are at work, are particularly sensitive to such a situation. Reducing groundwater recharge might in addition negatively impact on the hydrological dynamics of wetlands that surround sprawled cities (Salama *et al.*, 1999).

Changes in lifestyle associated with urban sprawl contribute as well to increases in resource use. As mentioned in Chapter 3, people are living increasingly in individual households, which tend to be less efficient, requiring more resources per capita than larger households. For instance, a two-person household uses 300 litres of water per day, two single households use 210 litres each. A two-person household will use 20 % less energy than two single person households. The number of households grew by 11 % between 1990 and 2000, a trend that increases land use and acts as a driver for expansion of urban areas. The general trend is for greater consumption of resources per capita with an associated growth in environmental impact. This adds pressure to the fact that about 60 % of large European cities are already over-exploiting their groundwater resources and water availability.

Figure 8 Growth of built-up areas outside urban areas (1990–2000)



Source: EEA (CLC 2000, UMZ 2000).

A further consequence of the increasing consumption of land and reductions in population densities as cities sprawl is the growing consumption of energy. Generally, compact urban developments with higher population densities are more energy efficient. Evidence from 17 cities around the world (Figure 9) shows a consistent link between population density and energy consumption, and in particular high energy consumption rates that are associated with lower population densities, characteristic of sprawling environments, dependent on lengthy distribution systems that undermine efficient energy use.

Transport related energy consumption in cities depends on a variety of factors including the nature of the rail and road networks, the extent of the development of mass transportation systems, and the modal split between public and private transport. Evidence shows (Table 2) that there

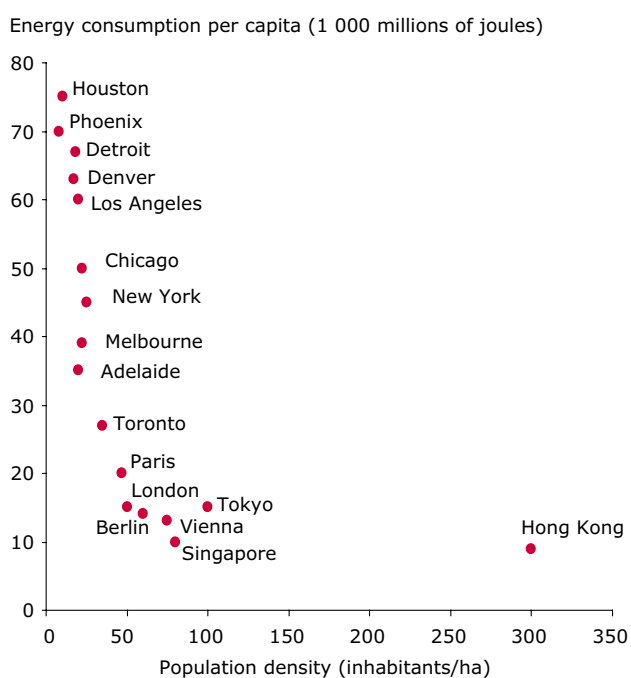
is a significant increase in travel related energy consumption in cities as densities fall. Essentially, the sprawling city is dominated by relatively energy inefficient car use, as the car is frequently the only practical alternative to more energy efficient, but typically inadequate, relatively and increasingly expensive public transportation systems.

Increased transport related energy consumption is in turn leading to an increase in the emission of CO₂ to the atmosphere. The relationship between population densities and CO₂ emissions (Figure 10) is apparent as emissions increase progressively with falling urban densities. Although there are several factors that may explain differentials in

CO₂ emissions between cities, including the level of industrial activity and local climatic conditions, the predominance of car borne transportation in sprawling cities is clearly a major factor in the growth of urban green house gas emissions. Urban sprawl therefore poses significant threats to the EU Kyoto commitments to reduce greenhouse gas emissions by 2020.

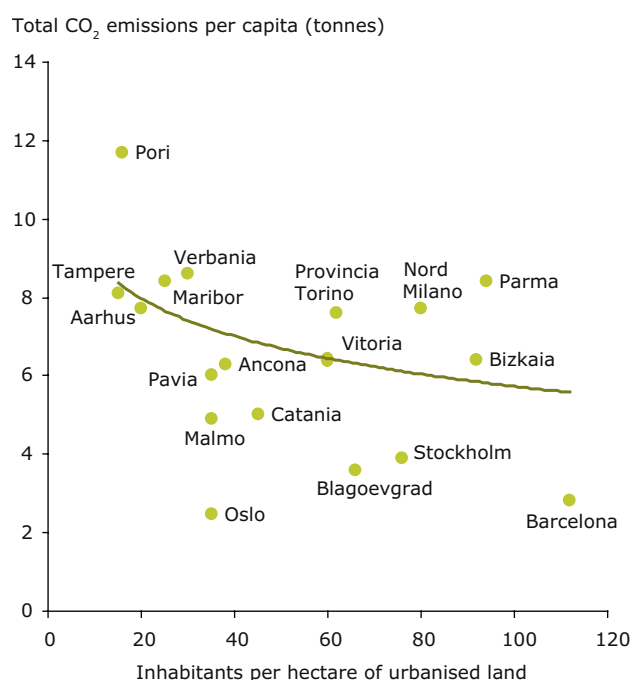
Sprawl also increases the length of trips required to collect municipal waste for processing at increasingly distant waste treatment plants and this is expected to continue as household waste grows 3–4 % annually. The material cycle is becoming geographically decoupled with increasing transport demands, impacting on transport related energy consumption and pollution emissions.

Figure 9 Population density and energy consumption, selected World cities



Source: Adopted from Newman, P. and Kenworthy, J., 1999.

Figure 10 Population density and CO₂ emissions, selected European cities



Source: Adopted from Ambiente Italia, 2003.

Table 2 Population density, energy consumption and cost of transport

Density (population + jobs per hectare)	Annual energy consumption for travel (mega joules per inhabitant)	Cost of transport (% of GDP)
< 25	55 000	12.4
25 to 50	20 200	11.1
50 to 100	13 700	8.6
> 100	12 200	5.7

Source: Adopted from Newman, P. and Kenworthy, J., 1999.

4.1.2 *Natural and protected areas*

The impacts of sprawl on natural areas are significant. Land sustains a number of ecosystems functions including the production of food, habitat for natural species, recreation, water retention and storage that are interconnected with adjacent land uses. The considerable impact of urban sprawl on natural and protected areas is exacerbated by the increased proximity and accessibility of urban activities to natural areas, imposing stress on ecosystems and species through noise and air pollution.

But even where the direct advance of urban land on natural and protected areas is minimised, the indirect fragmentation impacts of transport and other urban-related infrastructure developments create barrier effects that degrade the ecological functions of natural habitats. Immediate impacts such as the loss of agricultural and natural land or the fragmentation of forests, wetlands and other habitats are well known direct and irreversible impacts.

Urban land fragmentation, with the disruption of migration corridors for wildlife species, isolates these populations and can reduce natural habitats to such an extent that the minimum area required for the viability of species populations is no longer maintained. This process of degradation of ecological networks clearly threatens to undermine the important nature conservation efforts of initiatives such as Natura 2000 (see Box 7).

The environmental impacts of sprawl are evident in a number of ecologically sensitive areas located in coastal zones and mountain areas. Along the European coastal regions urban sprawl is endemic. Moreover, there is little prospect of relief over the next two decades, especially with a predicted increase in population of around 35 million people.

The development related impacts on coastal ecosystems, and their habitats and services, have produced major changes in these coastal zones. The Mediterranean coast, one of the world's 34 biodiversity hotspots, is particularly affected, and the increased demand for water for urban use, competes with irrigation water for agricultural land. This problem has been exacerbated by the increased development of golf courses in Spain, where the over-extraction of groundwater has led to salt water intrusion into the groundwater. Clearly all of this questions the sustainability of, in the long run, the economic development based on tourism that

largely fuels this population explosion and urban sprawl.

The mountain ranges of Europe are universally recognised as both the 'water tanks of Europe' and sensitive ecosystems. Currently, they are under severe threat from urban impacts. New transport infrastructures facilitate commuting to the many urban agglomerations with populations over 250 000 inhabitants that lie close to the mountain regions, encouraging urbanisation in the mountain zones. Increased transit and tourist traffic, particularly day tourism from the big cities, also adds to the exploitation of the mountain areas as a natural resource for 'urban consumption' by the lowland populations. More balance is needed in the urban-mountain relationship if the unique ecosystems of these regions are to be conserved.

4.1.3 *Rural environments*

The growth of European cities in recent years has primarily occurred on former agricultural land (Figure 11). Typically, urban development and agriculture are competing for the same land, as agricultural lands adjacent to existing urban areas are also ideal for urban expansion.

The motivations of farmers in this process are clear as they can secure substantial financial benefits for the sale of farmland for new housing or other urban developments. In Poland, for example, between 2004 and 2006 the price of agricultural land increased on average by 40 %. Around the main cities and new highway developments, increases in price are often much higher (Figure 12).

Soils need to be conserved. They are non-renewable resources and the loss of agricultural land has major impacts on biodiversity with the loss of valuable biotopes for many animals, and particularly birds. Sprawling cities also threaten to consume the best agricultural lands, displacing agricultural activity to both less productive areas (requiring higher inputs of water and fertilisers) and more remote upland locations (with increased risk of soil erosion). In addition, the quality of the agricultural land that is not urbanised but in the vicinity of sprawling cities has also been reduced (Figure 13).

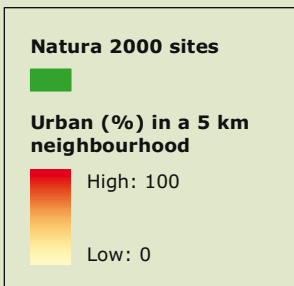
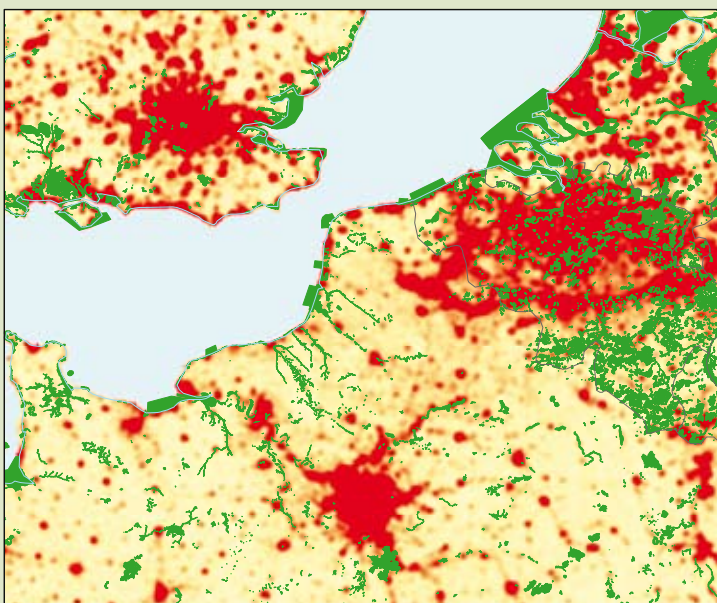
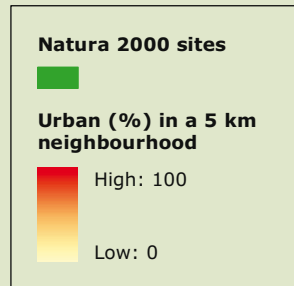
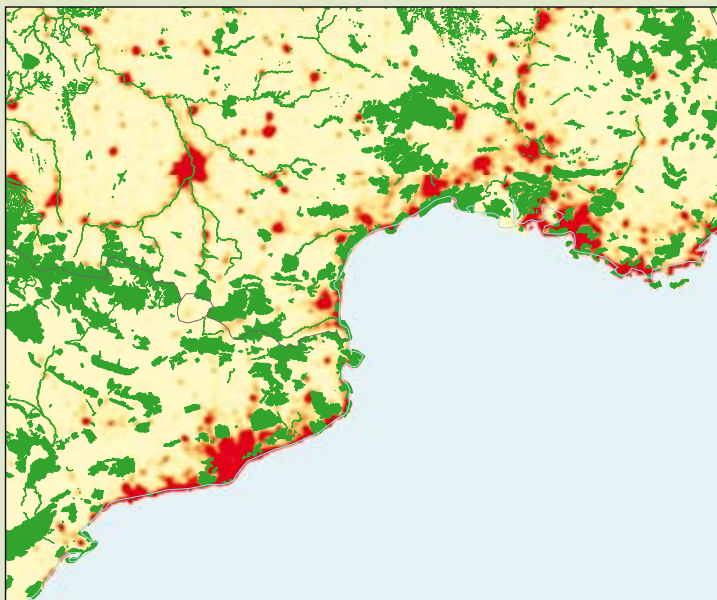
All these characteristic impacts of urban sprawl are well illustrated by the Mediterranean coast. Throughout the region 3 % of farmland was urbanised in the 1990s, and 60 % of this land was of good agriculture quality.

Box 7 Urban pressure on Natura 2000 sites

Pressures on natural areas are derived not only from new land use change but equally from the cumulative effects of land uses in the past. Impacts are generated not only from major urban areas but also from the combined impacts of several small sources that can have equally severe effects.

The map below shows the distribution of urban areas around Natura 2000 sites in the London metropolitan area, northern Belgium, the Netherlands and northern France. To the northeast of Paris, the urban fabric runs along the river Seine, adjacent to Natura 2000 sites. The strong interconnections between urban and natural areas are visible, with 10 % of forests in Belgium and 15 % in Netherlands within 5km of major cities with population in excess of 100,000. In the most extreme cases Natura 2000 sites are completely integrated within the urban areas, and so suffer major pressure from air pollution, noise and human disruption.

Map Urban pressure on Natura 2000 sites in the coastal areas of the English Channel and western Mediterranean



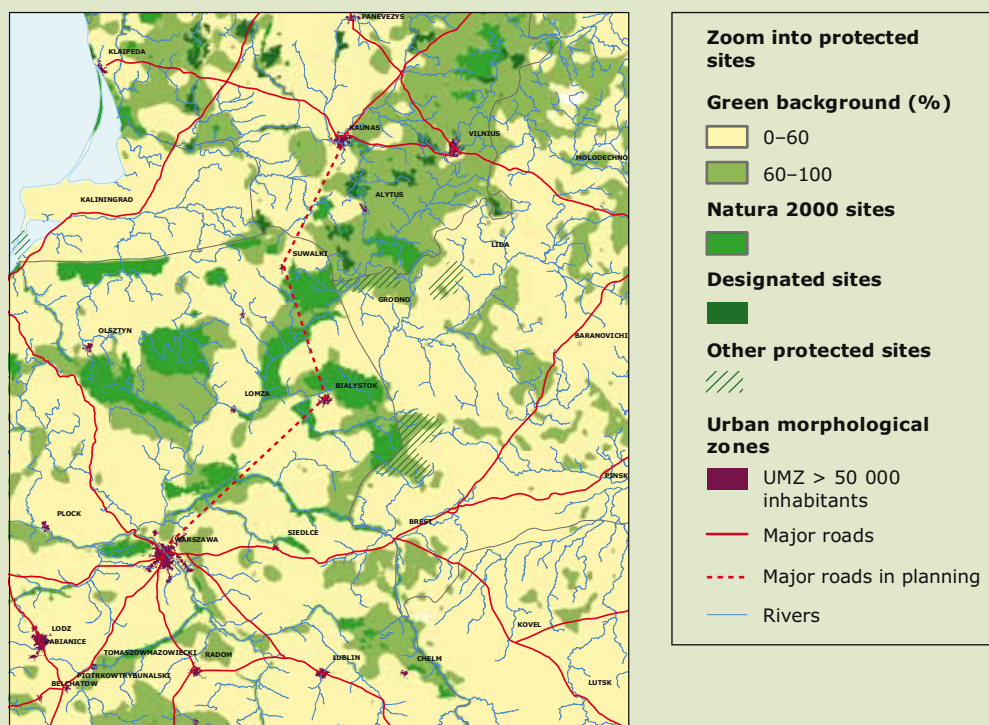
Source: EEA (based on Corine land cover 2000 and Natura 2000 data).

Box 7 (cont.)

Pressures on urban areas are also great on coastal zones, particularly in the western Mediterranean. The map below shows a clear contrast between the expansion of urban areas on the coast and inland. In the case of Barcelona geographic constraints are driving sprawl to the coast, and as a consequence Natura 2000 sites on the coast are becoming more isolated. Elsewhere new urban development is encroaching on inland protected areas. In some localities urbanisation is occurring within Natura 2000 sites.

Impact of transport infrastructure on protected sites: Via Baltica road development, southern part in Lithuania and North-Eastern Poland

Via Baltica is one of the routes planned within the TEN networks to connect the Baltic states and Finland with the rest of the EU. The route commences in Helsinki passing through the Baltic states to Warsaw and beyond. Via Baltica crosses the most important environmental zone in Poland. Unique in Europe, it consists of four very important natural forest and marshland sites (see map sites of environmental interest at regional, national, and European level). The marshes of Biebrza are the only natural wetlands remaining in the whole of Europe, and their protection is a key environmental priority for Poland.

Map Transboundary Environmental Protection Zone: Lithuanian-Polish border

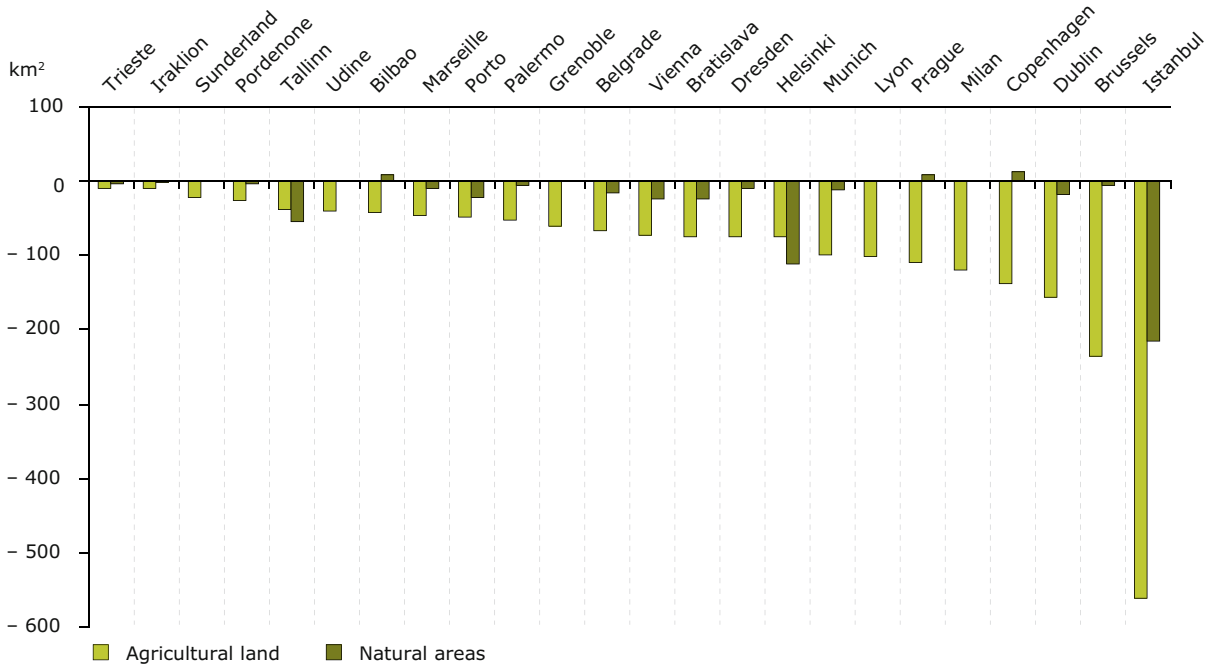
Note: The line indicating major roads in planning is an estimate only.

Source: EEA (based on multiple source data).

The EU funds have now provided financial aid for the Polish government to commit to the construction of this part of the TEN networks, and despite major protests from ecological groups, as well as questions raised at the EU level, most of the plans for the Via Baltica have been accepted.

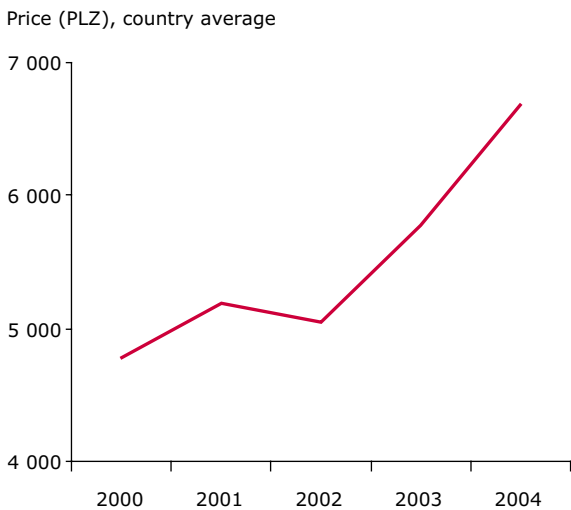
The proposal is to build a dual carriageway that connects the border zone with the main cities of the region as an extension to the existing national road. The proposal routes part of the road close to the borders of the Biebrza National Park, and part of the route is directed through one of the Natura 2000 sites. To minimise environmental damage the route will be limited to a dual carriageway, instead of a motorway, and elsewhere the route will be tunneled or constructed on raised embankments. Clearly, there are many questions raised regarding the environmental impacts of this section of Via Baltica on the Transboundary Environmental Protection Zone.

Figure 11 Sprawl impacts on agricultural land and natural areas, selected European cities



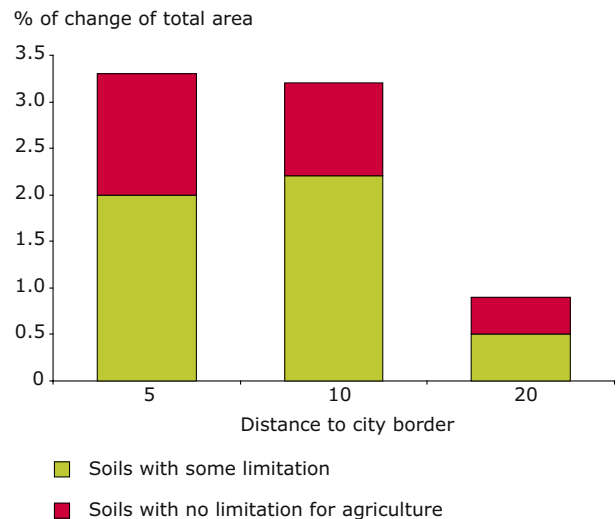
Source: MOLAND (JRC).

Figure 12 Trends in Polish agricultural prices 2000–2004 (Polish Zloty)



Source: Polish Central Statistical Office.

Figure 13 Loss of agricultural land outside urban areas



Source: EEA (CLC 2000, UMZ 2000).

4.1.4 Urban quality of life, hazards and health

As noted earlier, urban sprawl produces many adverse environmental impacts that have direct impacts on the quality of life and human health in cities, such as poor air quality and high noise levels that often exceed the agreed human safety limits.

In the period 1996–2002 significant proportions of the urban population were exposed to air pollutant concentrations in excess of the EU limit values (25–50 % of the urban population for different pollutants). It is estimated that approximately 20 million Europeans suffer from respiratory problems linked to air pollution. In particular,

the societal cost of asthma has been estimated at 3 billion euro/year. Although current legislation restricts the emission of harmful substances, certain extreme events facilitated by climatic conditions, or even accidents, are of concern given the large number of people potentially exposed to these threats. Moreover, the impact of air pollution is becoming a global problem as a consequence of long-distance transportation of bio-accumulative substances.

The level of air pollution exposure in the densely developed centres of cities may often be at higher levels than the suburbs due to the greater concentrations and slower movement of traffic. However, the noise produced by all vehicles, and the rapid growth in transport, particularly air and road transport, is more ubiquitous and has resulted in well over 120 million people throughout the EU being exposed to noise levels affecting their well-being.

Sprawl related growth of urban transport and greenhouse gas emissions have major implications for global warming and climate change, with the expectation of increasingly severe weather events in the coming years and increased incidences of river and coastal flooding. The risks from the continued development of these areas in the context of a changing climate is evident in the recent major floods in Europe that have affected large urban populations. The floods in central Europe in August 2002 caused 112 casualties and over 400 000 people were evacuated from their homes. These expected transformations pose major challenges for urban planning that are clearly focussed on the growth of urban sprawl along the coastal fringes throughout Europe, as well as development of sprawling extensions across greenfield sites in the river valleys and lowlands of Europe.

The more general permanent flooding of the coastal regions of Europe due to rising sea levels and climate change is particularly worrying considering the concentration of urban populations along the coasts and the importance of these areas for tourism. The countries of Europe most vulnerable to coastal flooding include the Netherlands and Belgium, where more than 85 % of the coast is under 5 m elevation. Other countries at risk include Germany and Romania where 50 % of the coastline is below 5 m, Poland (30 %) and Denmark (22 %), as well as France, the United Kingdom and Estonia where lowlands cover 10–15 % of the country.

Overall, 9 % of all European coastal zones lie below 5 m elevation. Even with conservative estimates of

predictions for sea level rise, a substantial part of the population of Europe living in the coastal regions are highly vulnerable to sea level rise and flooding. It is clear that this is not a specific issue generated by urban sprawl, however, the management of these risks and planning for adaptation will be made more complicated if urban sprawl is not controlled.

Furthermore, the majority of coastal lowlands have ageing defense systems and considerable resources are needed to maintain and improve these systems in order to provide the capacity to withstand the predicted rise in sea levels. In addition and just as important is the fundamental need for new visions for urban and regional planning policy that respond to these challenges. These visions must recognise that continued sprawl in the coastal regions of Europe is fundamentally unsustainable.

Finally, a further emerging issue is worth reporting: urban areas and their hinterlands are becoming increasingly vulnerable to geo-problems controlled by geological processes. The total cost of these problems to society ranges from major hazards (such as volcanic eruptions, earthquakes, floods, land subsidence, landslides) to minor hazards (such as local swelling or shrinking of clays in foundations). Reworking and removal of the soil surface by construction can unbalance watersheds and landscapes, contributing to the loss of biological diversity, ecosystem integrity and productivity, as well as to land degradation and erosion.

4.2 Socio-economic impacts

From a social perspective urban sprawl generates greater segregation of residential development according to income, as mentioned in Chapter 3. Consequently, it can exacerbate urban social and economic divisions. The socio-economic character of suburban and peripheral areas is typified by middle and upper income families with children, who have the necessary mobility and lifestyle to enable them to function effectively in these localities. However, the suburban experience for other groups, including the young and old, who lack mobility and resources can be very different and can reduce social interaction. Furthermore, large segments of urban society are excluded from living in such areas.

Social polarisation associated with urban sprawl is in some cities so apparent that the concept of the 'divided' or 'dual' city has been applied to describe the divisions between the inner city core and the suburban outskirts. In the inner city, poor quality neighbourhoods often house a mix of unemployed

people, the elderly poor, single young people and minority ethnic groups, often suffering from the impacts of the selective nature of migration and employment loss.

These socio-economic problems are not, however, unique to city centres. In many cities similar social and economic problems have increasingly developed in the more peripheral areas where post war re-housing schemes are today home to some of the most disadvantaged urban groups and the location of the lowest quality environments.

From an economic perspective urban sprawl is at the very least a more costly form of urban development due to:

- increased household spending on commuting from home to work over longer and longer distances;
- the cost to business of the congestion in sprawled urban areas with inefficient transportation systems;
- the additional costs of the extension of urban infrastructures including utilities and related services, across the urban region.

Urban sprawl inhibits the development of public transport and solutions based on the development of mass transportation systems, and the provision of alternative choices in transportation that are essential to ensure the efficient working of urban environments. These conclusions are reinforced by experience from both Munich and Stockholm where the efficient control of urban sprawl and resulting increase in population densities fosters the use of public transport and reduces the growth of car use (Lyons, 2003; Cameron *et al.*, 2004).

Economic inefficiency is also associated with the market orientated planning regimes that frequently generate sprawling urban areas. Market orientated land use allocations driving urban expansion and the transformation of economic activity often result in the abandonment of former industrial areas. As a result, there are many derelict or underused former industrial zones throughout Europe. In Spain about 50 % of sites contaminated from past industrial activities are located in urban areas (1999), and in Austria it is estimated that abandoned industrial sites cover about 2 % of all urban areas (2004).

Generally, the efficiency savings of more compact city development as compared with market driven suburbanisation can be as high as 20–45 % in land resources, 15–25 % in the construction of local roads and 7–15 % savings in the provision of water and sewage facilities (Burchell *et al.*, 1992).

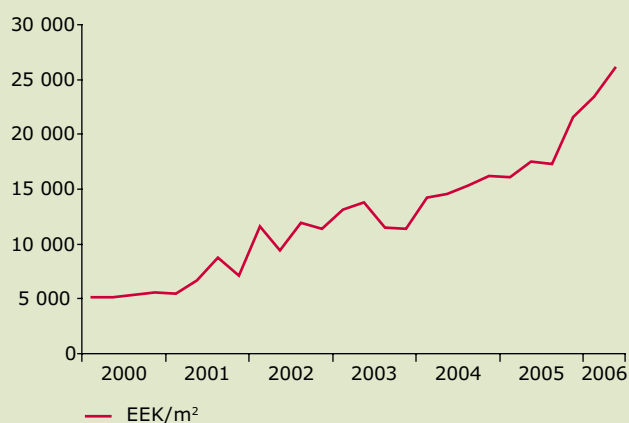
EU enlargement and the accession of new Member States have in some instances generated economic effects with associated impacts on the development of cities. In Tallinn, for example, over the past 2–3 years the price of apartments has risen considerably during a period of widespread increases in real estate and land market transactions (Box 8). Generally, increased land prices throughout western Europe, as a consequence of urban sprawl and speculation, is attracting investors to new markets in the new Member States. The input of external capital distorts internal markets, particularly in small countries like Estonia which has a small property market and a population of just 1.3 million.

The failure to control urban sprawl at the local level despite the policies and tools that are available supports the case for the development of new initiatives and new policy visions to address these policy failures. The EU has obligations to act to address the impacts of urban sprawl for a wide variety of policy reasons. These include its commitments under environmental treaties to ensure that these impacts do not seriously undermine EU commitments to the Kyoto Protocol on greenhouse gas emissions. Other legal bases for action originate from the fact that some problems of urban sprawl arise from European intervention in other policy domains. Overall, these obligations define a clear responsibility and mandate for the EU to take an active lead in the development of new initiatives to counter the environmental and socio-economic impacts of sprawl.

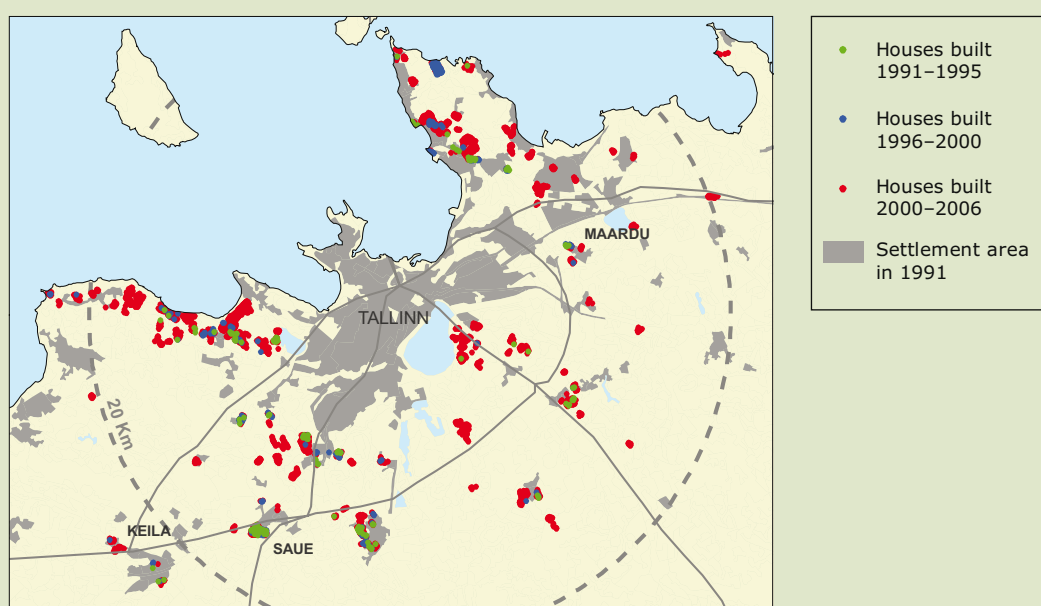
The following chapter examines the principles that should define the governance framework for action at EU level to combat urban sprawl. This includes policy definition according to the principles of sustainable development, policy coherence built around measures to secure policy integration via close coordination between different policies and initiatives, and better cooperation between different levels of administration.

Box 8 Effects of residential areas pricing on urban sprawl in Tallinn

An inventory of the new residential areas (minimum 5 houses or doors in limits of 200 m from each other) in the Tallinn metropolitan area was carried out during January 2006 (Ahas *et al.*, 2006; Tammaru *et al.*, 2006). The construction of the new residential areas has grown exponentially in 1991–2005. One third of all the households living in the suburbs of Tallinn live in the houses that were completed in 2005. The 171 settlements under study consist of 3 400 dwellings housing 5 600 families and 17 200 inhabitants. It becomes evident that 46 % of settlements consist of single-family houses, but only 20 % of the households live in them. New housing is concentrated very close to the capital city, in limits of 10–15 km from city centre. New settlement areas are spatially more scattered into the new small settlements, mainly on the previous farmlands. The majority of new residential areas are located not far from the existing social infrastructure, but they are poorly equipped with it themselves. The local populations living in the city are beginning to realise new opportunities to sell their inner city apartments at higher prices and purchase new housing outside the city. These houses are located in scattered developments approximately 10–15 km from the centre of Tallinn typically on former farmlands. The majority of these new residential areas are located adjacent to the existing social infrastructures but have nonetheless poor social provision.

Figure Tallinn average price of a two-room apartment (EEK/m²)

Source: Estonian Statistical Office, 2006.

Map New settlements in Tallinn metropolitan area, 2006

Source: Tammaru *et al.*, 2006.

5 Responses to urban sprawl

'Creating high quality urban areas requires close coordination between different policies and initiatives, and better cooperation between different levels of administration. Member States have a responsibility to help regional and local authorities to improve the environmental performance of the cities of their country' (Communication from the European Commission to the Council and the European Parliament on Thematic Strategy on the Urban Environment, 2006).

5.1 Initiatives to counter sprawl

This report presents the growing evidence that the drivers of many environmental problems affecting European urban land originate outside the urban territory where the changes are observed. The global market economy, trans-European traffic networks, large-scale demographic and socio-economic changes, cross-boundary pollution, as well as differences in land-planning mechanisms at national, regional and local levels, are the main drivers of change and environmental pressure on, and from, urban areas. As a result, there is now increasing awareness of the benefits of considering urban territory as an integrated unit for stimulating better coordination of policies and analysis of their economic, social and environmental impacts.

Managing cities is a complex and interrelated task which highlights the potential dangers of ad-hoc decision making: the solution to one problem, at one scale, is often the cause of another, at a similar or different scale. It is therefore of prime importance to recognise that while the city is the main focus of socio-economic activity, and the associated pressures and impacts on the environment, it cannot be managed in isolation from forces and decisions that originate well beyond the city borders.

The EU can take a lead role in developing the best frameworks for action at all levels and pave the way for local leaders to do more, as attempted through recent decisions (European Commission, 2005; 2006).

A key dimension of such frameworks is the division of responsibilities between the different levels of city and regional governance. Urban and regional managers at the local level have prime responsibility for the management of the city and its region. But the strategies and instruments to control urban sprawl strongly depend on the interconnectedness between local, regional and national conditions that are increasingly reshaped by the realities of Europe's spatial development. New planning responses to combat urban sprawl therefore would be built on principles that recognise what is locally driven and what should be EU driven.

A further dimension concerns the revision of the thrust of policy at the local level to counter sprawl, and the replacement of the dominant trends of urbanisation ('laissez-faire') with a new urbanism ('creative control') (Laconte P., 2006). At present, planning policy solutions at all levels of governance more typically reflect the logic of economic development rather than a sustainable vision of urban Europe.

New policy interventions to counter sprawl could be focused on the need to supplement the logic of the market and be based on demand-driven rather than supply-driven management. In this context, identifying the necessary spatial trade offs between economic, social and environmental objectives and the key requirements for the sustainable development of Europe's cities requires an improved regional contextualisation of the respective assets that should be maintained, restored or enhanced.

This is the role devolved to spatial development in policy making where the EU can support the envisioning of spatial planning of Europe's cities and regions to effectively address the issue of urban sprawl. This articulated vision of sustainable urban and regional development can provide the context for a range of integrated mutually reinforcing policy responses, offering a new policy coherence to be implemented at all levels. Particular focus can be given to the key EU policy frameworks which can make major contributions to policies to combat urban sprawl, namely transport and cohesion policy.

5.2 The European spatial development perspective

While EU territorial development is the subject of continuing debate, the links between territorial cohesion and economic and social cohesion, two fundamental aims of the European Union (Article 16 of the Treaty), require further clarification and analysis. Many benefits can be secured from a broader vision of cohesion that encompasses the many dimensions of the development of territories, urban areas in particular, and their interrelationships.

Europe has continued to debate the merits of a stronger and more balanced territorial focus for its policies since the Member States and the European Commission presented the European Spatial Development Perspective (ESDP) in 1999. This debate has produced commonly agreed policy orientations focused around better territorial balance and cohesion, improved regional competitiveness, access to markets and knowledge, as well as the prudent management of natural and cultural resources.

These policy orientations reflect the ongoing geographical concentration of many parts of European society in highly urbanised areas. The long-term aim is to see a European territory with many prospering regions and areas, geographically widespread, all playing an important economic role for Europe and providing good quality of life for their citizens. Polycentric spatial development is the main concept underpinning the aims of territorial cohesion. The concept can be described as a bridging mechanism between economic growth and balanced development. Accordingly, polycentric development can bridge the divergent interests of the Member States by encouraging more balanced and coordinated competitiveness. Interest in polycentric development is also fuelled by the hypotheses put forward in the ESDP that polycentric urban systems are more efficient, more sustainable and more equitable than either monocentric urban systems or dispersed small settlements. This process should be considered in conjunction with the perspectives of land prices mentioned earlier in this report. This is particularly pertinent for agricultural land prices in the context of the new intensification of agriculture, driven by the increase of world-market prices and the evident growing demand for biofuels.

One of the central tenets of the ESDP and its follow up studies, notably the Study Programme on European Spatial Planning (SPESP) is that 'many local problems cannot be solved nowadays

without an integrated way of looking at towns and countryside, since they tend to be regional problems'. In this context, a territorial dimension has been proposed for the conceptual basis of structural policies after 2007. The Commission has also proposed European territorial cooperation as an objective for Structural Funds interventions for 2007–2013 in support of territorial cohesion within the EU.

At the same time, although the Lisbon Strategy has no explicit territorial dimension, one of its three main priorities calls for Europe to be made an attractive area in which to invest and work. This priority includes considerations relating to access to markets and the provision of services of general interest, as well as to factors relating to the creation of a healthy environment for enterprise and the family. The implementation of the Lisbon Strategy and future structural policies will take place in cities, regions, in national territories and at European level (European Commission, 2005). Therefore, a key question for policy-makers at different levels is to explore, identify, understand and select potential areas for development within their own territory in order to contribute effectively to this overall European strategy.

5.3 Current barriers to addressing urban sprawl

Despite the complexity of urban systems, a piecemeal approach to urban management prevails in many cities; sprawl is seldom tackled as an integrated issue. In turn, issue integration is rarely matched by procedural integration through policy-making, problem analysis and impact assessment, planning, financing and implementation, precisely because of the wide scope of the issues involved. This constraint on effective urban management, already identified as far back as the 1980s (European Commission, 1990), still remains high on political agendas (European Commission, 2006).

In this context, there is a continuing perception of cities as isolated from their wider regional context. In reality, however, the functional influences of cities are recognised as reaching far beyond their immediate boundaries. There are also multidimensional links between urban and rural areas that are becoming more and more apparent. Typically, in Europe today, cities flow imperceptibly across municipal boundaries. This process is at different stages of development in different countries, but it occurs everywhere. At the same time, the responsibility for land use management

remains divided between different administrations and this fragmentation of management, frequently exacerbated by the political tensions of neighbouring administrations, may lead to incoherent and uncoordinated land use management.

There are many more dimensions to the management of urban sprawl. Societal behaviour, as mentioned in Chapter 3, is a major factor driving urban development as the desire for detached homes combines with the widespread use of cars. This reflects social values that place great emphasis on individual achievements rather than on group solidarity. Producers of consumer goods or services have made profitable use of this trend through detailed customer socio-cultural typologies and refined market segmentation (Laconte P., 2006).

Illustrative of this reality is the fact that, for the past 20 years, there have been four times more new cars than new babies, and vehicle-kilometres traveled in urban areas by road are predicted to rise by 40 % between 1995 and 2030. Levels of car ownership in the EU-10 are still not at the same levels as for EU-15, suggesting even further growth. If nothing is done, road congestion is expected to increase significantly by 2010 and the costs attributable to congestion will increase to approximately 1 % of Community GDP (EEA, 2006).

The issue of mobility, and accessibility, therefore remains a critical challenge for urban planning and management, as well as a key factor in European territorial cohesion. The challenge is to secure a global approach that takes into account the real impacts of investments directed at the creation and sustainability of local activities and jobs, based on a balanced and polycentric development of European urban areas.

These are challenges that must also be faced at regional, local and European levels, in the framework of the common transport policy and the Trans-European Transport Network (TEN-T). It is worth mentioning, in this respect, that in April 2004 the European Parliament and the Council identified 30 priority projects that represent an investment of EUR 225 billion by 2020, involving, for example, the construction of 12 000 km of highways. Will the history of urban sprawl in the EU-15 repeat itself in the EU-10?

EU regional policy perspectives will play a major role in developing new transport networks during the 2007–2013 period, in accordance with the priority objectives proposed by the Commission, including convergence, regional competitiveness

and employment, and territorial cooperation. Impact assessments of the effects on the expansion of city regions generated by these new transport investments will be critical for the attainment of all these priority objectives (Box 9).

That said, it is vital to recall that the very complex nature of urban systems remains the principal barrier for current administrative and political initiatives tackling the problems of urban sprawl. The fundamental challenge remains understanding, in both functional and operational terms, the unsustainable development patterns of our cities so that future unsustainable development can be corrected or avoided. This is still a challenge even for experts studying the most 'sustainable' forms of urban development.

In this context, the relationship between urban compactness and travel patterns (mobility) is central to the debate (Williams K. *et al.*, 2000). However, there are more dimensions, for example, to the simple causal relationship between high-density development and reductions in mobility demand. Current monitoring and analysis of such links could be improved greatly if employment catchment areas were used to define functional urban regions (Laconte P., 2006).

All things considered, the paradigm of the compact city as an immediate antidote to the sprawling city still cannot be fully substantiated. The effectiveness of compaction, as well as centralisation and concentration, have been thoroughly examined, including the various ways in which compaction can be achieved, such as intensification, new high-density development, traditional neighbourhood development etc. However, there are still uncertainties, particularly in the areas of ecological, social and economic impacts (Williams, K. *et al.*, 2000).

5.4 Policy coherence and effectiveness

To be effective policies should deliver what is needed on the basis of clear objectives, in terms of time and with an evaluation of future impacts. Effectiveness also depends on implementing policies in a proportionate manner, on taking decisions at the most appropriate level, and ensuring that decisions taken at regional and local levels are coherent with a broader set of principles for sustainable territorial development across the EU.

The EU has a responsibility and a specific capability to address the wide ranging and powerful pan-

European regional forces generating urban sprawl with impacts beyond the control of urban managers at the local level. For these reasons, policies at all levels need to have an urban dimension that tackles urban sprawl and helps to redress market failures that drive urban sprawl and undermine a sustainable vision for the spatial planning of urban Europe.

The EU white paper on European governance provides the following framework of principles underpinning good governance that assists in defining a framework for intervention to counter sprawl at all levels:

- Policy coherence: ensuring that policies are coherent and not sector-specific and that decisions taken at regional and local levels are coherent with a broader set of principles;
- Responsiveness to local conditions: flexibility in the means provided for implementing legislation and programmes with a strong territorial impact;
- Cooperation in policy development: development of systematic dialogue and increased cooperation with European and national associations of regional and local government.

5.4.1 Policy coherence

Policy coherence provides the first principle of good governance through which the EU can support initiatives to counter urban sprawl. Cities can benefit from initiatives and programmes spanning the entire realm of European Commission competence; the framework for trilateral agreements between the EU, national governments and regional/local authorities (COM(2002)709) provides a specific example, and some agreements have already been signed, e.g. Milan (Laconte P., 2006).

However, cities also need a long term sustainable policy vision to help synchronise the many critical success factors, including mobility, access to the natural environment, social and cultural opportunity, and employment, which all form the basis for sustainable urban development. At present, in many cases, the policy vision is poorly articulated permitting a market driven approach to dominate over the interests of sustainable development, a deficiency exacerbated by poor integration between the levels of governance. The EU can set the tone and direction for sectoral policy integration in cities whilst recognising that planning responses to the problem of sprawl must also be sensitive to the local and regional mix of priorities.

As it stands, EU Cohesion Policy (2007–2013) offers an effective framework to build a coordinated and integrated approach to the sustainable development of urban and rural areas. The approach is essential to ameliorate the impacts of urban sprawl and specific actions include:

- coordination of land use policies, as well as Structural and Cohesion Funds investments between urban areas, rural areas, the regions and the national levels to manage urban sprawl. Initiatives to make urban areas and city centres attractive places to live and support the containment of urban sprawl;
- encouragement to Member States to explicitly delegate to cities funds addressing urban issues within Structural Funds operational programmes, with full responsibility throughout the process for the design and implementation of the delegated portion of the programme;
- investments to achieve compliance with EU laws on air quality, waste-water treatment, waste management, water supply and environmental noise. Active management of congestion, transport demand and public transport networks, with a view to improving air quality, reducing noise and encouraging physical activity all of which can assist in addressing the sprawl of cities;
- co-financing of activities under the Structural Funds based on plans that address the key challenges posed by sprawl and the improvement of the overall environmental quality of urban areas.

5.4.2 Responsiveness to local conditions

Responsiveness to local conditions provides the second principle of good governance through which the EU can support initiatives to counter urban sprawl. The principle emphasises the need for flexibility in the means provided for implementing EU legislation and programmes with a strong territorial impact.

The EU Urban Thematic Strategy offers an umbrella framework to support actions and solutions developed at the local level to address urban management problems including urban sprawl. The strategy offers a coordinated and integrated approach to assist Member States and local and regional authorities to meet existing environmental obligations, to develop environmental management plans and sustainable urban transport plans, and so to reinforce the environment contribution to the sustainable development of urban areas.

Box 9 Dresden and Prague: economic growth and new transport links

German reunification and the collapse of the communist block led to changes in the economic regime from planned to market economy in both the former east Germany and the Czech Republic. Adaptation to the market economy caused many dramatic changes in traditional economic structures, such as a decrease in GDP and a high rate of unemployment, up to 25 % in Saxony. Towards the end of the 1990s, gradual but sustainable recovery of the economy commenced and political and social reforms took hold. These changes have created completely new driving forces for urban development. EU membership has also led to the growing engagement with European markets and access to EU development schemes e.g. TEN-T, ERDF, Cohesion Fund etc. For the new EU Member States (EU-10) gross domestic product is expected to triple and the number of households is projected to double between 2000 and 2030 (EEA, 2005). But in contrast to economic growth, the demographic trends for EU-10 show significant decreases of population, up to 7 % by 2030 (EEA, 2005). It is clear that all the above-mentioned changes will have a strong impact on land use patterns in the area.

Dresden–Prague: key driving forces for urban development

1950s to 1990s	1990s to present
Economy	
<ul style="list-style-type: none"> • Planning economy • Emphasis on heavy industry and mining 	<ul style="list-style-type: none"> • Market economy • Foreign (Czech Republic)/western German investments • Emphasis on modern high-tech industries, commerce and services • Construction boom
Population/urbanisation	
<ul style="list-style-type: none"> • Slowing population growth since the 1970s • Migration to the cities due to industrialisation 	<ul style="list-style-type: none"> • Decrease and ageing population • Migration of rural population into the cities compensates natural decrease of population in cities • Emigration to western Europe for better jobs (Saxony)
Housing and planning policy	
<ul style="list-style-type: none"> • Limited market for residential and land properties • Land price was not considered in the planning process, dominance of political decisions • Construction of vast areas of block houses for industry workers (especially the Czech Republic) 	<ul style="list-style-type: none"> • Open market for residential and land properties • Private sector interests competing with public interests in the planning process • Low land prices outside cities and people's preference to move to one-family houses
Infrastructure	
<ul style="list-style-type: none"> • Emphasis on public transport and rail 	<ul style="list-style-type: none"> • Growing importance of motorways

Future development paths: scenarios

Business-as-usual: Extrapolates moderate 1990s trends of land use change, indicating that the land use patterns of the area will not change considerably over the next two decades.

Built-up expansion: Elaborates the socio-economic projections of the European Environmental Agency.

Motorway impact: Evaluates the impact of motorway development (A17/D8 part of TEN Corridor IV).

Around Dresden new residential districts are situated adjacent to existing ones and lead to the merging together of former clusters. Construction of the new motorway around the city from west to south creates a new development axis for commercial and industrial areas. The simulation results for Prague show a very different, more clustered type of future development. The radial network of motorways connecting the city to different destinations attracts the development of commercial zones and produces more clustered patterns of growth. The municipalities located in the vicinity of Prague experience intensive residential development and hence it can be assumed that demand for new housing will remain strong.

Box 9 (cont.)

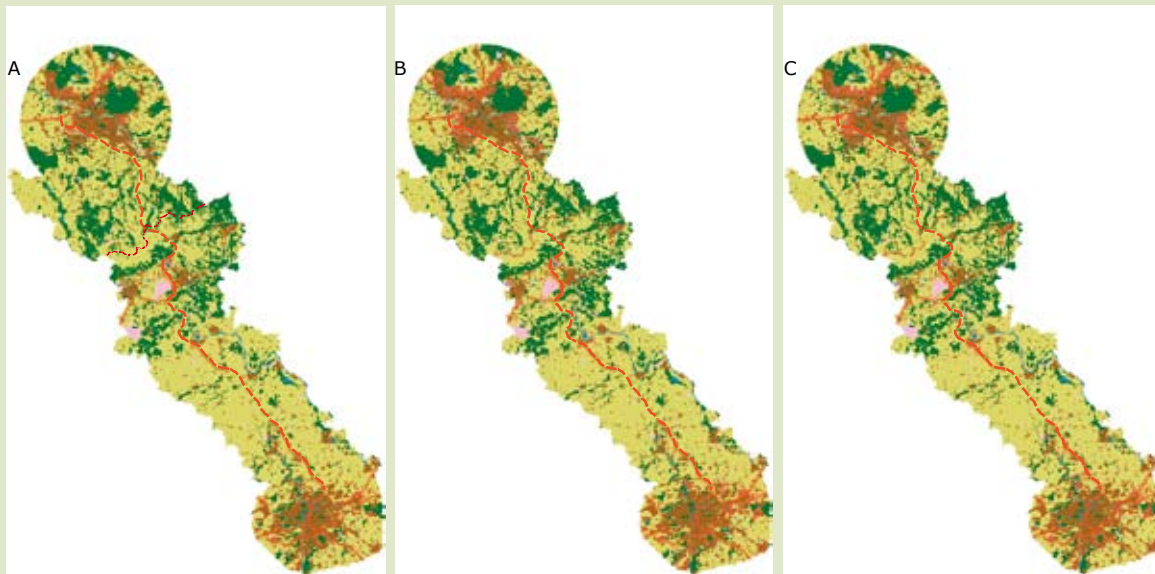
The motorway A17/D8 can reinforce regional development and lead to the establishment of commercial and service areas adjacent to larger settlements and towns. In most cases the future growth pressures of Dresden and Prague will focus on agricultural land and natural areas around both cities.

Map Dresden-Prague: scenarios of urban land use development – late 2000–2020

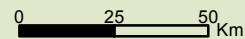
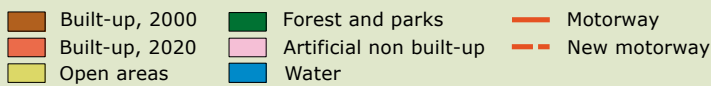
A: Business-as-usual

B: Built-up expansion

C: Motorway impact



Land use/cover classes



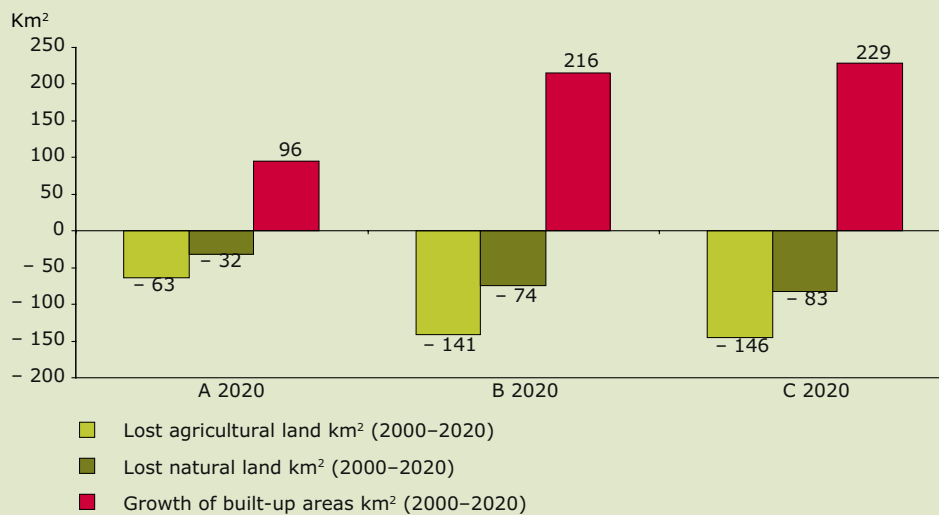
Source: Moland (JRC).

Figure Land use changes in the Dresden-Prague Corridor 2000–2020

A: Business-as-usual

B: Built-up expansion

C: Motorway impact



Source: Moland (JRC).

The Thematic Strategy provides a context in which good practice experiences of cities in combating urban sprawl can be applied and developed such as:

- the development of long term, consistent plans promoting sustainable development and the limitation of urban sprawl supported by monitoring and evaluation systems to verify results on the ground;
- policies for the the rehabilitation of derelict brownfield sites and renovation of public spaces to assist in the creation of more compact urban forms;
- policies for the avoidance of the use of greenfield sites and complementary urban containment policies;
- identification of the key partners including the private sector and community, as well as local, regional and national government and their mobilisation in the planning, implementation and evaluation of urban development;
- management of the urban-rural interface via cooperation and coordination between urban authorities and rural and regional authorities in promoting sustainable development.

5.4.3 Cooperation in policy development

Cooperation in policy development provides the third principle of good governance through which the EU can support initiatives to counter urban sprawl. At the EU level, the Commission can ensure that regional and local knowledge and conditions are fully taken into account when developing policy proposals. In particular the aim is to develop systematic dialogue and increased cooperation with European and national associations of regional and local government and other local partners including regional and city networks and other NGOs.

The essentials of this approach are based on the development of a reinforced culture of consultation and dialogue, a culture which is adopted by all European Institutions. In some policy sectors, where consultative practices are already well established, the Commission could develop more extensive partnership arrangements. The mobilisation of a broad range of partners with different skills has underpinned the 'Bristol Accord' in which local partnerships including public, private, voluntary and community interests are viewed as essential to deliver sustainable communities.

Such partnerships need to be developed and maintained over the long term based on flexible

cooperation between the different territorial levels. Regional and city networks and NGOs can in this manner make more effective contributions to EU policy development.

5.5 Local urban and regional management

The analysis of cities in this report confirms that the success of local planning policies and practices in restricting the physical expansion of built-up areas is critical to efforts to constrain urban sprawl.

The studies have identified planning policies and practices that have successfully restricted the sprawling expansion of built-up areas. Indeed, one fifth of the cities studied increased the density of residential areas from the mid-1950s. At the local level policies of urban containment are widely used in land use planning as a means of reducing urban sprawl and preserving farmland, including policies to limit greenfield and promote brownfield development based on more or less strict land use control.

Given the heterogeneity of the cities considered in this report, the array of policies and other means to limit and prevent urban sprawl is potentially extensive. Further examination of the policies and means to limit urban sprawl in these cities may therefore offer deeper insights into the nature of the effective local management of urban sprawl. The prime aim is to acquire a full understanding of the policies and practices behind the 'success stories' so that this know-how can be made available to all European cities in combating urban sprawl. The following analysis of Munich (Box 10) highlights some best practice experience that can provide catalysts for future integrated approaches to the management of urban sprawl throughout Europe.

The Munich area has remained exceptionally compact when compared to many other European cities. The roots of this success may be traced to the decisions by the city's planners in the post war period to rebuild the historical centre enclosed by a combined park and traffic ring. This was followed in the early 1960s by the replacement of traditional town planning with integrated urban development planning, providing guidelines for all municipal responsibilities including economy, social issues, education, culture as well as town planning.

By the 1990s comprehensive planning concepts were firmly established, based on an integrated

urban development plan and focused on the objective of keeping the Munich region compact, urban and green. Fundamental to the attainment of the plan's objectives are a mix of policy initiatives including the reuse of brownfield land, avoidance of expansion, mixed land use development integrating residential and commercial services, improvement of public transport as well as pedestrian and cycling facilities, and reinforcement of regional cooperation.

The Munich case study clearly emphasises the dominant role of local and regional policies in defining the spatial organisation of cities and regions. Munich has successfully adopted and implemented a compact city model in the planning of the city that has effectively contained urban sprawl based on the following key objectives and actions:

- integrated city development plan;
- regional cooperation;
- stakeholders' involvement in city planning;
- emphasis on reuse of vacant brownfields;
- continuously improving public transport with as few new roads as possible;
- compact-urban-green — keep the city compact and urban and green areas green;
- guarantee the necessary resources for implementing the strategies of all relevant policy areas (transport, housing etc.) for both 'business as usual' situations and through major renovation projects.

The lessons from Munich can also provide the good practice basis for sustainable development that many other cities throughout Europe urgently require.

As well as issues concerning the potential for transfer of good practice experience, it is also clear that conflict with policy objectives at national, regional and local levels can also undermine local efforts to combat urban sprawl. The role that EU can play in combating sprawl should therefore be set not only in the context of complementing what is locally driven, but also proactively engaging at all levels, given the evident potential for local policy failure.

5.6 By way of conclusion — combat against urban sprawl

Land use patterns across Europe show that tensions are arising almost everywhere between our need for resources and space and the capacity

of the land to support and absorb this need. Urban development is the main driver.

Throughout Europe in the 1990s, changes in land cover were mainly characterised by increases in urban and other artificial land development and forest area, at the expense of agricultural and natural areas. Anticipated growth of the urban population by 5 % in the coming decade, will further fuel these trends. Globalisation, transport networks, socio-demographic changes, societal aspirations for the 'urban culture' and uncoordinated land-planning mechanisms at various levels are the main sources of the environmental unsustainability of our cities.

Scientists, planners and policy-makers are becoming increasingly aware that adequate decisions on urban development cannot be made solely at the local level. This is especially important in a European context where more and more urban areas are becoming connected in order to realise common objectives, such as the Lisbon agenda for growth and competitiveness.

The history of human culture suggests that 'landscape' is one of the earliest and most obvious concepts for perceiving and describing our changing environment, be it artificial or not. It is at the landscape level that changes of land use, naturalness, culture and character become meaningful and recognisable for human interpretation. In that sense, landscape is as much vision as it is reality.

The way we perceive landscapes, the attraction we feel for some of them, and our feelings when conflicts arise over the use of land, are all matters of extreme importance for conservation and future human welfare. A landscape is essentially a photograph of what is going on; it reveals, in short, who we are. With urban sprawl-generated landscapes in continuous flux, we indeed reveal a lot about the footprints we will be leaving for the next generations.

The present report demonstrates, in this context, the potential for local policy to be isolated in overcoming the serious impacts of urban sprawl throughout Europe, a fact which highlights the requirement for urgent action by all responsible agencies and stakeholders. The EU governance white paper defines the preconditions for good governance emphasising the need to assess whether action is needed at the EU level and the principles for action when required.

Box 10 Munich – development of the compact city

Munich is the capital of the Bavarian state and the 3rd largest city in Germany. The MOLAND study area comprises the city of Munich (*Landhauptkapital*) and 44 surrounding municipalities (completely or partially). The total area is 791 km² and the resident population in 1990 was 1.69 million inhabitants. From 1955 to 1990 the population has grown by 49 %.

Munich – compact city

The Munich area has remained exceptionally compact if compared to many other European cities (see Chapter 2). It is the only urban area among the 24 urban areas studied where the built-up areas have grown at a clearly slower pace than the population. Another indicator of compactness is the share of continuous residential areas compared with all residential areas built after 1955. In all other Western European cities studied almost all residential areas, built after the 1950s, are discontinuous in character, but in Munich only one third is of this character and two thirds are densely built.

Bavarian planning solutions

Munich was heavily bombed and mostly destroyed in World War II and immediately after the war the city's planners faced a decision whether to completely rebuild or to reconstruct what was destroyed. The outcome, in what later proved to be an excellent decision, was a mix of both approaches. The historical centre was rebuilt largely following the pre-war pattern and style. To ease traffic problems and to increase green urban areas a combined park and traffic ring was constructed around the historical city.

By the early 1960s pressures to find new housing and transport solutions began to mount in Munich. The drivers for change were primarily the increased use of the private car, and strong inward migration from rural areas. At the same time at the Federal level in Germany, the new building law (*Bundesbaugesetz*) took effect. All these factors together influenced the far-sighted decision adopted by the Munich planners to move from traditional town planning to integrated urban development planning, providing guidelines for all municipal activities including economy, social issues, education, culture as well as town planning. The first integrated city-development plan of 1963 paved the way for Munich's modernisation.

In the late 1960s another innovative tool was also adopted as a response to citizens' opposition to the new development plans. The mayor organised an open discussion forum for urban development issues that became a permanent platform where the stakeholders and the city planners could exchange views and opinions. At the same time an independent department was created with the responsibility to coordinate all municipal planning activities, strengthen links with research and stakeholders involvement.

Regional cooperation was seen as the only way of safeguarding the balanced regional development of Munich and the mainly rural neighbouring municipalities. As early as 1950 the majority of the municipalities in the Munich region discussed common urban development issues in the form of a 'Planning Association of Munich's Economic Region' which became the Munich Regional Planning Association. However, this cooperation has remained on a voluntary and consultative basis and no planning authority has been transferred to the regional level, in contrast to other German city-regions.

The 1970s and 1980s were characterised by more incremental developments and the planning vision became less clear. Nonetheless, the steps taken in the earlier period maintained the high planning standards and resulted in a compact and high-quality urban environment. The main objectives of this era were as follows:

- city in equilibrium where various economic, social and environmental interests are in balance;
- development of areas inside the urban structure instead of urban expansion in the periphery supported by economic incentives, and made possible by large brownfields vacated by industry, the military, the Federal Railroads (DBB) and the old airport in Riem;
- strong emphasis on public transport and new road development limited to a minimum;
- preservation of large green recreational areas around the city.

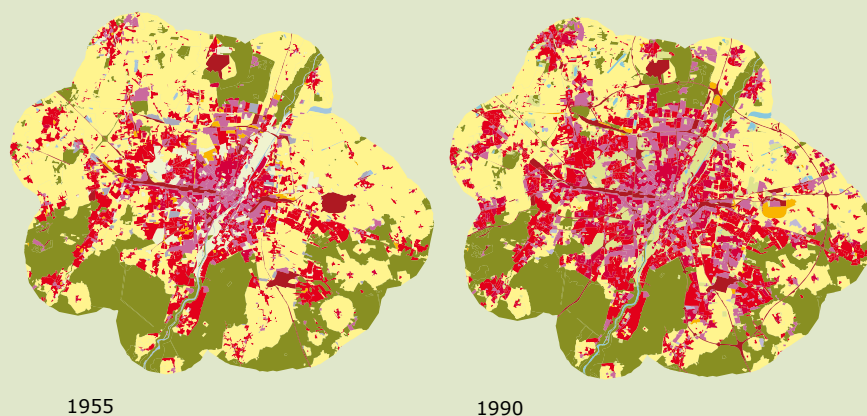
In the 1990s the comprehensive planning concept gained ground and a new version of the integrated urban development plan called 'Munich Perspective' was adopted in 1998. The slogan of the plan is to keep Munich region compact, urban and green. The plan covers economy, social issues, transport, environment and town planning. The main urban structure objectives include continued reuse of brownfields and avoidance of expansion. Mixed land use (residential, commercial, services) is seen as an important way of keeping the











Box 10 (cont.)

city compact. Improvement of public transport as well as pedestrian and cycling facilities and reinforcing regional cooperation are also seen as fundamental for the attainment of the plan objectives.

Key objectives and actions for the compact city

- Integrated city development plan
- Regional cooperation
- Stakeholders' involvement in city planning
- Emphasis on reuse of vacant brownfields
- Continuously improving public transport with as few new roads as possible
- Compact-urban-green — keep the city compact and urban and green areas green
- Guarantee the necessary resources for implementing the strategies of all relevant policy areas (transport, housing etc.) for both 'business as usual' situations and through major renovation projects.

Map Land use changes in Munich urban area from 1955 to 1990**Land use/cover classes**

	Continuous urban fabric		Mineral extraction
	Discontinuous urban fabric		Agricultural areas
	Industrial and commercial		Natural areas
	Transport areas		Other land uses
	Green urban areas		Water

Source: MOLAND (JRC).

It is clear according to the good governance criteria that the EU has specific obligations and a mandate to act and take a lead role in developing the right frameworks for intervention at all levels, and to pave the way for local action. Policies at all levels including local, national and European need to have an urban dimension to tackle urban sprawl and help to redress the market failures that drive urban sprawl. The provision of new visions for the spatial development of Europe's cities and regions is vital for the creation of a range of integrated mutually reinforcing policy responses.

The policy debate on sustainable visions for the spatial planning of urban Europe is already actively underway in the European Parliament. The Parliament's advocacy of the provision of urban green areas and large natural areas to bring citizens closer to nature, can form the *entrée* for wider EU contributions to this debate on the visions. This will set the tone and direction for sectoral policy implementation at all levels, and become the basis for the new urban planning model of city regional development.

In (re)developing integrated spatial planning for the key EU policy frameworks which make major

contributions to policies to combat urban sprawl, transport and cohesion policies are without doubt crucially important dimensions for the delivery of positive outcomes. EU Cohesion Policy offers in particular an effective framework to articulate better coordination of land use policies and Structural and Cohesion Funds investments between urban areas, rural areas, and the regions that can effectively manage urban sprawl.

Finally, good governance, in the context of the EU Urban Thematic Strategy, can be translated into the provision of support for actions and solutions developed at the local level to address urban management problems including urban sprawl. In this way the EU can directly assist in the transfer of good practice experience of the management of urban sprawl from one city to another and the dissemination of policy solutions that have proven effective.

The impacts of urban sprawl have for years and decades generated debates among scientists and practitioners, less so among the authorities and policy-makers in charge. We hope, with this report, to contribute to raising further awareness reactions to an issue crucial to Europe's sustainable future.

Annex: Data and methodological approach

A The challenge of scales

The assessment of the phenomena of urban sprawl at the European level requires appropriate information and tools effective at different scales. The issue of urban sprawl must be defined and comprehended in the urban-regional context in which the dynamics of urban sprawl are operational and urban management undertaken. Furthermore, there is a need to broaden the window of inquiry in order to assess the extent of the impacts of urban sprawl across on the political and geographic territory of Europe. This is the challenge of scales as both the information used and tools applied in the assessment of urban sprawl must be effective at these scales.

In this report two main data sets have been used, to establish linkages between the different scales:

- Corine land cover (1990 and 2000). CLC limitations include resolution of urban areas with minimum mapping unit 25 ha and minimum change detection of 5 ha. But CLC is currently the only harmonised spatial data covering all of Europe, with two time references shots for most countries. CLC makes it possible to assess the extent of urban sprawl in Europe, identifying different patterns and hot spots, and providing information about the neighbourhood of these zones so that change in the environmental context can be understood.
- MOLAND (Monitoring Land Use Dynamics) database. This is a comprehensive database of 28 urban areas and 6 wider regions developed by JRC since 1998. MOLAND has four time windows: mid-1950s, late 1960s, mid-1980s and late 1990s. The database includes cities from all EU-15 countries except the Netherlands and Luxemburg, from several EU-10 countries as well as some countries in the pre-accession phase. Most urban areas in the MOLAND database have 0.5 to 2 million inhabitants. The selection of urban areas and regions was influenced by European research interests, for example, the inclusion of areas with Structural Funds subsidies, border regions,

areas with specific development dynamics etc. For each urban area detailed information is available on land use/cover changes, but also on socio-economic data from the 1950s. The database provides a wide time frame that is generally lacking at the European level, and the wide distribution of cities is useful to illustrate issues that are not possible with a narrower frame of reference.

It is important to emphasise that both data sources share the same definitions of land cover classes. In the case of MOLAND a more detailed level of subclasses has been derived in view of its higher level of resolution. The common basis of land use classes ensures some comparability of results.

B Definition of urban areas

Urban sprawl is extending urban growth far beyond their administrative boundaries, and in order to ensure that there is full comparability of results between cities the units of analysis need to be clearly defined. In this report urban areas have been defined by morphology and the distribution of urban land across the territory. CLC and MOLAND data sources originate from different projects, and so the definitional bases are slightly different. It should also be borne in mind that both data sources possess different resolutions. Overall, however, general trends, such as direction of change and order of magnitude of built-up areas, are consistent between both data sets. Details are provided in the following paragraphs.

Delineation of urban morphological zones with Corine land cover

Urban morphological zones (UMZ) are defined as built up areas lying less than 200 m apart. Urban areas defined from land cover classes contributing to the urban structure and function are:

- continuous urban fabric (111 according to CLC code);

- discontinuous urban fabric (112 according to CLC code);
- industrial or commercial units (121 according to CLC code);
- green urban areas (141 according to CLC code).

In addition port areas, airports, and sport and leisure facilities, are also included if they are neighbours of the core classes or are contiguous with the core classes.

Once UMZ have been identified according to the procedure outlined above, a second step is undertaken to include road and rail networks, and water courses, if they within 300 m of the UMZ defined in the first step. Finally, forest and scrub (311, 312, 313, 322, 323, 324 CLC code) are also included if they are completely within the core classes.

The UMZ has been delineated for CLC2000 (with reference year 2000). In order to reduce the large number of UMZs identified and work with a relevant subset, only UMZs with more than 100 000 inhabitants have been selected. The allocation of the population has been undertaken as follows:

- EU-25: Population was derived multiplying land cover classes by Population Density Raster provided by JRC. The source data was from Eurostat (2001).

- Non-EU-25: Population data was derived from the CITYPOPULATION (www.citypopulation.de) database, which in turn collects the information from national statistical offices. Data is provided by settlement, and settlements are then aggregated according to UMZ and data from 2001 added.

Urban areas in MOLAND

The area of investigation was selected on the basis of the contiguous artificial surface or core area of the city, plus a peri-urban buffer zone. The former usually corresponds to the Artificial Surface class of the Corine land cover map and equals an area (A). The buffer zone was calculated as follows:

$$\text{Buffer zone width} = 0.25 \times \sqrt{A} \quad (\text{square root})$$

The buffer zone typically extends the urban area by approximately twice the core area. The calculated buffer has often been modified and adapted to the neighbouring structures in order to avoid excluding or cutting land uses of major significance such as an airport, village or, simply, the administrative boundaries. In this report urban area refers to the area that combines the core area and the buffer around it. The urban area is therefore always larger than the city, e.g. Munich includes the city of Munich and 44 surrounding municipalities either completely or partially.

Overview of the main databases used in this report

Data source	MOLAND	Corine land cover 1990	Corine land cover 2000
Responsible authority	JRC	EEA	EEA
Period	Start date	1950	1999
	End date	2000	2001
Geographic coverage	28 cities and 6 wider regions in Europe In this study are included: Belgrade, Bilbao, Bratislava, Brussels, Copenhagen, Dresden, Dublin, Grenoble, Helsinki, Iraklion, Istanbul, Lyon, Marseille, Milan, Munich, Palermo, Pordenone, Porto, Prague, Sunderland, Tallinn, Trieste, Udine, Vienna	EU-25 (with the exception of Sweden, Cyprus, Malta), Bulgaria, Croatia, and Romania	EU-25 Member States of the EU and Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Liechtenstein, Macedonia
Spatial resolution	Minimum mapping unit 1 ha for the artificial surfaces and 3 ha for non-artificial surfaces	Minimum mapping unit 25 ha	Minimum mapping unit 25 ha Minimum change detection 5 ha
Temporal coverage	mid-1950s, late 1960s, mid-1980s and late 1990s	1990 +/- 8	2000 +/- 3 years
Quality	Accuracy > = 85 %	Accuracy > = 85 %	Accuracy > = 85 %

C Assessing urban sprawl at the European level: Corine land cover

The assessment of urban sprawl has been undertaken within the framework of the land and ecosystem accounts method developed by the EEA and ETC/TE (EEA, 2006). It is based on the Corine land cover 2000 database which also contains a special data layer of 1990–2000 land cover changes. The land accounting methodology permits the measurement of land use change related to relevant socio-economic land use processes. It is especially relevant the grouping of all possible one-to-one changes between the 44 Corine land cover classes (1892 possible combinations) into 9 major land use process (see box below), called land cover flows, which facilitate the interpretation of the results.

For this report the land cover changes include:

- Urban land management: Change of use e.g. from residential to commercial.
- Urban sprawl: Residential land development (class 1.1 of CLC — urban fabric) with loss of non urban land.
- Sprawl of economic sites and infrastructures: Development of land for economic and infrastructure land uses (including sport and leisure facilities) with loss of non urban land. This can be further subdivided into industrial and commercial sites, services and recreation, transport networks and facilities, and waste disposal sites (see Figure 7 as an example).

Nomenclature of land cover change (Level 1)

LCF1	Urban land management
LCF2	Urban sprawl
LCF3	Extension of economic sites and infrastructures
LCF4	Agricultural rotation and intensification
LCF5	Conversion of land to agriculture
LCF6	Forests creation and management
LCF7	Water body creation and management
LCF8	Changes of land cover due to natural and multiple causes

These land cover changes have been analysed within the UMZs, for reference year 2000. As the focus is at the European scale, results can be aggregated in 1 x 1 km grids (e.g. Maps 1 to 4).

In order to assess the extent of urban sprawl outside the UMZ, 3 buffers were defined:

- 0–5 km outside the boundary of the UMZ;
- 5–10 km outside the boundary of the UMZ;
- 10–20 km outside the boundary of the UMZ.

Within each buffer, urban sprawl was calculated and the results provided as a percentage of the total area (see Figure 8).

D Assessing urban sprawl at regional and local levels: MOLAND

The MOLAND methodology for assessing urban sprawl consists of three phases which are described in the next paragraphs: change detection, understanding changes and the production of scenarios.

Change detection (CHANGE): The objective of change detection is to measure changes in the spatial extent of urban areas and wider regions.

CHANGE produces a reference land use database on the basis of satellite images (IRS) and ancillary data (such as maps, aerial photos etc.), typically for the years 1997 or 1998, and three historical land use databases for selected European urban areas. Historical databases are produced for three time periods: mid-1950s, late 1960s, and mid-1980s depending on the availability of source materials (aerial photos, satellite images etc.).

Understanding (UNDERSTAND): Identifying and testing a number of indicators to be used to measure the 'sustainability of urban and peri-urban areas'. The total number of indicators in the MOLAND indicator databank is approximately 50.

For the purpose of this report the following indicators have been calculated:

- Growth of built-up areas from the 1950s to the late 1990s.

Built-up area includes the following land use classes: residential areas, industrial and commercial and service areas and transport areas. It does not include green urban areas. The indicator has been calculated by taking the extent of the built-up area in the 1990s and the built-up area in the 1950s has been

subtracted from that area. The growth is expressed as a percentage.

- Annual growth of built-up areas from the mid-1950s to late 1990s (See above for definition). Growth has been calculated for three time periods: 1950s–1960s, 1960s–1980s and 1980s–1990s. It has then been divided into an annual percentage.
- Share of low density residential areas compared with all residential areas built after the mid-1950s. In the MOLAND database the residential areas have been classified into two main categories: continuous and discontinuous. The discriminating factor is density. If buildings and other structures cover more than 80 % of the land, the area is classified as continuous residential area and if they cover less than 80 % it is classified as discontinuous residential area. The threshold of 80 % has been used in this context as a boundary between dense and low-density residential areas. The indicator has been calculated by measuring the extent of all residential areas built after the 1950s and low density residential areas built after the 1950s. The share is the percentage of the latter as compared with the former.
- The growth rate of residential, industrial, commercial and transport areas (from the mid-1950s to the end 1990s). The indicator has been calculated by measuring the extent of residential, industrial, commercial and transport areas in the 1990s and comparing with the same areas in the 1950s. Growth is expressed as a percentage.
- City population and built up area growth from 1950s to 1990s. The population statistics have been collected from municipal, regional and national statistical offices. If a municipality is only partially included in the MOLAND database, the population figure for that municipality is proportionally reduced.
- Residential density (measured by inhabitants/residential km²). The indicator has been calculated by dividing the total number of the population by the area of residential land use.

Development of scenarios (FORECAST):

Development of 'urban growth' scenarios for a sub-

set of the 25 cities, using state-of-the-art urban cellular automata model.

The MOLAND urban growth model is based on dynamic spatial systems called 'cellular automata'. Inputs to the model are different types of spatially referenced digital data including:

- **Land use maps** showing the distribution of land use types in the area of interest. These maps are derived from the MOLAND reference and historical land use databases.
- **Suitability maps** showing the inherent suitability of the area of interest for different land use types. These maps are created using an overlay analysis of maps of various physical, environmental and institutional factors.
- **Zoning maps** showing the zoning status (i.e. legal constraints) for various land uses in the area of interest. These maps are derived from existing planning maps e.g. master plans, zoning plans, designated areas, protected areas, historic sites, natural reserves, land ownership.
- **Accessibility maps** showing accessibility to transportation networks for the area of interest. These maps are computed from the MOLAND land use and transportation network databases, based on the significance of access to transport networks for the various land uses.
- **Socio-economic data:** for the main administrative regions of the area of interest, comprising demographic statistics i.e. population and income, and data on production and employment for the four main economic sectors e.g. agriculture, industry, commerce, and services.

The outputs from the MOLAND urban model consist of maps showing the predicted evolution of land use in the area of interest over the next twenty years. By varying the inputs into the MOLAND urban model e.g. zoning status, transport networks etc, the model can be used as a powerful planning tool to explore in a realistic way future urban and regional development, under alternative spatial planning and policy scenarios, including the scenario of non-planning.

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- European Topic Center on Biological Diversity, <http://biodiversity.Eionet.eu.int/>.
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