Monitoring, planning and forecasting dynamics in European areas - The territorial approach as key to implement European policies.

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1. INTRODUCTION

The Directorate General Joint Research Centre (DG JRC) of the European Commission (EC) is performing a pilot project named MOLAND (Monitoring Land Use / Cover Dynamics the aim of which is to measure of the extent of urban areas and regional developments, as well as of their progress towards sustainable development, through the creation of land use and transport network databases for various cities and geographical areas in Europe. The project covers wider issues linked to sustainable development, and also aims to create a network of partners and collaborators within and outside Europe.

MOLAND addresses specifically the issues mentioned in the European Spatial Development Perspective (ESDP) that are related to urban and regional development, and those linked to sustainable land use management. Consequently, MOLAND is also of direct relevance to several environmental topics at the EU level, such as the actions on sustainable urban development and related communications, and the initiatives on Environmental Impact Assessment and on Strategic Environmental Assessment.

In particular, MOLAND contributes to the preparation and definition of the Thematic Urban Strategy of the 6th Environmental Action Plan of the European Union.

The aim of MOLAND is to provide an integrated methodology based on a set of spatial planning tools that can be used for assessing, monitoring and modelling the development of urban and regional environments. The main feature of the project is that it allows quantitative and qualitative comparisons at pan-European level, among areas subject to transformation due to policy intervention. A further characteristic is that it adopts a methodology that simultaneously addresses the EU perspective on the one hand, and the regional / local dimension on the other.

The aim of the presentation at the CORP2002 Workshop is twofold:

to provide an overview and up-date of the project;

to participate into the scientific discussions around themes and issues related to the sustainable land use management by stimulating the creation of an European network of excellence on the subject, in the frame of the upcoming European Research Area.

2. PROJECT OVERVIEW

The overall aim of the JRC's MOLAND Project is to provide a spatial planning tool for assessing, monitoring, and modelling the development of urban and regional environments. MOLAND was initiated in 1998 (under the name of MURBANDY – Monitoring Urban Dynamics), in support of the preparation of the European Spatial Development Perspective (ESDP). The aim of MURBANDY was to monitor the development of urban areas and to draw some conclusions on trends at a European scale. This work was subsequently extended (under MOLAND) to the computation of indicators (delivered to EUROSTAT, European Environment Agency and others), and to the assessment of the impact of anthropogenic stress factors (with a focus on expanding settlements, transport and tourism) in and around urban areas, and along development corridors.

The primary role of the MOLAND Project is to provide scientific and technical support to the European Commission's various Directorates-General (DGs), services, and associated bodies, that are responsible for the conception, development, implementation, and monitoring of EU policies related to urban and regional development. At present, the main EU policy areas that are supported by MOLAND include the following: the 6th EC Environment Action Programme's proposed Thematic Strategy on the Urban Environment, for DG ENV (Environment); Indicators for Sustainable Urban and Regional Development, for DG ENV, EUROSTAT, and the EEA (European Environment Agency); the ESDP, for DG REGIO (Regional Policy); Impacts of the Structural and Cohesion Funds, for DG ENV; Strategic Environmental Assessment (SEA) of the Trans-European Transport Networks (TEN-T), for DG TREN (Energy and Transport).

During 2001, MOLAND was extended to cover seven new study areas. This brings to forty-five the total number of study areas to which the MOLAND Project has been applied to date. The seven new study areas include two European urban areas (Belgrade in Yugoslavia and Istanbul in Turkey), one non-European urban area (Lagos in Nigeria), and four extended areas (Greater Dublin Area in Ireland, Harjumaa in Estonia, Malmo in Sweden, and the Prague-Dresden transport corridor, in the Czech Republic and Germany).

From a technical point of view, MOLAND has three specific aims:

- to produce quantitative information on the evolution of land use and transport networks, from 1950 onwards, in study areas subject to infrastructural changes (e.g. urbanisation, construction of transport links);
- to develop methods for performing a harmonised analysis of historical trends, including socio-economic aspects, impact of legislation, landscape fragmentation, etc.;
- to develop models for the harmonised simulation of future European-wide scenarios, at local and regional scales.

The implementation of MOLAND is divided into three phases, corresponding to the above specific aims. Central to the methodology is the creation of detailed GIS databases of land use types and transport networks for the study areas, at a mapping scale of 1:25,000. The databases are typically for four dates (early 1950s, late 1960s, 1980s, late 1990s), or for two dates (mid 1980s, late 1990s) in the case of larger areas. For each study area the reference land use database (late 1990s) is created from interpretation of satellite imagery, most commonly from the IRS (Indian Remote Sensing) satellite (pixels of 5.7x5.7 metres), and in a few cases from the

IKONOS or SPOT satellites. The three historical databases are created from the available data (aerial photographs, military satellite images, etc.) for these dates. MOLAND adopts the CORINE land cover legend, with a fourth, more detailed level of nomenclature added for artificial surfaces.

In the second phase of MOLAND, various spatial analysis techniques are applied to the land use and transport databases, and associated socio-economic data, in order to compute different types of indicators of urban and regional development. These indicators are used to assess and compare the study areas in terms of their progress towards sustainable development. Analysis of the fragmentation of the landscapes is also carried out. The land use and transport databases have also been used for a strategic environmental assessment (SEA) of the impact of transport links on the landscape.

In the third phase of MOLAND, an urban growth model is applied. This model, which is based on spatial dynamics systems called "cellular automata", takes as input the MOLAND land use and transport databases, as well as maps of land use suitability and zoning status, and simulates future land use development under the input urban and regional planning and policy parameters. Here, the aim is both to predict future land use development under existing spatial plans and policies, and to compare alternative possible spatial planning and policy scenarios, in terms of their effects on future land use development.

3. ANALYSING URBAN AND REGIONAL SUSTAINABILITY WITH THE TERRITORIAL APPROACH

MOLAND is being developed to meet various planning and assessment needs at different policy-making levels, from the European level to the local one in the context of sustainable development. MOLAND can be used in planning and assessment activities in a number of ways such as:

- Trend analysis
- Indicator analysis
- Landscape fragmentation analysis
- Spatial overlay analysis
- Neighbourhood/buffer analysis
- Simulations/Building alternative scenarios

The primary task within the project has been the development and/or computation of various indicators describing the degree of sustainability of urban and regional development. Since the MOLAND method is based on land use and transport network development analysis, it has also been the starting point for indicator development. This section of the paper will concentrate on the land use related indicators derived from the MOLAND database.

Land use related indicators have been divided into three categories within the MOLAND project:

- *Basic indicators which are calculated at a fixed point of time such as* proportion of various land use classes within the area under study, proportion of road network cutting the various land use, fragmentation indices.
- D*ynamic indicators* refer to change such as transition from a land-use class to another.
- *Sustainable development indicators* are produced combining territorial parameters and socio-economic and environmental data

The indicators are not necessarily newly defined but are coming from existing initiatives in The European Commission's DG Environment, European Environment Agency, EUROSTAT, etc.

3.1 Basic and Dynamic Indicators

Basic and dynamic indicators are mainly used for describing the past development of urban areas and for comparing the areas with each other. An example of a dynamic indicator is the growth of artificial areas in the selected European urban areas from 1950s to 1990s. The growth has been indicated as growth percentages compared to the size of built-up areas in the 1950s and absolute growth figures in km^2 (Fig. 1). The growth percentages reflect two things: firstly, a high growth percentage can indicate low starting level, as is the case for Algarve for example. Secondly, it can be an indication of intensive building activity within the study area, in which case both the growth percentage and the absolute growth figure are high, as in the case of Helsinki. This shows that the basic statistics need quite often to be combined to get reliable and easy-to-interpret information. Nor the absolute nor the relative growth figures tell anything precise on urban sprawl (whether the growth has taken place in vicinity of or directly neighbouring other artificial areas or as an isolated island in the middle of agricultural or natural areas far away from the city centre). To analyse issues such as urban sprawl, more sophisticated indicators are needed.

3.2 Sustainable development indicators

In the indicator work related to the MOLAND project the main emphasis is on sustainability indicators. Most of them are a combination of land use, population, socio-economic and environmental data. So far the primary focus has been on the development of land use related indicators. In the chapters below we will shed light firstly on indicators related to urban sprawl and secondly on indicators related directly to the quality of living environment of urban inhabitants.

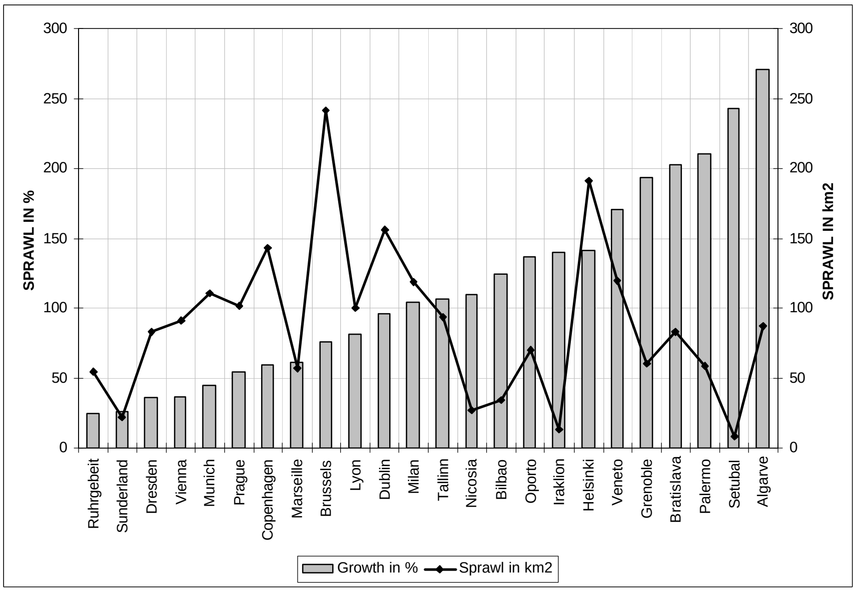

Figure 1. Growth of artificial areas in the selected European cities in the 1950s – 1990s.

Urban Sprawl and the (re)use of abandoned lands

Urban sprawl, which means the spatial disintegration of towns and cities in a way that more and more unbuilt land farer and farer away from the city centre is used for housing and as a location for industries and services, is one of the factors making urban development unsustainable. It increases traffic flows and makes the development and use of public transport very expensive. In most cities in which urban structure is very incompact the mobility relies heavily on the use of private cars. Urban sprawl also equals with unnecessary loss of natural areas, agricultural land and open recreational space, increases the cost of public services and loosens social fabric in towns and cities.

In the MOLAND project several methods to assess the degree of urban sprawl are being tested. The one which is based on the weighted average distance of each residential area from the city centre has proved to be the most useful of the ones tested so far. It is based purely on land use data. Both absolute and relative sprawling indices have been calculated. The index describes the change in time (between two points in time).

Test calculations have been done in a GIS environment. First, the city centre has been identified (normally the main railway station or a central point in the downtown commercial area). Then the geographical central point of all residential areas has been calculated. All the centre points of residential areas have been given a weight factor which corresponds to their geographic area. Then the distance between the centre and the centre point of each residential area has been calculated and weighted with the area specific weight factor.

The absolute sprawl index is measured in meters. It tells how much farer/closer the area weighted centre points of each residential area are from the city centre in the year t_2 than in t_1. On the basis of that indicator one can give rough estimates of the length of trips the inhabitants have to travel in their daily life. The relative sprawl index is computed on the basis of the absolute one by calculating how much longer/shorter the distances in the year t_2 are if compared to the year t_1. This is expressed in percentages.

So far the indices have been calculated for ten cities. The results are shown in figure 2. It shows for instance that the new residential areas built between 1960s – 1980s are located on average 1700 m farer away from the Dublin city centre than the areas built before that time period. In Helsinki the difference in distance is only approximately 300 meters.

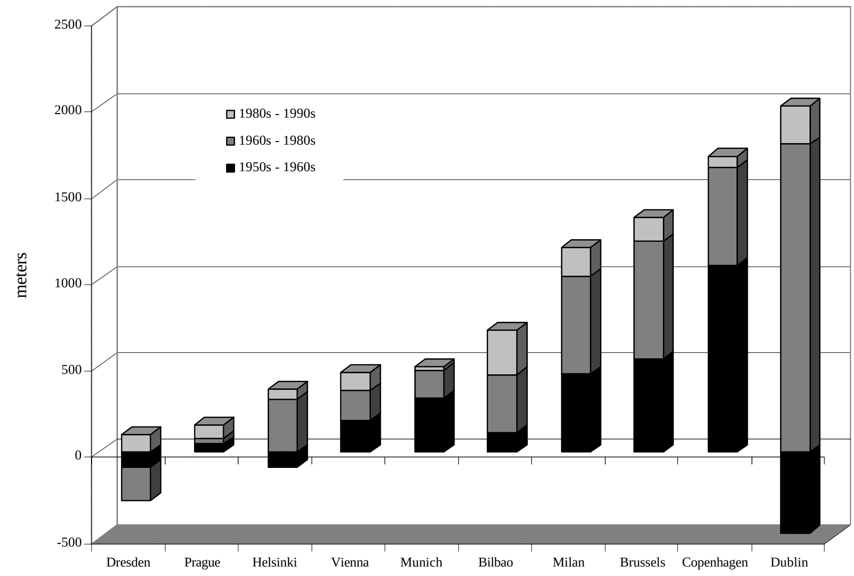

Figure 2. Absolute sprawl index for ten European cities (1950s – 1990s).

When this data is combined with data concerning the relative growth of the surface of artificial areas the below cross-tabulation (Fig. 3) can be drawn. It shows how differently the selected European cities have developed spatially during the period of past 50 years. Some cities such as Helsinki have been able to increase the artificial area quite considerably without letting the structure to become too loose. The development of Copenhagen has been quite the opposite. Relatively small increase in the surface of residential areas has resulted in quite a considerable increase in distances. Prague and Dublin are another pair of cities whose development contrasts quite dramatically. Dublin has grown both in area and distance while the growth in both dimensions in Prague has remained quite modest.

However some restrictions have to be kept in mind while interpreting the results of the above charts. Firstly, the calculations are purely based on land use data. Although the distances have been weighted by the geographical size of the residential areas, it does not necessary reflect fully the number of inhabitants living in that area. Hence no direct estimates on how much the more trips (in km) are made in an urban area can be done. Nor does it take into account the location of residential areas close to or far away from the public transport network. Secondly the analysis does not take into account the geographical circumstances of different cities. For example for land locked cities it is more often easier to grow symmetrically than for cities located on the seaside or lakeside. On the other hand the examples of Helsinki, Dublin and Copenhagen, all of which are located on seaside, prove that other factors influence more the development of urban structure. Third source of inaccuracy is the delimitation of study areas. Although the same formula has been used for all of them (see page 3), in most cases it is clear that the sprawl takes mainly place outside the study area. Although the analysis could be made more accurate by combining the land use data with population and public transport network data and taking into account a larger area, the sprawl index is a relatively good indicator of the sustainability of urban structure and in particular it can be used for monitoring the development of urban structure in time to see what is the direction of development. It is encouraging in a sense that it shows that urban planning and land use policy can have a clear impact on the compactness of urban areas.

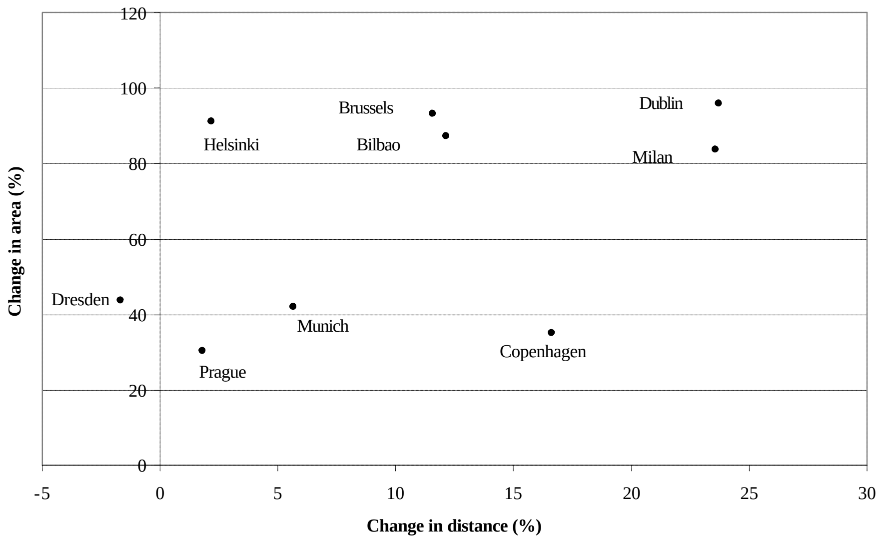

Figure 3. Changes in the area of residential areas and their distance from the city centre in the selected European cities in 1950s – 1990s.

Another important feature related to urban sprawl is the issue of **abandoned land**. Normally abandoned lands are old abandoned industrial areas or mining sites (often called brownfields) or barren agricultural lands. In the MOLAND project, the definition of abandoned land is 'land where no particular use can be seen' since the classification is mainly based on visual interpretation of satellite images. However in most study areas ancillary information has been available and the class includes also abandoned industrial sites where buildings are still in place (which looks on a satellite image as industrial site). The amount of abandoned land mapped in MOLAND varies between the cities (Fig. 4). In most cases due to the main mapping method (photo-interpretation of satellite images) it is probably underestimated.

The MOLAND data makes it possible to make a life-cycle analysis of abandoned land. It is possible to analyse which type of land turns into abandoned land. From the point of view of sustainable development it is more interesting to see a) how large percentage of abandoned land again changes status into other land use classes and b) which classes they tend to move into. The first couple of cities which have been studied so far seem to follow approximately the same pattern. In the 50 year time span half of the abandoned land is taken back into use. The other half seems to be permanently abandoned.

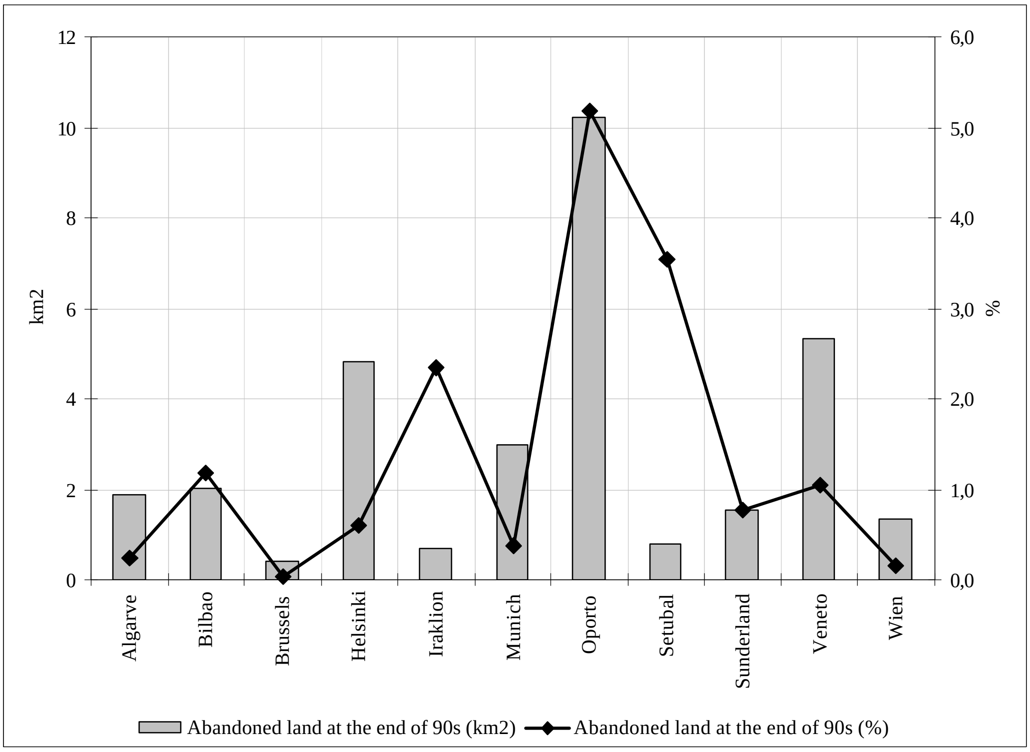

Figure 4. Abandoned land in km2 and percentages of total land area in selected European cities in late 1990s.

Table 1 below shows the case of Helsinki. The columns indicate how big a percentage of land which has been abandoned in the year indicated in the column heading line is in the year 1998 in the respective land use classes indicated in the left-most column. In Helsinki it seems that quarter of the abandoned land has turned into residential use in the 50 year time span. In the shorter run change into industrial and commercial uses seem to dominate.

	Abandoned in 1950 (%), use in 1998	**Abandoned in 1966 (%), use in 1998**	**Abandoned in 1984 (%), use in 1998**
Residential areas	25,76	2,29	0,57
Industrial or commercial areas	5,63	13,07	16,76
Traffic infrastructure	1,52	3,98	0,18
Abandoned land	58,98	55,36	75,06
Green areas, sport and leisure areas	7,04	12,25	0,00
Forests	0,95	13,05	7,44
Sea	0,11	0,01	0,00

Table 1. The life-cycle of abandoned land in Helsinki.

With the aid of MOLAND it is possible to study in quite a detailed way the lifecycle of abandoned land. This is important with a view to the central role of the reuse of brownfields and other abandoned land in the fight against urban sprawl. A more systematic and thorough comparative analysis of the life-cycle of abandoned land is under way.

Indicators related to living environment

The MOLAND method has been used to calculate indicators selected by a project called "European Common Indicators', which is co-ordinated by the EU Expert group on the Urban Environment. The project has identified ten common indicators which will be used for measuring urban sustainability at local level. So far within MOLAND the test work has concentrated on the calculation of two out of ten indicators, namely on access to green urban areas and on noise exposure.

Indicator number four is linked to the access of local inhabitants to near-by green public areas. The walking distance has been fixed at 500 meter. The MOLAND database provides a good starting point for calculations and comparisons between urban areas. In MOLAND the minimum size for green urban areas to be mapped is one hectare, which corresponds quite well to the minimum area of green areas with recreational value.

Calculations have been made by using 500 meters wide buffers around green urban areas and simple overlay techniques to see how many percent of residential areas are within the accessibility buffer. In Copenhagen, where population data is available, the analysis has been taken a step further by calculating the number of people living in the accessibility belts. The preliminary results are shown in Table 2 below. A common methodology for calculating the above-mentioned indicators, for example such as MOLAND offers, is a prerequisite for comparable results between different cities.

Name of Community	Number of Inhabitants	Population Density	Area of Community (km^2)	Area of Urban Fabric (km^2)	Area of Urban Fabric within belts (km^2)	Inhabitants within belts	Percentage of all inhabitants within belts (%)
ALBERTSLUND	30331	1316,45	23,17	5,16	2,85	18726	**61,74**
BROENDBY	37615	1821,55	20,94	6,38	3,32	18149	**48,25**
DRAGOER	12695	699,84	18,02	3,23	2,18	5307	**41,80**
FREDERIKSBERG	88167	10053,25	8,56	3,60	1,65	27716	**31,44**
GENTOFTE	66782	2614,80	25,47	21,77	8,64	32610	**48,83**
GLADSAKSE	64213	2568,52	25,06	13,10	4,77	22074	**34,38**
GLOSTRUP	19645	1475,96	13,35	6,02	2,69	9384	**47,77**
GREVE	41743	693,41	55,38	11,57	5,75	15938	**38,18**
HERLEV	28190	2341,36	11,89	7,53	3,73	15305	**54,29**
HVIDOVRE	51059	2330,40	21,54	14,45	5,52	28983	**56,76**
ISHOEJ	20856	842,67	24,97	1,67	0,34	1683	**8,07**
KOEBENHAVN	493771	5595,14	87,09	39,93	21,77	283888	**57,49**
LYNGBY-TAARBAEK	51703	1329,81	38,55	4,64	2,16	8807	**17,03**
ROEDOVRE	37673	3108,33	12,13	10,23	6,24	30555	**81,11**
SOELLEROED	31705	797,21	35,20	1,87	0,91	2360	**7,44**
TAARNBY	41517	662,58	62,64	1,76	0,87	3592	**8,65**
VALLENSBAEK	12256	1333,62	9,36	1,49	0,98	4078	**33,27**

Table 2. Accessibility of green urban areas in the city of Copenhagen.

The other Common Indicator the computation of which has been tested with the aid of MOLAND is indicator number eight “Noise Exposure”. MOLAND can help in identifying the noise sources and in the estimation of the area of residential blocks situated close to potential noise source. When population statistics are available, a rough estimation of a number of exposed inhabitants can be given. The potential noise sources identified are roads, railways, airports and the corridors used by planes and industrial sites. The analyses are done at the scale of 1:25 000. In the testing phase terrain contours have not been taken into account although technically it would be possible. In noise exposure analysis MOLAND is a complementary tool to more accurate noise modelling. It helps making rough calculations and comparisons of potential noise exposure. As table 3 shows, for example in Munich one sixth of all residential areas are closer to than 200 meters from a motorway. Although the noise abatement measures (such as noise barriers) are not taken into account, the analysis gives a good indication of land use close to motorways and above all enables European level comparisons about potential noise exposure.

	Urban fabric within 100 m distance from motorway (%)	Urban fabric within 200 m distance from motorway (%)
Residential continuous urban fabric	9,1	17,6
Residential discontinuous urban fabric	7,0	13,5

Table 3. Motorway noise traffic exposure in Munich in 1990.

4. MOLAND METHOD AS A PLANNING AND DECISION-MAKING SUPPORT TOOL

The MOLAND method has and is been developed with a view to different types of planning and decision-making situations. The main area of application is the implementation of integrative planning and policy-making approach that is necessary if the urban areas are to meet the requirements of sustainable development. In practice this means that MOLAND will be a tool which integrates all types of spatially disaggregated data related to different aspects of sustainable development. It is based on land use data, but will be developed to encompass a whole array of environmental and socio-economic data as well.

The MOLAND method can be applied in various planning and decision-making situations. Due to its scale it is best suited for **trend analysis and policy and strategy level planning and monitoring**. Trend analysis refers to the study of general development trends needed as an information basis when carrying out various planning and decision-making tasks. Policy level includes the formulation and impact assessment of policy options (mainly aims, objectives and resource allocation). At strategic level the main instruments are plans and programmes. They are more detailed in content, and their objectives and impacts are easier to put into context and to locate.

Strategic planning and decision-making seem to be the most appropriate level for applying the MOLAND method. The adaptation of the European directive on Strategic Environmental Assessment (SEA) will make ex-ante impact assessments of all programmes and plans obligatory in the European Union. MOLAND offers a good platform for those kinds of impact assessments.

The most detailed level of planning and decision-making, which is often called project level, is partially unreachable by the MOLAND method due to the scale of most projects. On the other hand there are a lot of big projects such as major transport and building projects, the impact of which is well compatible with the MOLAND scale. It can be used in Environmental Impact Assessment (EIA DIR97/11/EC) of major projects at regional and national level. In various impact assessments, both environmental and integrated, one strength of the MOLAND method is capacity to combine environmental and socio-economic data with land use patterns.

Monitoring and ex-post assessment are tasks in which the MOLAND method can show its strengths. The possibility of updating the land use data even yearly, makes it possible to construct, phase by phase, the chain of land use changes which a policy, plan or project has triggered of. The combination of socio-economic, environmental and land use data at the same scale and in a spatially disaggregated format, allows carrying out complex impact assessments, capable of taking into account different effects and their interactions.

5. CONCLUSIONS

MOLAND is being developed to meet the needs related to sustainable spatial planning at European level. It is a methodology composed of land use and transport databases created by the aid of photo-interpretation of satellite images, various statistical datasets, integrated indicators and analysing and modelling tools. The project is still under way but on the basis of the experience gained so far MOLAND has opened new avenues for analysing various aspects of urban and regional development such as urban sprawl, and life-cycle of abandoned land. The method is being further developed to become a comprehensive tool suitable for complex impact assessments at strategic planning level.

The main focus in the future research will be in the field of impact assessments. The urban and regional growth model needs to be calibrated to suit different urban and regional contexts (ranging from Lagos to developed European urban areas). Further work is also needed to better incorporate the existing indicators into MOLAND and to develop and test new ones.

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