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# **CORINE Land Cover 2000 in Nation-wide and Regional Monitoring of Urban Land Use and Land Consumption**

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## **Abstract**

Whereas remarkable efforts have been made to implement environmental information systems, the observation of urban land use change within nation-wide or regional monitoring approaches still remains dissatisfying. One key problem is the absence of land use data which allows the analysis of land use trends over longer periods of time and with appropriate spatial resolution. This paper asks to what degree CORINE land cover 2000 (CLC 2000) could fill these data gaps. For this purpose, CLC 2000 is compared to other land use data sources. Some indicators focussing on the measurement of land consumption and urban sprawl are to be exemplified.

## **1 Background**

Following the increasing concern over urban sprawl and its negative implications on environmental conditions and quality of life, it is now widely recognised that it is important to monitor urban land use development in order to facilitate sustainable urban management. The lack of precise information about current land use, land use changes and their driving forces must be acknowledged as one crucial reason for some serious shortcomings of urban management practices such as inabilities in measuring urban growth, time lags in recognizing increasing or decreasing demand for land or lacking information about the effects of urban land use policies and regulations. Political progress towards resource efficient, equitable and ecological urban structures can only be made with contemporary information about the patterns of urban growth and the future demand for land.

Urban land use monitoring carried out by national or regional governments supports different tasks of urban and regional management such as

- analysing current development trends (Where is new development occurring and what are the spatial characteristics or urban growth?),
- analysing the impacts of urbanisation (What are impacts on valued ecological components and the quality of life?) or
- evaluating the implementation of land use plans (What are the effects of policies and regulations aiming at controlling urban growth, especially discouraging further urban sprawl?).

Whereas remarkable efforts have been made to implement environmental information systems, the observation of land use change within nation-wide or regional monitoring approaches still remains dissatisfying. One key problem is the absence of land use data which allows the analysis of land use trends over longer periods of time and with appropriate spatial resolution. Another problem is directly linked to data gaps: there is great concern of land consumption and urban sprawl, but poor definition and measurement hampers discussion about it. As Robert Cervero (2000) stated, "sprawl is like pornography, it is hard to define, but you know it when you see it". Currently most definitions and measuring approaches fail to express the spatial complexity of land use patterns labelled as urban sprawl (Theobald, 2001; Galster et al., 2000).

This paper asks to what degree CORINE land cover 2000 could fill this data gap. It presents a first assessment of CLC 2000 focussing on its capacity to observe the process of land consumption – also termed "land take" (EEA, 2001), "land conversion for urban uses" or "urban sprawl". We are doing this in three main steps. At first general methodological requirements regarding the observation and assessment of land use trends are to be stated. Second we want to ask to what extent CLC 2000 is able to detect total land consumption for urban purposes. An appropriate observation of land use trends presumes a high rate of change detection. The third part presents first results of test data analysis to demonstrate possible applications of CLC 2000 within state-wide and regional monitoring approaches.

## **2 Methodological requirements**

### **2.1 General requirements**

In Germany nation-wide and regional monitoring of land use is operating with different data sources (Figure 1). The official monitoring of regional development carried out by the Federal Office for Building and Regional Planning is based on land survey data. Although these data are available area-wide in Germany, their geographical scope is limited due to their spatial dimension through a municipality zonal system (administrative boundaries). But zone-based spatial models do not take account of topological characteristics of land use patterns (Spiekermann/Wegener, 1999). Therefore there is a broad consensus that land use monitoring needs spatially disaggregated data models with vector representation of land use patterns. Such land use patterns are generally being collected on basis of remote sensing data.

However, it must be pointed out that there are certain conditions that have to be fulfilled by the applied database, especially when land use detection is based on remote sensing technologies:

- Multi-temporal land use detection should be realised with the same satellite sensor for image comparison. However, land use mapping is often based on the latest sensor technology because users have advantages due to better spatial resolution. For example Saxony's land use monitoring began on basis of Landsat5-Data in the year 1992/93, whereas the survey for the years 1998 and 2000 used IRS data. Thus the mapping results are not completely comparable, in particular if semiautomatic classification procedures are used (different spectral signatures).

- Furthermore, land use monitoring requires a uniform data collection methodology. That concerns the digitization rules (delimitation of land use classes, minimum mapping units, generalization rules etc.) and the classification scheme. Otherwise a comparability of monitoring results for different points of time is limited. The classification scheme should distinguish urbanised areas in different land use classes (e.g. residential, industrial, recovery, commercial, traffic use).
- The mapping process should make use of experience from former surveys. A sound data gathering can only be ensured, when the “old” land use map is used as a background data base. This is of special importance in the case of “difficult” land cover classes like urban areas (e.g. where is the border of an airport?)
- The analysis of land consumption requires a high spatial resolution of image data to identify also smaller changes of urban land use patterns. A mapping scale of 1:25.000 with a minimum cartographic unit for urban areas of 1 hectare – like in the MOLAND project (EEA, 2002) – seems to be suitable.
- Land use data should be connectable with statistical data regarding population, employment or housing in order to analyse land use trends in relation to their socio-economic framework. By this means, indicators like the intensity of land use (inhabitants per km<sup>2</sup> urbanised area, GDP per km<sup>2</sup> urbanised area) can be derived.

The first three requirements are satisfactorily fulfilled by CLC 2000. Limitations for urban land use monitoring result from the large scale of data collection (1:100 000) and the implemented minimum cartographic unit of 25 hectares. In the future methodological advancements focussing on the spatial resolution of CORINE have to be taken into account. A possible approach would be a more detailed data collection in urban areas according to the MOLAND project. The last requirement addresses problems not caused by CLC 2000 but rather by spatial resolution of statistical data. Although in the meantime socio-economic data sets up to the municipal district level are available in Germany, most data are related to the municipality as a whole.

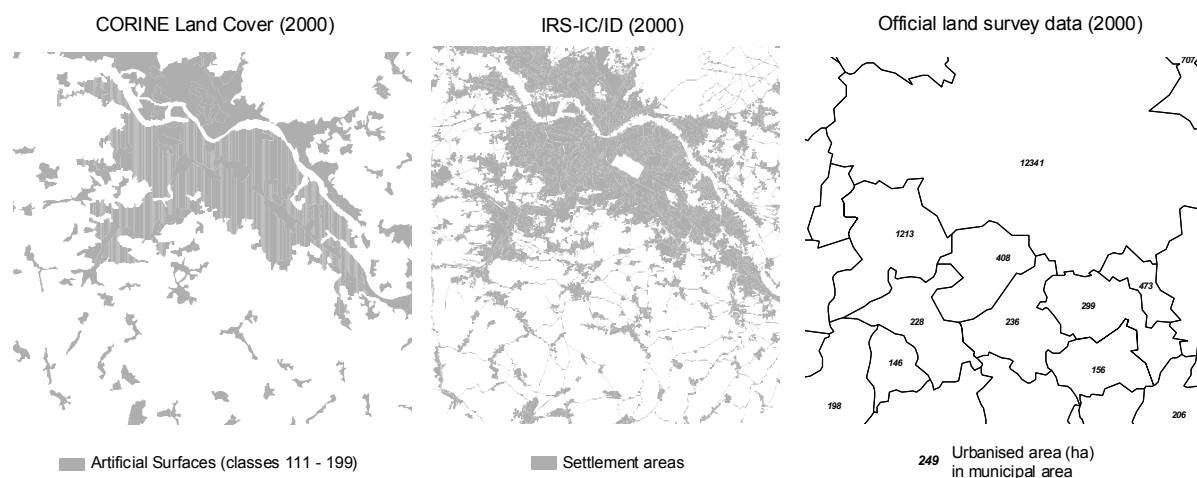


Figure 1: CORINE land cover 2000 in relation to other data sources used for land use monitoring (City of Dresden and its southern environs)

## 2.2 Quality of CORINE land cover 2000

For a relatively small test area the quality of the CLC data (2000) data has been determined by the authors. We chose the metropolitan region of Dresden (circle with 20 km radius around the city centre, 1254 km<sup>2</sup>) for this test because of local knowledge of places. We compared CLC 2000 with a land use mapping on basis of IRS-1C/1D data (IRS2000) (Table 1). Saxony's IRS 2000 map can serve as good reference due to the fact that its spatial resolution is much higher than CLC (scale 1:25,000, no minimum cartographic unit) (LfUG, 2003). It can be stated that the main land cover classes of CLC were collected with relatively high accuracy (settlement areas 82.3 %, agriculture areas 83.9 %, forest areas 82.7 % and water areas 85.5 %). However, in the case of subclasses significant differences become apparent (Table 1).

Tab. 1: Accuracy of the determination of the CLC classes by comparison with reference mapping (IRS2000)

CLC class	Accordance with IRS2000 [ % ]	main fault [ % ]	reason of fault
Water bodies 512	85.4	4. arable land	-
Rivers 511	84.0	8.9 grassland	-
Residential continuous 111	82.6	13.9 roads	-
Industrial/commercial 121	79.1	11.2 arable land	-
Arable land 211	79.1	7.4 grassland	assignment problem
Residential discontinuous 112	74.6	10.6 arable land	generalization
Airports 124	61.7	25.5 settlement inside	delimitation problem
Broad-leaved forest 311	54.8	13.7 field	assignment problem
Coniferous forest 312	46.2	35.0 mixed forest	assignment problem
Mineral Extraction sites 131	41.6	35.7 settlement inside	delimitation problem
Meadow/pastures 231	36.2	39.0 arable land	assignment problem
Mixed forest 313	22.4	42.1 hardwood forest	assignment problem
Roads/Railway 122	0.3	89.4 settlement inside	digitization rules

High classification quality can be attested for the CLC classes water bodies (85.4 %), rivers (84.0 %), residential continuous areas (82.6 %) and arable land (79.1 %). A higher classification quality is prevented by assignment problems and the CLC generalization rules. The CLC class road/railway (122) cannot address the spatial representation of traffic land uses because of the specific digitization rules for line infrastructure (>100 m). The important class urban green areas (141) and sport and leisure facilities (142) could not be evaluated since no suitable IRS reference data were available.

## 3 CORINE land cover 2000 in land use monitoring approaches

Ecological impacts of urban growth on the environment depend on the amount of newly urbanised areas on previously virgin land (Greenfield sites) and the spatial patterns of new development. Furthermore, the analysis of land use dynamics within existing urban areas

must be a topic of monitoring. Great importance can be attached to the number and size of derelict areas in cities and the amount of new development on derelict land. However, it is impossible to obtain detailed data regarding brown-field areas and their functional change with CLC 2000. Therefore the specific function of CORINE within land use monitoring approaches mainly aims at the analysis of locational attributes of new development sites.

Before some first results of the test data analysis (state of Saxony) are presented, it is necessary to question the quantitative detection of total land consumption through CORINE land cover 2000. This is done here by a comparison of the rate of new urban development calculated with CLC 2000 to official land statistics derived from land survey data. This comparison seems to be useful because the latter database is able to account for the totality of land use change in a four-year period.

According to CLC 2000 approximately 152 km<sup>2</sup> previously undeveloped (mainly agricultural) land has been converted to urban uses in Saxony between 1990 and 2000. The proportion of artificial land cover (without mineral extraction sites) had increased from 9.3 % to 10.2 %. In contrast, the official land statistics reported a volume of 250 km<sup>2</sup> land converted to residential, industrial, commercial and traffic uses for the period between 1992 and 2000. Based on this information, it can be estimated that CLC 2000 detects only two third of total land consumption (digitizing rules exclude small areas!). Due to the fact that small development projects account for a significant proportion of total land consumption in Germany, this benchmark seems to be realistic. In either case, the results for Saxony should be reviewed through same analysis for other reference areas in Germany.

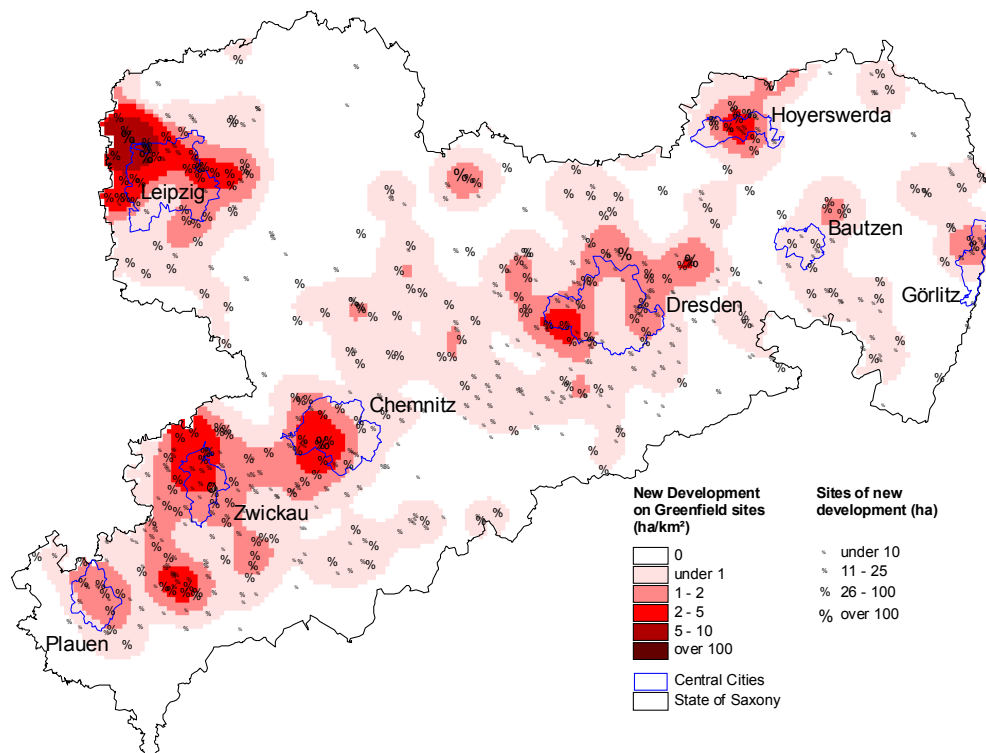


Figure 2: Intensity of urbanisation in Saxony – new development on Greenfield sites 1990 – 2000; interpolation of site data (point data) with a 10 km search radius (source: CORINE land cover 2000)

But the mere statement of the amount of newly developed areas in Saxony's total area has rather low informational value because their regional distribution is highly different. A more detailed analysis demonstrates that most of Saxony's urban growth has taken place around the major central cities (Chemnitz, Dresden, Leipzig) and along the large transport corridors (in particular along the motorways A4 and A14) (Figure 2).

Another important attribute of sprawl is the growing distance of newly urbanised areas from the city centre (Lavallo et al., 2002). This indicator can be implemented with one kilometre concentric rings beginning at the CBD (city centre) of the metropolitan region and continuing to its outer periphery. For each concentric ring the proportion of new development has to be calculated (here recorded as hectare new development per km<sup>2</sup> ringzone). This generalisation of CLC-change data allows land-use change to be compared between large cities and their environs over time. Figure 3 shows that in the case of Chemnitz and Dresden land conversion is highest at the urban fringe (kilometre 5 and 6), but continues towards the rural hinterland. In contrast, the metropolitan region of Leipzig is characterised by a “double peak” at kilometre 9 and 14. The first peak is caused by development next to the inner suburbs of Leipzig. The outer peak demonstrates the massive urbanisation around Leipzig airport caused by large infrastructure projects and industrial development.

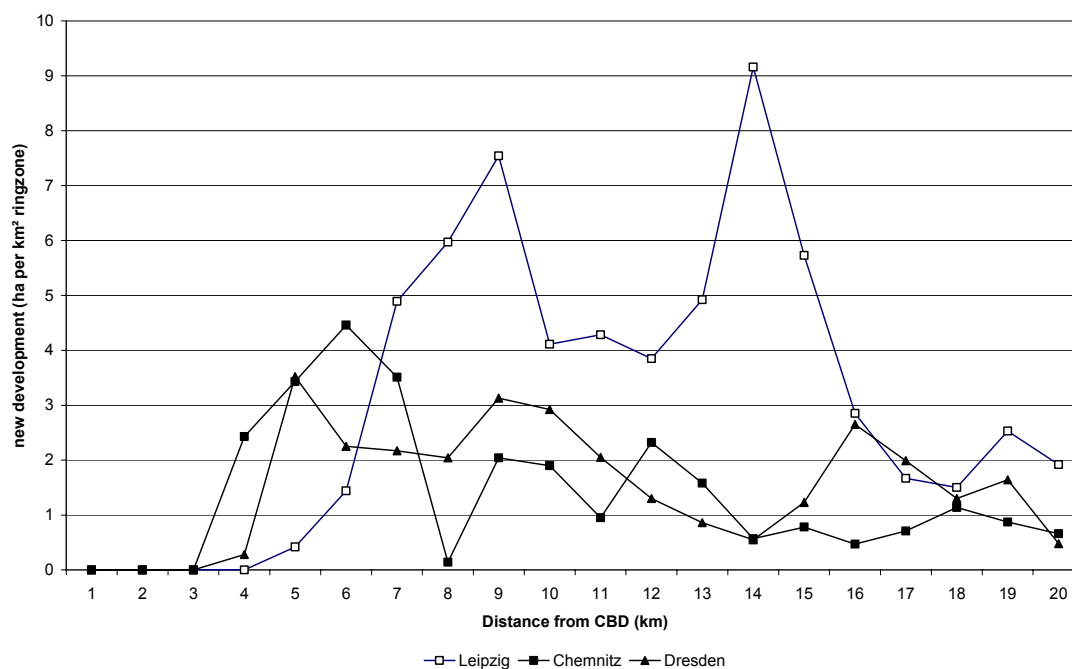


Figure 3: Distance of newly urbanised areas from the CBD for the three metropolitan regions of Saxony (20-km-radius) (source: CORINE land cover 2000)

The sprawl effect of new development on Greenfield sites also depends on the degree of continuity of newly developed areas to already existing urbanised areas. New development can be well integrated into existing settlements (esp. by infill development) but also be discontinuous. In this article we distinguish between four general types of integration characterised by the ratio B of the boundary of new development areas to the boundary of existing settlements (Meinel/Winkler 2003; Meinel/Neumann 2003, Figure 4). This variable B can vary between 0 and 1. The value 0 means that new development is located totally outside existing urban areas (type 4). In contrast, the value 1 indicates new development totally in-

tegrated into the already existing urbanised area (type 1). Whereas type 1 and 2 can be positively associated with a compact urban form, type 3 and 4 stands for less sustainable, “sprawling” forms of urban development.

The results for the three large metropolitan regions of Saxony demonstrate the massive sprawling effect of new development in the post-GDR era. In the case of Dresden and Leipzig, a quarter of newly urbanised areas must be attributed as not integrated (type 4). In all regions less than 50 % of new development can be labelled as totally or well-integrated into existing urban areas (type 1 and 2).

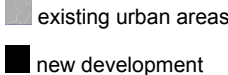
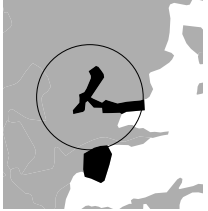

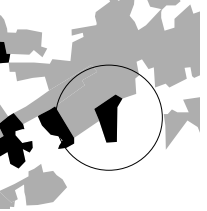
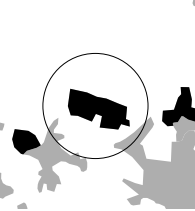
Type	totally integrated (1)		well integrated (2)		less integrated (3)		not integrated (4)	
Example 								
Ratio of boundary to already existing urbanised areas	$2/3 < B < 1$		$1/3 < B < 2/3$		$0 < B < 1/3$		0	
Metropolitan regions	number (%)	share (%)	number (%)	share (%)	number (%)	share (%)	number (%)	share (%)
Chemnitz	10	16	29	22	45	46	16	17
Dresden	6	7	41	35	41	34	13	23
Leipzig	8	5	40	28	26	45	26	22

Fig. 4: Integration of new development (1990 – 2000) into already urbanised areas in three saxonian metropolitan regions (source: CORINE land cover 2000)

## 4 Conclusions

CORINE land cover 2000 could be used as a complementary database in urban land use monitoring programs. CLC 2000 provides a database with a finer spatial resolution than traditional land survey data used in nation-wide and regional monitoring in Germany. Therefore, CORINE offers a more sophisticated picture of the patterns of land consumption in urban regions. Its strengths arise from its capability to support the analysis of locational attributes of new development. Many indicators used in the urban sprawl studies can be implemented with CLC 2000. Moreover CORINE offers opportunities to apply more complex assessment methods with ambitious tools like Fragstats and Patch Analyst (see for example Rainis 2003).

Of course there are limitations due to the relatively large minimum cartographic units of 5 ha for land cover changes. In Saxony binding land use plans with an areal extension of less than 5 hectares account for approximately more than 20 % of the total newly developed area. This “masking” of small-scaled development runs a risk of underestimation of sprawl dynamics. On this background it must be clearly stated that the potential fields of CLC-application are mainly directed towards higher levels of urban land use monitoring. For local approaches CORINE 2000 cannot provide a meaningful database.



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