NATIONAL LAND COVER DATABASE AT SCALE 1:50,000 IN HUNGARY

György Büttner, Gergely Maucha, Mária Bíró, Barbara Kosztra, Róbert Pataki and Ottó Petrik

Institute of Geodesy, Cartography and Remote Sensing (FÖMI),
1149 Budapest, Hungary; buttner(at)rsc.fomi.hu

ABSTRACT

The standard CORINE Land Cover (CLC) database (scale 1:100,000) covers most of the EU Member States (including the majority of the new members as well) and is used to support policy making at the pan-European level. National applications, however, require a more detailed database on Land Cover. As part of Hungary's preparation to join the European Union, a CLC mapping programme at scale 1:50,000 has been implemented. The standard (level-3) CORINE Land Cover nomenclature was enhanced to include nearly 80 level-4/5 classes. Orthorectified SPOT-4 satellite images taken in 1998-99 and visual photointerpretation on computer screen have been applied to provide high positional accuracy. The 4 ha minimum mapping unit (1 ha for water) provides enhanced geometric details. Internal and external quality control procedures are other key elements to yield a high quality database. The paper highlights the European co-operation aspects, as well as introduces the technical novelties of the CLC50 project. Some of the applications of CLC50 are described.

Keywords: land cover, high-resolution, photointerpretation, Hungary.

INTRODUCTION

The idea to produce a uniform pan-European land cover database dates back to the early 80's. It has been recognised that land cover is a basic information requirement for the management of the environment and natural resources. Land cover mapping has become an integral part of the CORINE (Co-ordination of Information on the Environment) Programme, started in 1985 by the European Commission with the main aim to compile consistent and compatible information on the environment for EU Member States. Information provided by Earth observation satellites serves as the base data to support the production of a land cover inventory. Mapping is supplemented by ancillary data (topographic maps, aerial photographs, vegetation maps, etc.) (1). The CORINE Land Cover (CLC) project has been implemented in most of the EU countries as well as in the 13 Phare partner countries in Central and Eastern Europe (2). The choice of scale (1:100,000), minimum mapping unit (25 ha) and minimum width of linear elements (100 m) represents a trade-off between the costs of production and the details of land cover information derived. Updating of the first CLC inventory is recently going on in the frames of the CLC2000 project, based on orthocorrected Landsat-7 ETM imagery (IMAGE2000), and is expected to be completed in 2004 (3).

The aim of the CORINE Land Cover project is to provide an inventory of the Earth surface features for managing the environment. Computer assisted visual interpretation of satellite images has been chosen as the preferred mapping technology, but digital image classification oriented approaches exist as well (4,5,6).

To support Hungary's accession to the European Union a strong need for detailed and up-to-date land cover information was recognised. The standard CLC (CLC100) was already outdated for Hungary (produced using satellite images taken in 1990-92), in addition it did not provide sufficient details. A resolution of the Hungarian government on the "Development of environmental information systems" (2339/1996(XII.6.)) ordered the "Setting up a CORINE Land Cover database at a scale of 1:50,000". In 1999, in the frames of the Acquis National Programme - the Ministry of Agriculture and Regional Development initiated the CORINE Land Cover mapping project at a scale of

1:50,000 (CLC50) (7). The whole country had been mapped by the end of 2003. The objective of the paper is to introduce the applied methodology and to present some of the application results.

THE CLC50 PROJECT

The CLC50 project has direct links to the standard European CLC100. Thematic classes have been developed from the standard (level-3) nomenclature, using recommendations of Phare countries for 1:50,000 scale mapping, prepared for the European Environmental Agency (8). This enhanced nomenclature (level-4 and level-5 classes) includes nearly 80 categories, adapted for Hungarian conditions. Orthorectified SPOT-4 satellite images taken in 1998-99 and the visual photointerpretation on computer screen allowed for high positional accuracy of polygon delineation. The 4 ha and (1 ha for water) size of minimum mapping unit provided enhanced geometric details. A rigorous internal supervision and an independent external quality control were the other key elements of this high quality database. The main technical parameters of CLC100 and CLC50 are summarised in Table 1. Figure 1 shows the flowchart of CLC50 data processing.

Table 1. Comparison of main parameters of CLC100 and CLC50

Parameter	CLC100 Hungary	CLC50
Nomenclature	standard EU level-3	extended level-4/5
Methodology	hardcopy PI	softcopy PI
Area resolution	25 ha for all categories	4 ha; 1 ha for lakes
Linear resolution	100 m	50 m
No. of classes	27 (out of 44)	79
No. of polygons	24,000	174,000
Positional accuracy	<100 m (RMS)	<20 m (RMS)
Thematic reliability	>85%	>90%
Supervision	not documented: direct corrections on plastic overlays	documented: remarks on polygon level (instructions for corrections)
External quality control	no	yes
Final product	topologically structured database in ArcInfo format	

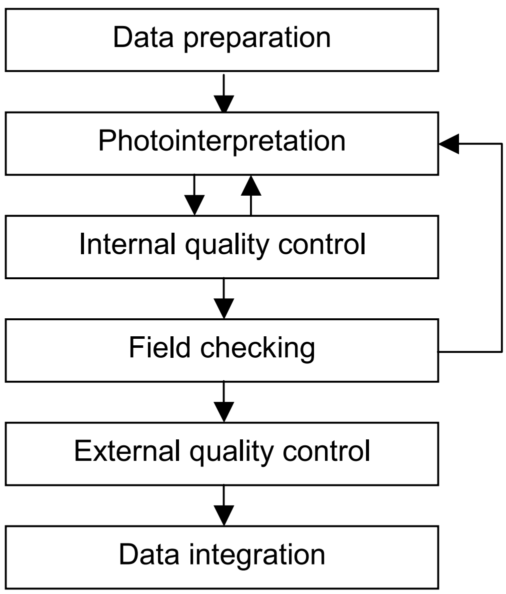

Figure 1. Flowchart of CLC50 project

Preparation

The SPOT-4 satellite was programmed to acquire simultaneous XI (multispectral) and M (monospectral) imagery for the whole area of Hungary during the summer period. About 85% of the country was acquired cloud-free during 1998, and the remainder during 1999. Altogether, 49 XI and M image pairs have been acquired with <1% cloud cover.

The SPOT-4 level-1A imagery was orthocorrected using a rigorous mathematical model of the imaging geometry, the actual Earth surface and the cartographic projection. Ground control points (GCP) were selected from 1:10,000 scale topographic maps. A digital elevation model (DEM) derived from 1:100,000 scale topographic maps and improved by measured elevations of the 4th order geodetic network was used. For flat regions, rectification was performed on a single image basis. For hilly regions block adjustment was used with fewer GCPs, but with several tie points selected from overlapping areas between images. Positional accuracy of the rectified images was <10 m (RMSE) for the entire country. Orthocorrected XI and M images were finally merged using the HPF method (9) to provide an optimal support data for photointerpreters.

In order to increase the thematic accuracy of interpretation, photointerpreters were provided with other, additional satellite images as well. Images taken in spring enhanced the interpretation of e.g. coniferous forests. Images of the CLC100 project taken in 1990-92 and recent (1997-99) summer time series provided additional data to improve the interpretation of those classes, where time evolution yielded important information (e.g. arable land or fallow land, transient or permanent water body).

Computer assisted photointerpretation

The first standard CLC100 inventory in Europe was based on traditional photointerpretation. A transparent overlay was fixed on top of the satellite image hardcopy, and the photointerpreter drew polygons with a three-digit CLC code on it. After completing and supervising the interpretation, the polygons were digitised, a topology was created and the CLC codes were entered. This procedure often causes several types of error:

- geometrical errors given by an imprecise hardcopy image size, distortions of the hardcopy image, improper alignment of overlay and image;
- geometrical errors of digitisation;
- thematic mistakes introduced during the database coding phase;
- thematic errors because of the limitations of hard copy image and single-image interpretation.

Computer-assisted photointerpretation completely eliminates the first three of the above errors, and reduces the last one by an optimal combination of the capabilities of the human expert and those of the computer. The main benefits over the traditional approach include:

- magnification of the imagery using the zoom function;
- possibility of using multitemporal imagery;
- more precise delineation of polygons;
- easy corrections (lines, codes);
- automatic checking of validity of codes;
- automatic checking of polygon geometry (area, average width);
- on-line nomenclature;
- the possibility to use comments and remarks at a polygon level (i.e. a tool for „discussion” between photointerpreter and quality supervisor);
- data exchange via e-mail.

The above functions were implemented under ArcView V3.1/3.2 as a macro package, called InterView (10). Special care was taken to support an error-free conversion of ArcView shape files into polygon topology under workstation ArcInfo V7.2.1.

Internal quality control

The role of internal quality control was to harmonise the work of the photointerpreter team to ensure similar understanding and application of the nomenclature in order to provide a homogeneous database. In the frames of the first standard CLC100 project quality control was accomplished by visual evaluation of drawings on the plastic overlay and indicating corrections by red pencil.

In the CLC50 project members of the photointerpreter team (located in different parts of the country) submitted their intermediate results (shape files) for supervision usually by e-mail. To the expert controlling the work the same images and ancillary data were available as to the photointerpreter. An ArcView macro package called InterTest (11) was used for supervision. This allowed for entering remarks on polygon level to inform the interpreter about the problem and help or instruct him/her on correction.

External quality control

After the final internal quality control the photointerpretation was subject to an external quality control. Experts from two networks, the National Park Directorates and Plant Health and Soil Protection Service were contracted to control the results of photointerpretation. These two networks operated by the Ministry of Environment and Ministry of Agriculture and Regional Development have lots of field knowledge and access to field data, which were compared to the photointerpretation. Experts provided the central team with their written, georeferenced remarks. After critical examination remarks were entered into the database.

Data integration

This step included the following procedures:

- controlled integration of the results of external quality control phase;
- converting ArcView shape files into a topologically structured vector database (ArcInfo);
- checking of neighbouring polygons with the same code (whether intentionally or by mistake), since such polygons are dissolved during further processing;
- merging adjacent sheets into a seamless coverage.

RESULTS

Using financial support from the Ministry of Environment and the Ministry of Agriculture, a relatively small team needed 4 years to map the whole country (from 1999 to 2003). 15 photointerpreters and about 50 external experts have contributed to the work.

An operational software tool based on ArcView has been developed to support computer assisted visual photointerpretation. Orthocorrected SPOT-4 images provided a high quality basis for photointerpretation. Additional satellite images were very useful to supplement interpretation. The detailed nomenclature could be applied without major difficulties, but required more field control. The rigorous internal quality control was a key element of the methodology, and importantly contributed to the homogeneous application of the interpretation rules. Electronic communication was great advantage for working with experts located in different parts of the country. Good quality satellite image photomap prints and interpretation overlays helped external experts to control and amend the database by integrating their knowledge into the land cover interpretation.

There has not yet been time for a quantitative evaluation of geometric and thematic accuracy. Naturally, results of CLC50 include more details than CLC100 (Figure 2). The ratio of the total number of polygons in CLC50 to that of CLC100 is 7.31 (Table 2). The number of linear elements (rivers, channels, highways, railway sections) has increased significantly compared to CLC100.

The number of polygons in some categories, that have smaller characteristic sizes, also increased significantly, such as industrial-commercial units, ports, dump sites, construction sites, urban green areas, coniferous forests, transitional-woodland, scrub and peat-land. The very large increase in the number of polygons for natural grassland class (321) is due to the modified understanding of this class for national purposes. The large increase in the number of polygons for the arable land class (211) is explained by the introduction of two subclasses in CLC50 characterizing the dominant size of parcels. Concerning the comparison of class areas, the largest increase can be seen in the road and rail network class (122). The reason is that highways and several railway stations are included in the CLC50 database (and missing in CLC100) because of smaller geometrical limits (Table 2).

Table 2. Comparison of CLC50 (1998) and CLC100 (1990)

Code	CLC50		CLC100		Ratio (CLC50/CLC100)	
	counts	% area	counts	% area	counts	areas
111	97	0.04	10	0.02	9.70	1.70
112	5939	3.79	3373	4.83	1.76	0.78
121	9097	1.21	784	0.51	11.60	2.37
122	615	0.17	28	0.02	21.96	10.00
123	26	0.01	2	0.00	13.00	2.79
124	57	0.10	16	0.07	3.56	1.46
131	679	0.10	126	0.09	5.39	1.08
132	615	0.09	60	0.04	10.25	1.96
133	308	0.04	16	0.01	19.25	3.70
141	966	0.10	48	0.03	20.13	3.37
142	1224	0.34	152	0.19	8.05	1.74
211	33352	52.18	2143	57.04	15.56	0.91
212	117	0.39		0.00	Not present in CLC100 (1990)	
213	34	0.12	27	0.10	1.26	1.15
221	2528	1.50	602	1.32	4.20	1.14
222	2182	0.77	701	0.68	3.11	1.13
231	18177	4.29	4384	7.91	4.15	0.54
242	14653	2.64	1829	2.31	8.01	1.14
243	6059	0.90	1519	2.12	3.99	0.43
311	28744	16.71	3800	14.59	7.56	1.15
312	8580	1.76	831	0.98	10.32	1.80
313	3918	0.85	1170	2.38	3.35	0.36
321	12373	5.89	202	1.49	61.25	3.95
324	14519	2.39	1121	0.96	12.95	2.48
331	16	0.00		0.00	Not present in CLC100 (1990)	
332	17	0.00		0.00	Not present in CLC100 (1990)	
333	392	0.10		0.00	Not present in CLC100 (1990)	
334	6	0.00		0.00	Not present in CLC100 (1990)	
411	4707	1.23	509	0.71	9.25	1.71
412	152	0.12	9	0.02	16.89	5.93
511	347	0.73	34	0.36	10.21	2.04
512	3328	1.44	455	1.20	7.31	1.20
	173824	**100.00**	**23951**	**100.00**	**7.31**	**1.00**

Some of the important applications of CLC50 are:

- CORINE Habitat Mapping: Natural / semi-natural classes of CLC50 are further detailed by botanists according to a habitat nomenclature, using field data. The CORINE Habitat Map is available for most of the areas under nature conservation.
- Lake inventory as preparation for the EU Water Framework Directive: Preparation of the list of all those water bodies that potentially fulfil the “larger than 50 ha” criteria.
- Important Bird Areas: Study of correlation between recorded bird occurrences and the landscape, represented by CLC50 (12).
- Computation of agri-environmental indicators by comparing CLC100(1990) and CLC50(1998) for three mezo-regions of Hungary (13).
- CLC2000 project: The update of the first European CLC database (CLC2000) is realised in Hungary by using a generalized CLC50 (14). This way a high level of the compatibility between the national and the European CLC databases is maintained.

CONCLUSIONS

As a fulfilment of the government resolution on the “Development of environmental information systems” the implementation of the CORINE Land Cover database at scale 1:50,000 has been finished in 2003. The database supports Hungary’s accession to the EU in various programmes, such as the planning of sustainable agriculture, rural development, agri-environment and nature conservation.

The CLC50 project has direct links to the standard European CORINE Land Cover project, however, most elements of the methodology were upgraded according to the present level of technology in geo-data processing. The CLC50 nomenclature is compatible with the standard (level-3) nomenclature and includes nearly 80 level-4 and level-5 classes, which have been adapted for Hungarian conditions. Orthorectified SPOT-4 satellite images taken in 1998-99 and computer-assisted photointerpretation allow for high positional accuracy of delineation. The 4 ha size minimum mapping unit (1 ha for lakes) provides enhanced geometric details. A rigorous internal supervision and an external quality control are the other key elements to producing a high quality database. Polygon density is 7.3 times higher than in the standard CLC100 database. The number of useful applications is increasing.

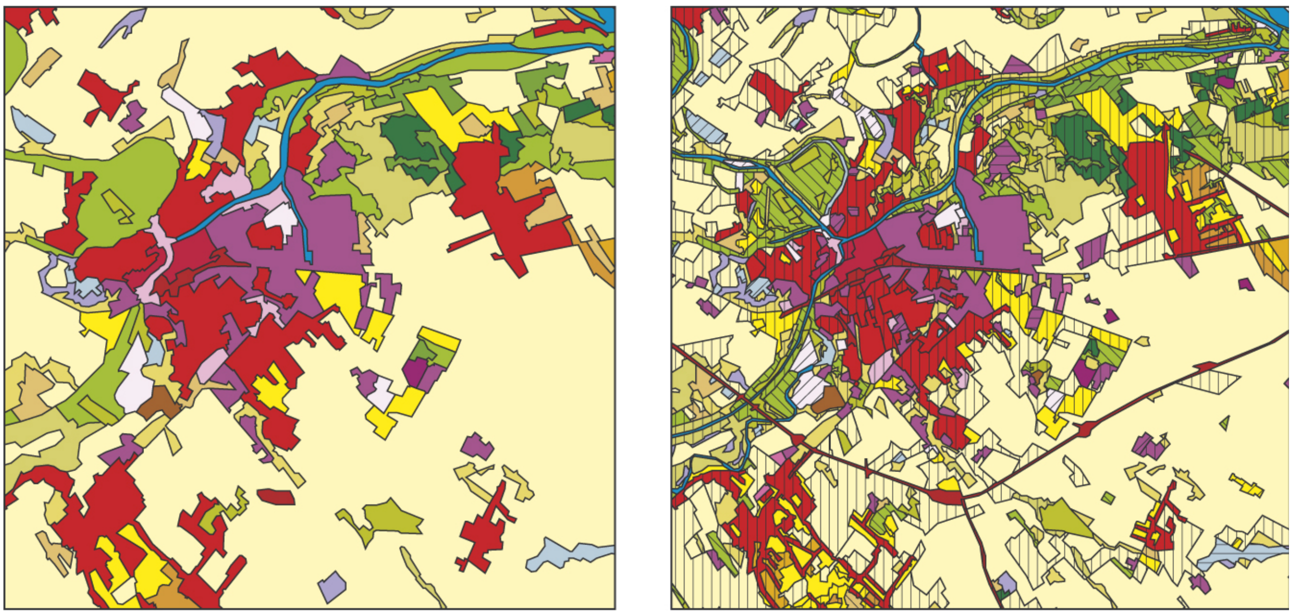

Figure 2: Comparison of CLC100 (left) and CLC50 (right) for Győr (NW-Hungary) and surroundings

ANNEX 1: CLC50 NOMENCLATURE (V 1.42)

1 ARTIFICIAL SURFACES

1111 Areas of urban centres
1112 Areas of ancient cores
1121 Discontinuous built-up areas with multiflat houses prevailingly without gardens
1122 Discontinuous built-up areas with family houses with gardens
1123 Discontinuous built-up areas with greenery
12111 Industrial and commercial units
12112 Agro-industry
12113 Education and health facilities
1212 Areas of special installations
1221 Road network and associated land
1222 Rail network and associated land
1232 River and lake ports
1233 Shipyards
1234 Sport and recreation ports
1241 Airports with artificial surfaces of runways
1242 Airports with grass surfaces of runways
1311 Open cast mines
1312 Quarries
1321 Solid waste dump sites
1322 Liquid waste dump sites
1331 Construction sites
1411 Parks
1412 Cemeteries
1421 Sport facilities
1422 Leisure areas
1423 Recreation settlements

2 AGRICULTURE AREAS

2111 Arable land with large fields
2112 Arable land with small fields
2113 Greenhouses
2121 Permanently irrigated arable land
2131 Rice fields
22111 Vineyards with large fields
22112 Vineyards with small fields
2221 Orchards
2222 Berry fruit plantations
2223 Hop plantations
2226 Wild willow plantations
2311 Intensive pastures, degraded grassland without trees and shrubs
2312 Intensive pastures, degraded grassland with trees and shrubs
2421 Complex cultivation patterns without scattered houses
24221 Complex cultivation patterns with scattered houses
24222 Farmsteads
2431 Agricultural areas with significant share of natural vegetation and with prevalence of arable land
2432 Agricultural areas with significant share of natural vegetation and with prevalence of grasslands
2433 Agricultural areas with significant share of natural vegetation and with prevalence of scattered natural vegetation
2434 Agricultural areas with significant share of ponds and with prevalence of scattered natural vegetation
2435 Agricultural areas with significant share of permanent crops and with presence of scattered natural vegetation

3 FORESTS AND SEMINATURAL AREAS

3111 Broad-leaved forest with continuous canopy, not on wet area
3112 Broad-leaved forest with continuous canopy, on wet area
3113 Broad-leaved forest with discontinuous canopy, not on wet area
3114 Broad-leaved forest with discontinuous canopy, on wet area
3115 Plantations of broad-leaved forests
3121 Coniferous forests with continuous canopy
3125 Plantations of coniferous forests
3131 Mixed forests created by alternation of single trees with continuous canopy
3135 Mixed forests created by alternation of stands of trees with continuous canopy
3139 Plantations of mixed forests
3211 Natural grassland prevailingly without trees and shrubs
3212 Natural grassland with trees and shrubs
3241 Young stands and clear-cuts
3243 Bushy woodlands, natural regeneration areas
3244 Forest nurseries
3245 Damaged forests
3312 Dunes
3313 River banks
3321 Bare rocks
3331 Sparse vegetation on sands or loess
3332 Sparse vegetation on rocks
3333 Sparse vegetation on salines
3341 Burnt areas

4 WETLANDS

4111 Fresh-water marshes
4113 Saline (alkali) inland marshes
4121 Explored peat bogs
4122 Natural peat bogs with scattered trees and shrubs

5 WATERS

5111 Rivers
5112 Channels
51211 Natural water bodies with continuous water supply
51212 Natural, temporary, salt-affected water bodies
51221 Artificial lakes, reservoirs
51222 Fish ponds

REFERENCES

1 Heymann Y, Ch Steenmans, G Croissille & M Bossard, 1994. CORINE Land Cover. Technical Guide. Office for Official Publications of the European Communities, EUR12585 (Luxembourg)

2 Büttner G et al., 1998. The European CORINE Land Cover Database, ISPRS Commission VII Symposium, Budapest, September 1-4, 1998. Proceedings, 633-638

3 EEA-ETC/TE, 2002. CORINE Land Cover update. I&CLC2000 Project, Technical Guidelines, http://terrestrial.eionet.eu.int

4 Finnish Environment Institute, 2003. CORINE Land Cover 2000 and Image 2000 in Finland. Interim Report (Helsinki, Finland)

5 Swedish Space Corporation, 1994. CORINE landtackning – ett pilotprojekt i Sverige (in Swedish, with English summary)

6 Smith G M, N J Brown & A G Thomson, 2002. CORINE Land Cover 2000: Semiautomated updating of CORINE Land Cover in UK. Phase I: Interim Report, Centre for Ecology and Hydrology (Monks Wood, UK)

7 Büttner G, M Bíró, M Maucha & O Petrik, 2001: Land Cover mapping at scale 1:50.000 in Hungary: Lessons learnt from the European CORINE programme. In: A Decade of Trans-European Remote Sensing Cooperation, edited by M F Buchroithner. Proceedings of the 20th EARSeL Symposium, 14-16 June 2000 (Balkema Publishers, Lisse, The Netherlands) 25-31

8 Feranec J, J Oťaheľ & J Pravda, 1995. Proposal for a methodology and nomenclature scale 1:50,000 CORINE Land Cover Project. Final Report. Institute of Geography, Slovak Academy of Sciences (Bratislava)

9 Chavez P et al., 1991. Comparison of three different methods to merge multiresolution and multispectral data: Landsat TM and SPOT Panchromatic. Photogrammetric Engineering and Remote Sensing, 57(3): 295-303

10 Taracsák G, 1999. InterView macro package for satellite image interpretation (V2.1). FÖMI internal report (Budapest, Hungary)

11 Taracsák G, 2000. InterTest macro package to evaluate satellite image interpretation (V1.0). FÖMI internal report (Budapest, Hungary)

12 Báldi A, 2003. Land cover and breeding of bird species in the Important Bird Areas of Hungary (in Hungarian with English and French summary), Hungarian Ornithological and Naturea Conservation Society (Budapest), ISBN: 963 8641800

13 Büttner G, G Maucha & B Kosztra, 2002. Towards agri-environmental indicators using land cover changes derived from CORINE Land Cover data; in: Building Agro Environmental Indicators – Focussing on the European area frame survey LUCAS. JRC-EEA-EUROSTAT; EUR Report 20521 EN

14 Büttner G, 2003. CLC2000-Hungary – Phase-I. Final Report, FÖMI, Available on EEA website (password protected) http://eea.eionet.eu.int:8980/Public/irc/eionet-circle