

DATA LAYERS OF CORINE LAND COVER – CONTRIBUTION TO COGNITION OF LAND COVER CHANGES OF EUROPE

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Abstract: By the accomplishment of the *Image and CORINE Land Cover 2000* Project, data sets that allow analysis and evaluation of the European land cover (LC) changes for the years 1990 – 2000 were obtained. The aim of this paper is to demonstrate the applied method of LC change identification at scale 1:100 000, which is based on the use of satellite images and the most striking changes identified in the urbanised technicised, agricultural and forest landscapes of Europe. The applied method and obtained results have been already presented in some European countries. At present, LC changes at the level of Europe are being intensively analysed. It was found out that from the point of view of scope, the changes of forest landscape (changes between the transitional woodland-shrub and forest classes) and changes between meadows, arable land and complex cultivation pattern prevail. Enlargement of areas of discontinuous urban fabric and industrial and commercial units in urban landscape dominate at the cost of arable land.

Key words: satellite image, CORINE, land cover, landscape change, Europe

1. INTRODUCTION

CORINE Land Cover (CLC) and CLC2000 (Büttner et al., 2004, EEA-ETC/TE 2002) Projects contributed to cognition of the land cover development of Europe in the 1990s and 2000 (+/- one year), as interpreted from satellite images. The Projects yielded CLC90 and CLC2000 data layers that make it possible to identify, analyze, assess and compare the LC changes in Europe and its individual countries. CLC data were already used, for instance, in the LACOAST (Perdigao a Christensen, 2001), Phare Topic Link (Feranec et al., 2000) and BIOPRESS (<http://www.creaf.uab.es/biopress>) Projects. After finishing the CLC2000 data layer and its presentation to users (<http://dataservice.eea.eu.int>) in the course of 2005, conditions for identification of LC changes for Europe for the 1990s and 2000 at scale 1 : 100 000 were created.

The aim of the contribution is to present the dominant landscape changes (urbanisation, structural changes in agriculture, deforestation and forestation) by

application of CLC90 and CLC2000 data layers, as well as their applicability to solution of different landscape problems at the all-European level.

2. DATA AND THE PROCESSING METHOD

The applied method and data are characterised in detail in works of Büttner et al. (2004) and Feranec et al. (2005). Identified LC changes for the 1990s and 2000 were the results of the GIS overlay of CLC90 CLC2000 data layers (minimum area of identified LC change was 5 ha, its minimum width was 100 m and the minimum area of newly identified area was 25 ha). Table 1 brings the sizes of identified LC changes in the European countries, where the CLC90 and CLC2000 data layers were generated.

Table 1 Sizes of identified LC changes in the European countries for the 1990s and 2000

Country	Total size of LC changes in ha	% LC change from the country area
AT (Austria)	36,423.84	0.43
BE (Belgium)	61,126.71	1.99
BG (Bulgaria)	123,110.89	1.11
CZ (Czech Republic)	524,233.32	6.65
DE (Germany)	882,305.55	2.44
DK (Denmark)	56,705.94	1.29
EE (Estonia)	121,748.64	2.68
ES (Spain)	2,407,620.78	4.83
FR (France)	1,134,049.29	2.05
GR (Greece)	286,242.75	2.17
HR (Croatia)	109,452.17	1.93
HU (Hungary)	421,053.44	4.53
IE (Ireland)	566,897.81	8.02
IT (Italy)	395,605.19	1.31
LT (Lithuania)	165,824.75	2.50
LU (Luxembourg)	4,139.39	1.59
LV (Latvia)	255,864.90	3.96
NL (Netherlands)	172,669.49	4.34
PL (Poland)	259,036.66	0.83
PT (Portugal)	991,876.32	11.11
RO (Romany)	311,667.80	1.31
SI (Slovenia)	2,378.27	0.12
SK (Slovak Republic)	207,675.84	4.24
UK (United Kingdom)	342,409.74	1.38

Source: EEA ETC/TE 2005

Changes of CLC classes (see Table 2) were used for characterisation of four LC change types:

- ♦ urbanisation (enlargement of area of LC classes 11, 12 a 13 at the cost of classes 21, 22 and 23; Table 2 explains the codes of classes),
- ♦ structural changes in agriculture (changes of LC class 211 in favour of classes 231 and 24),
- ♦ deforestation (changes of LC class 31 in favour of class 324),
- ♦ afforestation (changes of LC class 324 in favour of class 31).

Table 2 The CORINE land cover nomenclature (Heymann et al., 1994, Bossard et al., 2000)

1 Artificial surfaces	3 Forest and semi-natural areas
11 <i>Urban fabric</i>	31 <i>Forests</i>
111 Continuous urban fabric	311 Broad-leaved forests
112 Discontinuous urban fabric	312 Coniferous forests
12 <i>Industrial, commercial and transport units</i>	313 Mixed forests
121 Industrial or commercial units	32 <i>Scrub and/or herbaceous vegetation associations</i>
122 Road and rail networks and associated land	321 Natural grasslands
123 Port areas	322 Moors and heathland
124 Airports	323 Sclerophyllous vegetation
13 <i>Mine, dump and constructions sites</i>	324 Transitional woodland-scrub
131 Mineral extraction sites	33 <i>Open spaces with little or no vegetation</i>
132 Dump sites	331 Beaches, dunes, sands
133 Construction sites	332 Bare rocks
14 <i>Artificial, non-agricultural vegetated areas</i>	333 Sparsely vegetated areas
141 Green urban areas	334 Burnt areas
142 Sport and leisure facilities	335 Glaciers and perpetual snow
2 Agricultural areas	4 Wetlands
21 <i>Arable land</i>	41 <i>Inland wetlands</i>
211 Non-irrigated arable land	411 Inland marshes
212 Permanently irrigated land	412 Peat bogs
213 Rice fields	42 <i>Maritime wetlands</i>
22 <i>Permanent crops</i>	421 Salt marshes
221 Vineyards	422 Salines
222 Fruit trees and berry plantations	423 Intertidal flats
223 Olive groves	5 Water bodies
23 <i>Pastures</i>	51 <i>Inland waters</i>
231 Pastures	511 Water courses
24 <i>Heterogeneous agricultural areas</i>	512 Water bodies
241 Annual crops associated with permanent crops	52 <i>Marine waters</i>
242 Complex cultivation patterns	521 Coastal lagoons
243 Land principally occupied by agriculture, with significant areas of natural vegetation	522 Estuaries
244 Agro-forestry areas	523 Sea and ocean

3. CHARACTERISTICS OF RESULTS

As Table 1 shows, the largest LC changes were identified in Spain (2,407,620.78 ha), France (1,134,049.29 ha), and Portugal (991,876.32 ha). Estimating by the share of LC in total area of a State, the largest changes were found in Portugal (11.11 %), Ireland (8.02 %) and in the Czech Republic (6.65 %).

Important LC changes were also identified in Slovakia (207,675.84 ha) placing the country at the 14th position among the 24 evaluated European countries. As far as the percentage of LC changes in the total area of a State is concerned, Slovakia with its 4.24 % ranks at the 7th position.

Intensity of changes and landscape dynamics in the individual European States can be demonstrated according to the four types of LC changes quoted above. The sizes of landscape changes are presented in Tables 3 – 6.

3.1. Urbanisation

As far as the area of urbanisation is concerned, the largest changes were identified (see Table 3) in Germany (172,743 ha), France (112,181 ha), and Spain (111,435 ha).

Table 3 Urbanisation

Country	Urbanisation v ha	Urbanisation % of total change area
AT	6,340.54	17.41
BE	16,466.90	26.94
BG	2,816.21	2.29
CZ	9,197.79	1.75
DE	172,743.01	19.58
DK	8,736.08	15.41
EE	1,483.49	1.22
ES	111,435.59	4.63
FR	112,181.67	9.89
GR	23,708.43	8.28
HR	3,429.46	3.13
HU	8,980.67	2.13
IE	23,839.61	4.21
IT	77,932.58	19.70
LT	542.52	0.33
LU	1,371.45	33.13
NL	71,602.85	41.47
PL	16,876.80	6.52
PT	41,081.25	4.14
RO	7,322.71	2.35
SI	118.55	4.98
SK	4,571.40	2.20
UK	22,975.74	6.71

Source: EEA ETC/TE 2005

These changes are represented above all by enlargement of areas of the settlement and industrial constructions, the mineral extraction and building.

The largest share of urbanisation in the total area of changes was identified in Netherlands – 41.47 % (71,602.85 ha) followed by Luxembourg – 33.13 % (1,371.45 ha), and Belgium – 26.94 % (16,466.90 ha). Changes in urbanisation area in Slovakia compared to the rest of Europe were not striking. Slovakia ranks at the 17th position in terms of urbanised areas (4,571.40 ha) and at the 19th position, as far as the share of urbanisation in total change area of all assessed European countries (24) is concerned. Changes in Slovakia are related to the increased settlement fabric, industrial and commercial areas but also transport networks and associated land.

3.2. Structural changes in agriculture

The largest areas of this type of change occurred (see Table 4) in the Czech Republic (291,483 ha), Germany (214,462 ha) and Spain (84,044 ha). These changes are connected first of all with extensification of agricultural production (for example, with change of arable land to pastures in the Czech Republic) and the like.

The highest share of structural changes in agriculture was also identified in the Czech Republic (55.60 %) and Germany (24.31 %). These countries, as far as the share

of changes in agriculture in total changes is concerned, are followed by Latvia (23.97 %, 161,339.95 ha). Changes in agricultural areas in Slovakia compared to the European countries were also considerable. Slovakia ranks at the 13th position in this respect (19,237.54 ha) and at the 9th place when considering the share of changes in agriculture in total change area among all evaluated European countries. Area of complex cultivation pattern enlarged by 16,550 ha mostly at the cost of arable land (by 13,210 ha). The distinct diminution of pastures by 201,500 ha was related to their reduced cultivation and subsequent overgrowing by shrub formations (with area of 10,270 ha). Size of heterogeneous agricultural areas diminished by 8,970 ha above all in favour of transitional woodland-scrub (4,860 ha). Diminishment of arable land by 5,690 ha was the result of extensified agricultural production and particularly by its change into meadows and pastures (4,620 ha).

Table 4 Structural changes in agriculture

Country	Structural changes in agriculture in ha	Structural agricultural change % of total change area
AT	206.54	0.57
BE	1,278.55	2.09
BG	7,377.76	5.99
CZ	291,483.38	55.60
DE	214,462.28	24.31
DK	2,929.70	5.17
EE	25,415.66	20.88
ES	84,044.30	3.49
FR	41,272.22	3.64
GR	3,723.55	1.30
HR	12,002.31	10.97
HU	48,172.36	11.44
IE	65,219.53	11.50
IT	22,416.38	5.67
LT	25,321.36	15.27
LU	118.59	2.86
NL	61,339.95	23.97
PL	4,198.52	2.43
PT	17,750.19	6.85
RO	7,872.99	0.79
SI	22,564.94	7.24
SK	19,237.54	9.26

Source: EEA ETC/TE 2005

3.3. Deforestation

As Table 5 shows, the largest deforested areas occur in France (314,799 ha), Portugal (274,705 ha) and Spain (238,042 ha). The causes ensue of logging and the damage to forest by diverse natural calamities. In terms of the share of deforestation in total area of changes, the largest deforested area was identified in Latvia (49.82 %), Luxembourg (47.21 %) and Denmark (45.78 %).

Slovakia is among the European countries with important deforestation. Change in deforestation to 58,031.81 ha was identified. It means the 11th position among all evaluated countries and in terms of the share in total area of changes (27.94 %), Slovakia ranks at the 9th position. These changes in forest landscape ensue of social and political transition and intensive logging. The total area of forest diminished by 2,690 ha.

Table 5 Deforestation

Country	Deforestation in ha	Deforestation % of total change area
AT	3,739.84	10.27
BE	5,747.90	9.40
BG	28,355.13	23.03
CZ	59,344.51	11.32
DE	68,755.49	7.79
DK	25,962.78	45.78
EE	44,399.69	36.47
ES	238,042.57	9.89
FR	314,799.47	27.76
GR	84,015.64	29.35
HR	35,031.72	32.01
HU	78,422.72	18.63
IE	69,427.59	12.25
IT	8,384.43	2.12
LT	57,811.18	34.86
LU	1,954.24	47.21
NL	127,469.90	49.82
PL	17.88	0.01
PT	83,890.57	32.39
RO	274,705.49	27.70
SI	73,981.09	23.74
SK	523.24	22.00
UK	58,031.81	27.94

Source: EEA ETC/TE 2005

Table 6 Afforestation

Country	Afforestation in ha	Afforestation % of total change area
AT	3,008.01	8.26
BE	14,794.97	24.20
BG	36,767.85	29.87
CZ	123,215.76	23.50
DE	44,135.21	5.00
DK	444.63	0.78
EE	4,183.76	3.44
ES	274,712.39	11.41
FR	351,284.23	30.98
GR	32,082.77	11.21
HR	30,242.72	27.63
HU	133,956.00	31.81
IE	31,713.32	5.59
IT	88,802.06	22.45
LT	1,347.53	0.81
NL	525.60	0.30
PL	48,042.39	18.55
PT	223,058.91	22.49
RO	90,938.13	29.18
SK	52,974.29	25.51
UK	112,878.06	32.97

Source: EEA ETC/TE 2005

3.4. Afforestation

This type of change is connected with natural or artificial regeneration of forest. The largest size of regenerated forest (see Table 6) was observed in France (351,284 ha), Spain (274,712 ha), and Portugal (223,058 ha).

As far as the share of forestation in overall change area is concerned, the largest forestation was observed in United Kingdom (32.97 %, 112,878,06 ha), Hungary (31.81 %, 133,956.00 ha) and France (30.98 %).

Slovakia is the country with a significant share of forestation on total area of 52,974.29 ha and ranks at the 9th position among the evaluated countries. The share of forestation in overall area of changes (25.51 %) has placed Slovakia at the 7th position in Europe. Enlargement of forest is due to that of coniferous (37,250 ha), broad-leaved (13,690 ha) and mixed forest (7,090 ha).

4. CONCLUSION

Presented results demonstrate that CLC90 a CLC2000 data layers allow derivation of information on landscape changes at the all-European level and at the levels of the individual states for the 1990 and 2000.

Land cover/land use changes indicate the social interest in spatially important economic activities (agriculture, forest and water management), but also the dynamics of the development of urbanized areas and technical infrastructure. Significant land cover changes in the individual states of Europe suggest relation to socio-economic and political stimuli but also possible natural calamities (fires in the Mediterranean region, floods, wind calamities and the like). Urbanisation in the BENELUX countries, structural changes in agriculture of the central and east European countries, deforestation in the south-western, central and eastern Europe, forestation in United Kingdom, France and central Europe are also reflected. Explanation of causes of the identified changes also requires a more detailed analysis of socio-economic circumstances in the individual countries. However, identification and quantification of the LC changes provide valuable information on European landscape changes.

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Dátové vrstvy CORINE land cover – príspevok k poznávaniu zmien krajinej pokrývky Európy

Resume

V príspevku prezentované výsledky dokumentujú, že z dátových vrstiev CLC90 a CLC2000 možno odvodiť informácie o výskyte a rozlohe zmien krajiny na celoeurópskej úrovni, ako aj na úrovni jednotlivých štátov za obdobie 90. rokov a roku 2000.

Zmeny krajinej pokrývky/využitia krajiny indikujú spoločenský záujem o priestorovo významné hospodárske aktivity (poľnohospodárstvo, lesné a vodné hospodárstvo), ale aj dynamiku rozvoja urbanizovaných areálov a technickej infraštruktúry. Významné zmeny krajinej pokrývky v jednotlivých štátoch Európy poukazujú na súvis so spoločensko-ekonomickými a politickými stimulmi, ale aj možnými prírodnými kalmitami (požiare v mediteránnych oblastiach, záplavy, veterné kalamity a pod.). Možno dokumentovať urbanizáciu v krajinách BENELUX-u (v Holandsku dosiahla 41,5 %, v Luxembursku 33,1 % a v Belgicku 26,9 % z celkovej rozlohy identifikovaných zmien krajinej pokrývky), štrukturálne zmeny v poľnohospodárstve zvlášť v krajinách strednej a východnej Európy (v Českej republike zaberajú 55,6 % a v Lotyšsku 24 % z celkovej rozlohy zmien), odlesňovanie v krajinách juhozápadnej, ale aj strednej a východnej Európy (napr. v Lotyšsku 49,8 % z celkovej rozlohy zmien), zalesňovanie vo Veľkej Británii (33 % z celkovej rozlohy zmien), vo Francúzku (31 % z celkovej rozlohy zmien) a v strednej Európe napr. v Maďarsku 31,8 % z celkovej rozlohy zmien). Explanácia príčin identifikovaných zmien si vyžaduje aj detailnejšiu analýzu prírodných a spoločensko-ekonomických súvislostí v jednotlivých krajinách. Ale aj identifikácia výskytu a kvantifikácia zmien LC poskytuje cenné informácie o zmenách európskej krajiny.