



Changes of artificial surfaces in Slovakia 1990-2006

*Ján Feranec, Monika Kopecká, Ján Ořahel, Jozef Novaček
Institute of Geography, Slovak Academy of Sciences, Bratislava, Slovakia*

The aim of this paper is to demonstrate on example of Slovakia:

➤ Possibilities of the use of CORINE land cover (CLC) data for observation of the building process with stress on the CLC classes 11 (urban fabric), 12 (industrial, commercial and transport units), 13 (mine, dump and construction sites) and 14 (artificial, non-agricultural vegetation areas),

➤ The trend of land cover flow urbanization (LCFU) changes focusing on spatial pattern and intensity in the years 1990-2000 and 2000-2006 by means of a map.

- Artificial surfaces allude to all urban growth – they include residential areas, industrial and commercial areas, transport infrastructure, mining areas, dumps, areas under construction, sport and leisure facilities (Molini and Saldago 2012).
- Occupation with subsequent isolation of land by construction is the phenomenon referred to by term “soil sealing” – the EEA glossary (2006) points to implementation with the changing soil properties. Soil becomes an impermeable medium as it is covered by impermeable materials.
- Hasse (2007) reports that during 1992-2002 in the USA as many as 2,080,000 acres of land was built-up annually (3.95 acres/min or 1.6 ha/min).
- Characteristics of changes in artificial surfaces, including soil sealing, are referred to by a common term LCFU (Feranec et al. 2010).

Used data and methods

➤The areas of CLC 1990, CLC 2000 and CLC 2006 classes and their changes are available at <http://terrestrial.eionet.eu.int>

CLC nomenclature (Heymann et al. 1994)

1 Artificial surfaces

11 Urban fabric

- 111 Continuous urban fabric
- 112 Discontinuous urban fabric

12 Industrial, commercial and transport units

- 121 Industrial or commercial units
- 122 Road and rail networks and associated land
- 123 Port areas
- 124 Airports

13 Mine, dump and constructions sites

- 131 Mineral extraction sites
- 132 Dump sites
- 133 Construction sites

14 Artificial, non-agricultural vegetated areas

- 141 Green urban areas
- 142 Sport and leisure facilities

2 Agricultural areas

21 Arable land

- 211 Non-irrigated arable land
- 212 Permanently irrigated land
- 213 Rice fields

22 Permanent crops

- 221 Vineyards
- 222 Fruit trees and berry plantations
- 223 Olive groves

23 Pastures

- 231 Pastures

24 Heterogeneous agricultural areas

- 241 Annual crops associated with permanent crops
- 242 Complex cultivation patterns
- 243 Land principally occupied by agriculture, with significant areas of natural vegetation
- 244 Agro-forestry areas

3 Forest and semi-natural areas

31 Forests

- 311 Broad-leaved forests
- 312 Coniferous forests
- 313 Mixed forests

32 Scrub and/or herbaceous vegetation associations

- 321 Natural grasslands
- 322 Moors and heathland
- 323 Sclerophyllous vegetation
- 324 Transitional woodland-scrub

33 Open spaces with little or no vegetation

- 331 Beaches, dunes, sands
- 332 Bare rocks
- 333 Sparsely vegetated areas
- 334 Burnt areas
- 335 Glaciers and perpetual snow

4 Wetlands

41 Inland wetlands

- 411 Inland marshes
- 412 Peat bogs

42 Maritime wetlands

- 421 Salt marshes
- 422 Salines
- 423 Intertidal flats

5 Water bodies

51 Inland waters

- 511 Water courses
- 512 Water bodies

52 Marine waters

- 521 Coastal lagoons
- 522 Estuaries
- 523 Sea and ocean

- The LCFU represents the change of agricultural (classes 21, 22 and 23) and forest land (classes 31, 32 and 33), wetlands (classes 41 and 42) and water bodies (51 and 52) into urbanized land (construction of buildings designed for living, education ...) as well as industrialized land (for the production, transport ...).
- The smallest identified change area in the frame of the CLC mapping is 5 ha – it is too small to be presented on a map either on the national or European level.
- A solution how to “visualize” such small areas of change is the presentation of their intensity through a regular grid pattern.
- The mean LCFU value presented on map of Slovakia was calculated by summing up all areas within the 1×1 km squares that are characterised by this specific LCF, divided by the number (a sum) of 1×1 km squares where such changes took place – the mean value of LCFU 1990-2000 was 12.9% and LCFU 2000-2006 was 10.2%.

➤ The obtained value of LCFU change in the square was compared with the mean change value of the particular LCFU and it was assigned **red** colour hues if the percentage of the changed parts was greater than the mean change value or hues of **blue** if the percentage of the changed parts was smaller than the mean change value.

G1 – G2: LCFU above mean value – LCFU above mean value

S1 – G2: LCFU below mean value – LCFU above mean value

N1 – G2: Without LCFU – LCFU above mean value

S1 – S2: LCFU below mean value – LCFU below mean value

N1 – S2: Without LCFU – LCFU below mean value

G1 – S2: LCFU above mean value – LCFU below mean value

G1 – N2: LCFU above mean value – Without LCFU

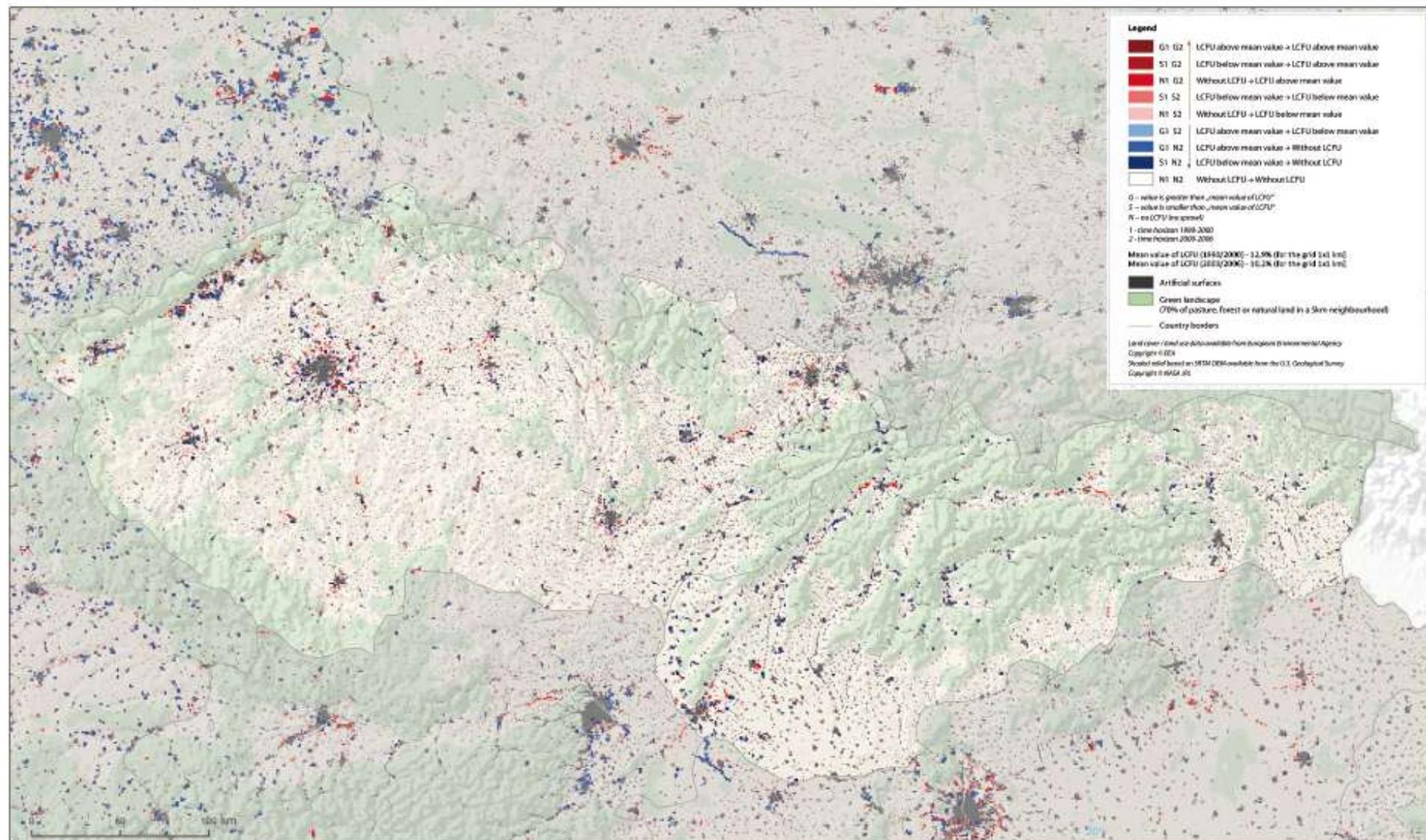
S1 – N2: LCFU below mean value – Without LCFU

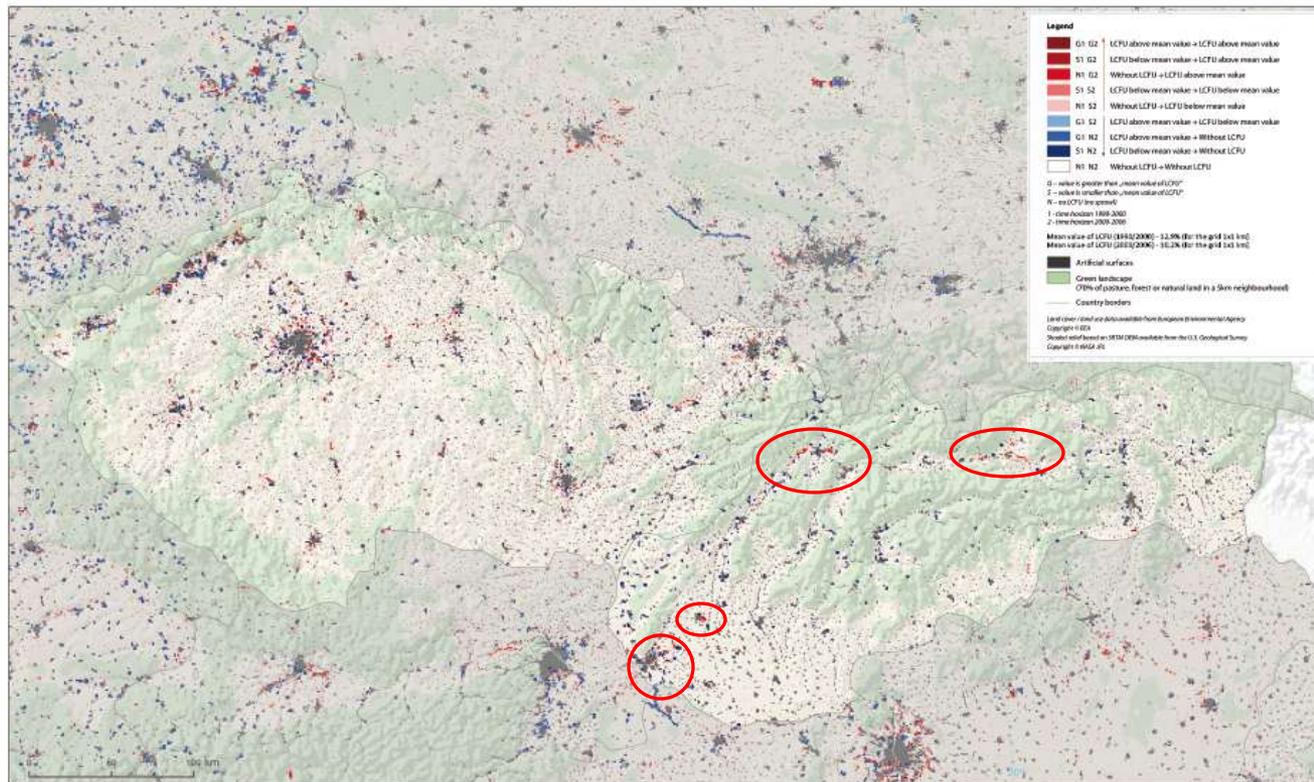
N1 – N2: No LCFU – No LCFU

G – value is greater than the “mean value of LCFU”(changes in favour of LCFU), **S** – value is smaller than the “mean value of LCFU”; **1** – time horizon 1990-2000, **2** – time horizon 2000-2006, **N** – without LCFU identification

Results

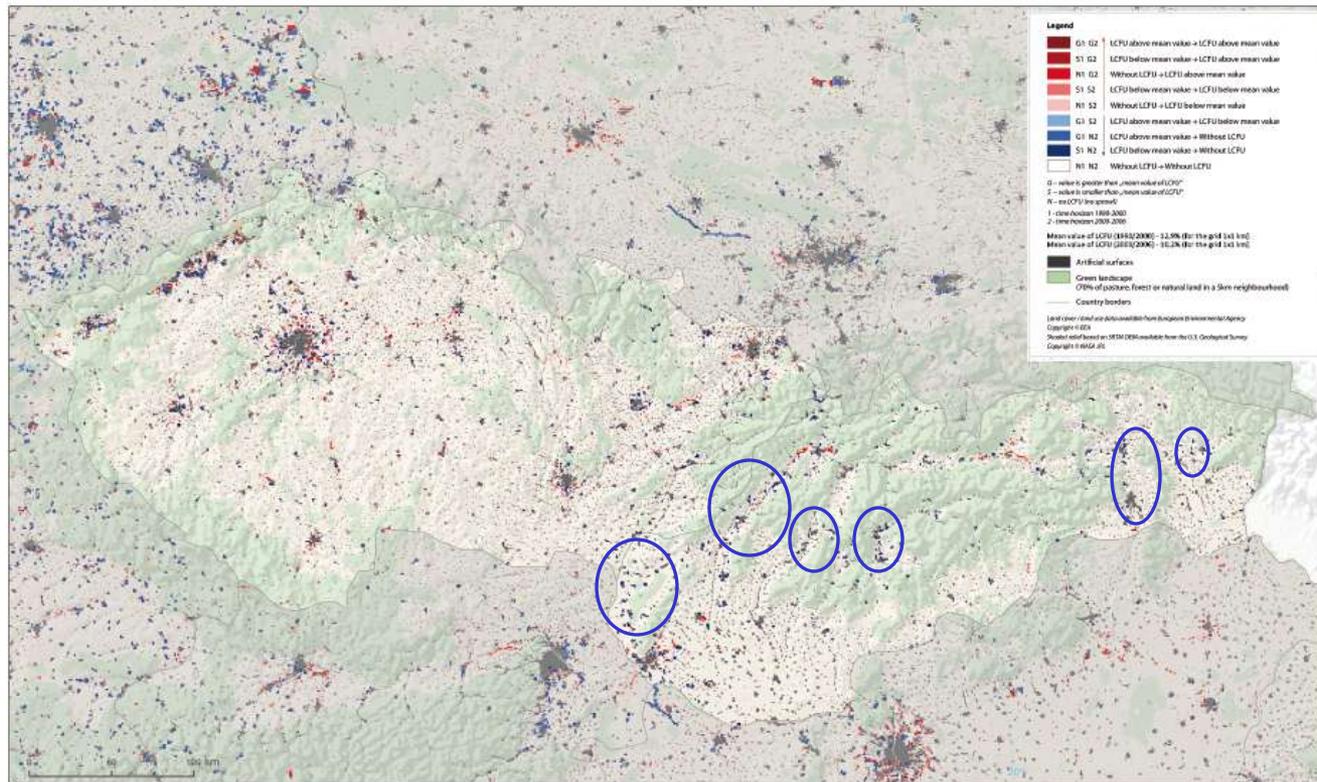
Changes of LCFU (artificial surfaces) in Slovakia in 1990-2000-2006.





The colour differentiation used in the map makes it possible to perceive two basic LCFU trends:

- **G1-G2, S1-G2, N1-G2, S1-S2, N1-S2** (red colour hues) enlargement or standstill of the LCFU – eastern and north-eastern environs of Bratislava, central and upper Považie and eastern parts of Liptovská and Popradská Basins (LCFU increased due to construction of motorway, centres of logistic and residential quarters); environs of Trnava and Žilina (KIA and Peugeot-Citroen car factories); upper Považie, eastern part of the Liptovská and Popradská Basins (construction of road networks and discontinuous urban fabric); enlargement of 112 in the whole of Slovakia with the dominance of its western part.



➤ **G1-S2, G1-N2, S1-N2** (light **blue** to dark **blue**) – decrease of the LCFU rate (decrease of the LCFU rate – decrease in the period 2000-2006 compared to the period 1990-2000) – western and south-western parts of Záhorie, south-east of Bratislava, central Považie, upper Ponitrie, between Zvolen and Banská Bystrica, in the eastern part of the country – environs of Prešov, Košice and Humenné.

LCFU (country)	Area of change (in ha)		% from European yearly change	Area of change (in ha)		% from European yearly change	Difference (in a/year)	Difference and trend (in a/year)
	1990-2000	Yearly in 1990-2000		2000-2006	Yearly in 2000-2006			
Slovakia	5,338	534	0.5%	3,300	550	0.5%	16	3.0%
Europe	980,620	98,062	x	684,884	114,147	x	16,085	16.4%

Table brings the summarizing statistical picture of Slovak LCFU – artificial surfaces in 1990-2006

Expansion of the National Statistics (NS) class “Built-up areas and courtyards” of Slovakia in the period 2000-2006 – **7,754** ha (yearly **1,292** ha).

Possible cause of this difference:

- Only LC changes larger than 5 ha were recorded by CLC methodology; NS records all changes (no area limit); the construction of residential houses above all in urban but also rural settlements (constructed areas were smaller than 5 ha);
- The disparity between the real and legal status of plots that were exempted from the arable land for construction which was not realized for various reasons.

Conclusions:

- Mean annual (1990-2006) increase of LCFU in Slovakia was pronounced 3%.
- Average annual increase of LCFU in Slovakia (3%) represented only one fifth of the pan-European trend (16.4%) in compared period.
- Unification of the content of classes that are parts of CLC and NS classifications will contribute to an increased compatibility of CLC and NS data.
- Map presentation of the changed LCFU, their spatial distribution and their intensity may present a valuable source for the identification and assessment of factors causing landscape changes, not only from the research but also the applied points of view.

Thank you for your attention