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Changes of agricultural landscape in the administrative regions of Slovakia in 1990–2000

Abstract: *The paper shows the results of analysis and assessment of the changes in the agricultural landscape in Slovakia in the years 1990–2000, obtained through identification of the transfers from the CORINE land cover class 211 (arable land) in favour of classes 231 (pastures) and 242 (complex cultivation patterns). The area of class 242 increased by 13,111.7 ha, mainly in the hinterland of rural settlements of northern and central Slovakia and in the viticultural regions of south-western Slovakia. The cause of this change lies in restitution of farmland and its lease to new private farmers. The area of class 231 increased at the cost of the class 211 by 4,530.9 ha. This change was observed in almost all districts of mountain and sub-mountain regions of Slovakia and primarily it is due to the transformation in the agrarian policy of the State after 1989.*

Key words: *CORINE land cover, land cover change, agricultural landscape, Slovakia*

Introduction

Different approaches from the domain of geoinformatics (such as interpretation of remote sensing data, application of GIS, etc.) make it possible to obtain subject-oriented information about landscape. The CORINE (Coordination of Information on the Environment) land cover database (CLC, Heymann *et al*. 1994) from the years 1990 and 2000 produced by application of Landsat satellite images is considered to be an important information source concerning the contemporary landscape of 29 European countries (Büttner *et al.* 2004). Contemporary landscape is covered by the CLC database by means of land cover classes.

Land cover represents a materialized projection of the natural spatial assets (morphopositional and bioenergetic) and at the same time, the reflection of the contemporary land use i.e. by man (society), involving the recreated cultivated objects or created artificial objects of landscape (Oťaheľ and Feranec 1999).

Land cover is interpreted in this sense as an important information source about contemporary landscape, which can be used first of all in the assessment, as well as in decision-making and planning processes (Oťaheľ *et al*. 2004).

Land cover is an immanent part of the landscape system and also a good indicator of numerous processes connected with natural conditions and the impact of various human activities carried out within it. Nowadays, the impact of changes induced by humans gained such a magnitude as to be perceived as global. Conform to Turner (2002), it can be stated that there remain no such places on the Earth where human impact is absent.

Especially distinct and relatively easily distinguishable on the satellite images is the impact on landscape resulting from farming. Its intensity increases with the increasing intensification of agriculture focused on production.

Agricultural landscape represents an important part of the rural space in the central European countries. It is concentrated in the so-called basins of Slovakia around the settlements and it often indicates a reduction of land use intensity with increasing distance from centres.

The aim of this paper is to present the results of analysis and assessment of agricultural landscape changes in Slovakia for the period 1990–2000 by means of the transfer of areas under CLC class 211 (non-irrigated arable land) in favour of classes 231 (pastures) and 242 (complex cultivation pattern), see Table 1. Authors consider these changes one of the indicators, whose knowledge contributes to comprehension of the respective trend in the development of agricultural landscape.

The data applied and the method

Land cover change is understood as a categorical change – conversion of one of its classes, or its part, into another class (Coppin *et al*. 2004, Feranec *et al*. 1997). Changes of CLC class 211 into CLC classes 231 and 242 that are a part of agricultural landscape (see Table 1, Heymann *et al*. 1994, Bossard *et al*. 2000) are identified, analysed and assessed in the study.

The CLC nomenclature is mainly based on physiognomic attributes (shapes, size, colour, texture and pattern) of landscape objects, that are natural, cultivated and artificial, as well as on cognition of spatial relationships of the landscape objects (Feranec *et al*. in print). Obviously, identification of the man-made land cover requires source material about the features that are characteristic for land use. This is especially true of land cover classes in the agricultural landscape where partially cultivated and recreated objects call for correct identification by means of satellite images and field checking accompanied by the ancillary data use.

Parts of the *non-irrigated arable land* (211) (Heymann *et al*. 1994, Bossard *et al*. 2000, Feranec and Oťaheľ 2001) are areas where cereals, legumes, root crops, and fodder crops (such as alfalfa, etc.) are grown. This land cover class

Table 1. CORINE land cover nomenclature

1 Artificial surfaces	**3 Forest and semi-natural areas**
11 Urban fabric	*31 Forests*
111 Continuous urban fabric	311 Broad-leaved forests
112 Discontinuous urban fabric	312 Coniferous forests
12 Industrial, commercial and transport units	313 Mixed forests
121 Industrial or commercial units	*32 Scrub and/or herbaceous vegetation associations*
122 Road and rail networks and associated land	321 Natural grasslands
123 Port areas	322 Moors and heathland
124 Airports	323 Sclerophyllous vegetation
13 Mine, dump and constructions sites	324 Transitional woodland-scrub
131 Mineral extraction sites	*33 Open spaces with little or no vegetation*
132 Dump sites	331 Beaches, dunes, sands
133 Construction sites	332 Bare rocks
14 Artificial, non-agricultural vegetated areas	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 Arable land	*41 Inland wetlands*
211 Non-irrigated arable land	411 Inland marshes
212 Permanently irrigated land	412 Peat bogs
213 Rice fields	*42 Maritime wetlands*
22 Permanent crops	421 Salt marshes
221 Vineyards	422 Salines
222 Fruit trees and berry plantations	423 Intertidal flats
223 Olive groves	**5 Water bodies**
23 Pastures	*51 Inland waters*
231 Pastures	511 Water courses
24 Heterogeneous agricultural areas	512 Water bodies
241 Annual crops associated with permanent crops	*52 Marine waters*
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

Source: Heymann *et al.* 1994, Bossard *et al.* 2000

includes also gardens growing (also under foil or glass) flowers, medicinal herbs, seedlings of trees, vegetables and fallows. This class also includes all seasonally irrigated fields in Slovakia.

Pastures (231) according to definitions of Heymann *et al.* (1994), Bossard *et al.* (2000) and Feranec and Oťahel' (2001) represent the mowed and grazed grassland areas – permanent, temporary and artificial pastures which are not covered by the field rotation system. The class also includes areas of abandoned land overgrown by herbaceous associations that is not used for more than three years (Bossard *et al.* 2000).

Complex cultivation pattern (242) represents the areas formed by juxtaposed parcels (smaller than 25 ha) with annual and permanent crops (for instance, juxtaposition of small arable land parcels with those of grassland, orchards and vineyards.). This class also includes small garden colonies next to towns and small parcels of permanent cultures and fields next to rural settlements (Heymann *et al*. 1994, Bossard *et al*. 2000, Feranec and Oťaheľ 2001).

The method of identifying land cover changes consisted of the following steps (Feranec *et al*. 2005):

- georeferencing, mosaic definition, preparation of synthesis in false colours composites (452-RG) and splitting of the Landsat 7 ETM satellite images from 2000 (IMAGE2000) according to the map sheet sequence at the scale of 1:100 000;
- check and corrections of the CLC90 data layer by application of computer aided visual interpretation of satellite images in the PC ArcView 3.2a environment;
- preparation of source material for identification of CLC2000 land cover (vector data, aerial orthophotomaps of the territories under clouds and topographic maps) and their distribution according to topographic map sheet sequence at the scale of 1:100 000;
- identification of CLC2000 classes by modification of the source material produced from CLC90 by means of Landsat ETM satellite images from 2000 (IMAGE2000) through application of computer aided visual interpretation. Interpretation criteria were: the minimum area of the identified area change in the initial CLC2000 layer compared to its appearance at IMAGE2000 was 5 hectares, the minimum identified width of changes was 100 m, and the area of the newly identified area had to be at least 25 hectares. Theoretically there were four possible changes with regards to the initial CLC90 data layers and the IMAGE 2000 layer: change of the area content, enlargement and diminution of the area, disappearance of the area and formation of a new area;
- mosaic definition for the individual land cover segments of Slovakia for the period 1990–2000 by the GIS overlay of CLC90 and CLC200 data layers with emphasis on identification of conversion from class 211 to classes 231 and 242 (Table 2);
- thematic verification, check of geometry and application of control procedures and tests;
- assessment of identified transfers from the CLC class 211 to classes 231 and 242.

Results and discussion

The analysis of land cover changes in Slovakia (Feranec *et al*. 2005) shows for the period 1990–2000 distinct changes in agricultural landscape. More detailed characteristics of conversion of CLC class 211 into classes 231 and 242 have also been obtained. The scope of these changes according to administrative dis-

Table 2. Transformation of agricultural landscape ("211") into pastures ("231") and complex cultivation patterns ("242") in the years 1990–2000

District	Area of "211" (in hectares) in 1990 (CLC90)	Area transferred from "211" to "231" (in hectares) by 2000 (CLC2000)	Area transferred from "211" to "242" (in hectares) by 2000 (CLC2000)
Bánovce nad Bebravou (BN)	15631.5	108.5	0.0
Banská Bystrica (BB)	7051.1	70.4	87.9
Banská Štiavnica (BS)	1993.7	0.0	0.0
Bardejov (BJ)	23745.3	359.4	0.0
Bratislava I (BA I)	0.0	0.0	0.0
Bratislava II (BA II)	3553.5	0.0	0.0
Bratislava III (BA III)	785.9	0.0	0.0
Bratislava IV (BA IV)	2876.7	0.0	0.0
Bratislava V (BA V)	4825.5	30.9	0.0
Brezno (BR)	8635.7	131.4	365.3
Bytča (BY)	2975.7	0.0	0.0
Čadca (CA)	3064.1	70.5	253.0
Detva (DT)	6285.3	196.7	355.9
Dolný Kubín (DK)	2605.9	35.3	121.7
Dunajská Streda (DS)	79700.7	0.0	0.0
Galanta (GA)	51539.2	0.0	231.3
Gelnica (GL)	1947.2	0.0	0.0
Hlohovec (HC)	17116.1	14.8	25.1
Humenné (HE)	14906.8	0.0	0.0
Ilava (IL)	6597.9	40.7	0.0
Kežmarok (KK)	18321.3	193.1	301.9
Komárno (KN)	83307.6	0.0	206.3
Košice – okolie (KS)	62237.0	85.2	0.0
Košice I (KE I)	589.2	0.0	0.0
Košice II (KE II)	3977.5	0.0	0.0
Košice III (KE III)	245.7	0.0	5.4
Košice IV (KE IV)	3287.9	0.0	9.6
Krupina (KA)	19291.7	0.0	0.0
Kysucké Nové Mesto (KM)	1376.9	9.3	89.6
Levice (LV)	99384.4	0.0	439.0
Levoča (LE)	10970.7	84.3	5.7
Liptovský Mikuláš (LM)	17876.8	269.2	509.5
Lučenec (LC)	26728.1	102.0	0.0
Malacky (MA)	30649.0	12.4	35.9
Martin (MT)	14294.4	37.5	437.3
Medzilaborce (ML)	5486.2	27.8	0.0
Michalovce (MI)	61715.1	381.6	0.0
Myjava (MY)	14314.1	49.9	0.0

Námestovo (NO)	11289.4	301.6	3499.7
Nitra (NR)	63810.5	0.0	839.8
Nové Mesto nad Váhom (NM)	20097.8	0.0	0.0
Nové Zámky (NZ)	101377.1	0.0	461.5
Partizánske (PE)	12365.1	0.0	0.0
Pezinok (PK)	12582.3	0.0	217.8
Piešťany (PN)	22749.9	5.7	36.7
Poltár (PT)	11134.9	61.7	0.0
Poprad (PP)	16410.1	72.6	26.0
Považská Bystrica (PB)	5699.1	40.6	252.7
Prešov (PO)	35721.7	0.0	17.1
Prievidza (PD)	19153.9	108.8	250.5
Púchov (PU)	5433.5	0.0	71.4
Revúca (RA)	13130.4	0.0	0.0
Rimavská Sobota (RS)	53891.4	15.6	0.0
Rožňava (RV)	15658.6	13.2	0.0
Ružomberok (RK)	3828.6	0.0	54.4
Sabinov (SB)	15834.5	163.0	325.6
Senec (SC)	28688.0	0.0	28.3
Senica (SE)	37316.5	0.0	29.5
Skalica (SI)	21954.3	0.0	269.5
Snina (SV)	6772.6	0.0	167.8
Sobrance (SO)	23655.5	27.9	0.0
Spišská Nová Ves (SN)	13503.8	11.1	0.0
Stará Ľubovňa (SL)	10569.0	150.8	0.0
Stropkov (SP)	7863.6	175.1	0.0
Svidník (SK)	12111.4	43.8	0.0
Šaľa (SA)	29886.7	0.0	100.7
Topoľčany (TO)	34948.6	0.0	0.0
Trebišov (TV)	67742.6	62.4	27.9
Trenčín (TN)	18352.3	25.5	0.0
Trnava (TT)	51191.7	0.0	111.4
Turčianske Teplice (TR)	10119.5	41.4	36.8
Tvrdošín (TS)	6297.7	390.7	2052.5
Veľký Krtíš (VK)	34474.1	73.7	213.1
Vranov nad Topľou (VT)	29134.5	0.0	0.0
Zlaté Moravce (ZM)	20842.5	109.6	27.7
Zvolen (ZV)	15411.5	198.3	0.0
Žarnovica (ZC)	2510.1	36.9	75.1
Žiar nad Hronom (ZH)	8610.5	52.9	25.5
Žilina (ZA)	13922.7	37.3	412.8
Total	**1675939.5**	**4530.9**	**13111.7**

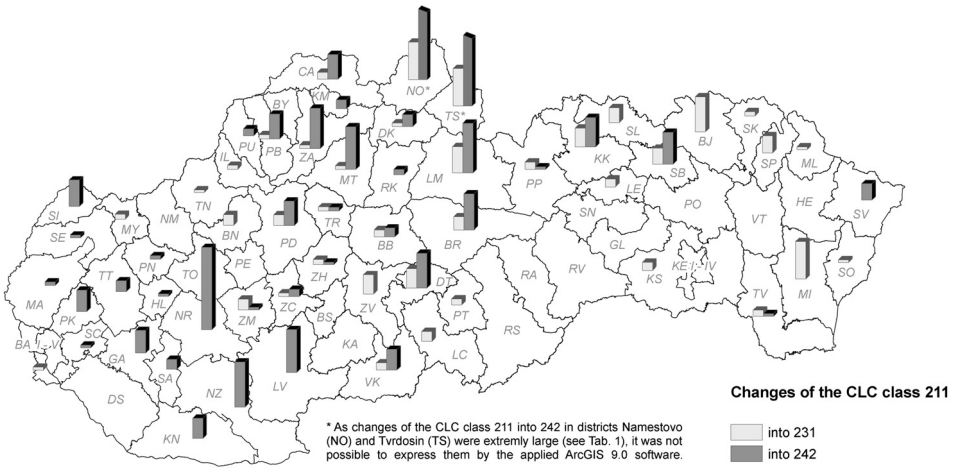

Figure 1. Transformation of the CLC 211 class into classes 231 and 242 according to administrative districts of Slovakia

tricts of Slovakia is presented in Table 2 and Figure 1 (the changes smaller than 20 hectares were not shown on the map).

Scope and occurrence of transfers from CLC class 211 (agricultural landscape) to class 242 (complex cultivation patterns)

As far as scope and occurrence of this type of change, four regions were identified in Slovakia.

The first region comprises two districts of northern Slovakia: Námestovo (area transferred: 3,499.7 ha) and Tvrdošín (2,052.5 ha). The rate of identified change in these districts distinctly surpasses its scope in other districts of Slovakia. It consists of the change of arable land into grasslands, which form together the pattern of juxtaposed parcels smaller than 25 hectares of classes 211 and 231. This tendency was also confirmed by official statistical data (for the years 1987-2001), presented in Table 3. They show that the area of arable land in Námestovo decreased by 1,259 hectares and the area of meadows and pastures increased by 1,152 hectares and the area of arable land in Tvrdošín decreased by 939 hectares, while the area of meadows and pastures increased by 876 hectares. It should be noted that grassland areas quoted by the national statistics are larger as they contain all grassland parcels regardless of the size. The CLC class 231 area though, contains only the grassland areas larger than 25 hectares, with the grassland areas smaller than 25 hectares being mostly included in the CLC class 242.

Figures 2 and 3 represent the occurrences of the changes mentioned in the framework of the first region. The resumed way of the tillage as it had been before collectivisation by the owners and the lease to private farmers are considered the causes of this change.

Table 3. Areas of arable land (AL) and pastures (P) and their changes in the districts of Námestovo and Tvrdošín in the years 1987–2000 (in hectares)

District	1987		2001		Change	
	AL	P	AL	P	AL	P
Námestovo	7591	22971	6332	24123	-1259	+1152
Tvrdošín	4095	16970	3156	17846	-939	+876
Total	11686	39941	9488	41969	-2198	+2028

Source: Overview of the total land use value in cadastres of the Slovak Republic, 1987, 2001. Institute of Geodesy and Cartography, Bratislava.

The second region comprises the districts of northern, north-western and central Slovakia: Liptovský Mikuláš (transfer of 509.5 ha), Martin (437.3 ha), Žilina (412.8 ha), Brezno (365.3 ha), Detva (355.9 ha), Čadca (253 ha), Považská Bystrica (252.7 ha), Prievidza (250.5 ha), Veľký Krtíš (213.1 ha), and Dolný Kubín (121.7 ha) (Table 2 and Figure 1).

The CLC class 242 areas, newly formed at the expense of class 211, represented by the pattern of juxtaposed grassland and arable land parcels also occur in this region. Part of the 242 class pattern may also consist of juxtaposition of arable land with vineyard parcels (smaller than 25 hectares) in district Veľký Krtíš. As in the preceding case, restitution of farmland by original owners and its lease to private farmers, who changed the way of tillage introduced by the collective farming, are considered the main cause of class 211 conversion to class 242.

The third region is represented by the districts of western and south-western Slovakia which occupy above all the lowland and mountain basin landscape (with the scope of change larger than 100 hectares): Nitra (840 ha of change), Nové Zámky (461.5 ha), Levice (439 ha), Skalica (269.5 ha), Galanta (231.3 ha), Pezinok (217.8 ha), Komárno (206.3 ha), Trnava (111.4 ha) and Šaľa (100.7 ha) (Table 2 and Figure 1). The CLC class 242 patterns in this region that were formed at the expense of the CLC class 211 consist of new garden colonies around towns, alternating with the newly established small parcels of vineyards and arable land. Restitution and lease of farmland are the decisive reasons of the changed way of tillage and hence conversion of class 211 into class 242.

The fourth region comprises three districts of northern and north-eastern Slovakia: Sabinov (with the extent of change of 325.6 ha), Kežmarok (301.9 ha), and Snina (167.8 ha). In this part of Slovakia, like in the first two regions, the newly formed CLC class 242 pattern is the alternation of small arable land parcels and grassland. Again, restitution of farmland by original owners and its lease to private farmers, who changed the way of tillage introduced by the collective farming, are considered the main causes of the described change.

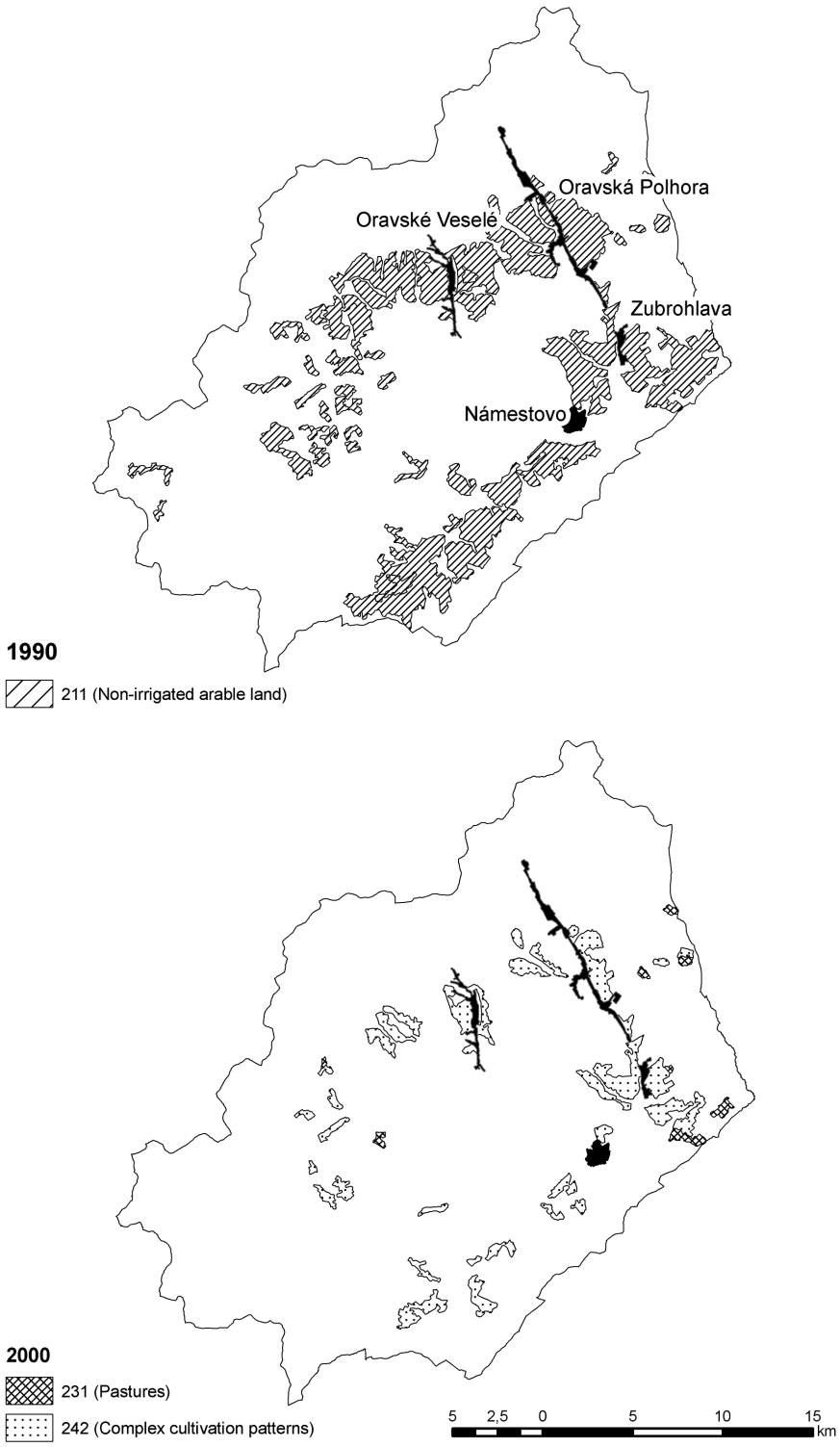

Figure 2. Occurrence of the transfer from the CLC class 211 to classes 231 and 242 in the district of Námestovo

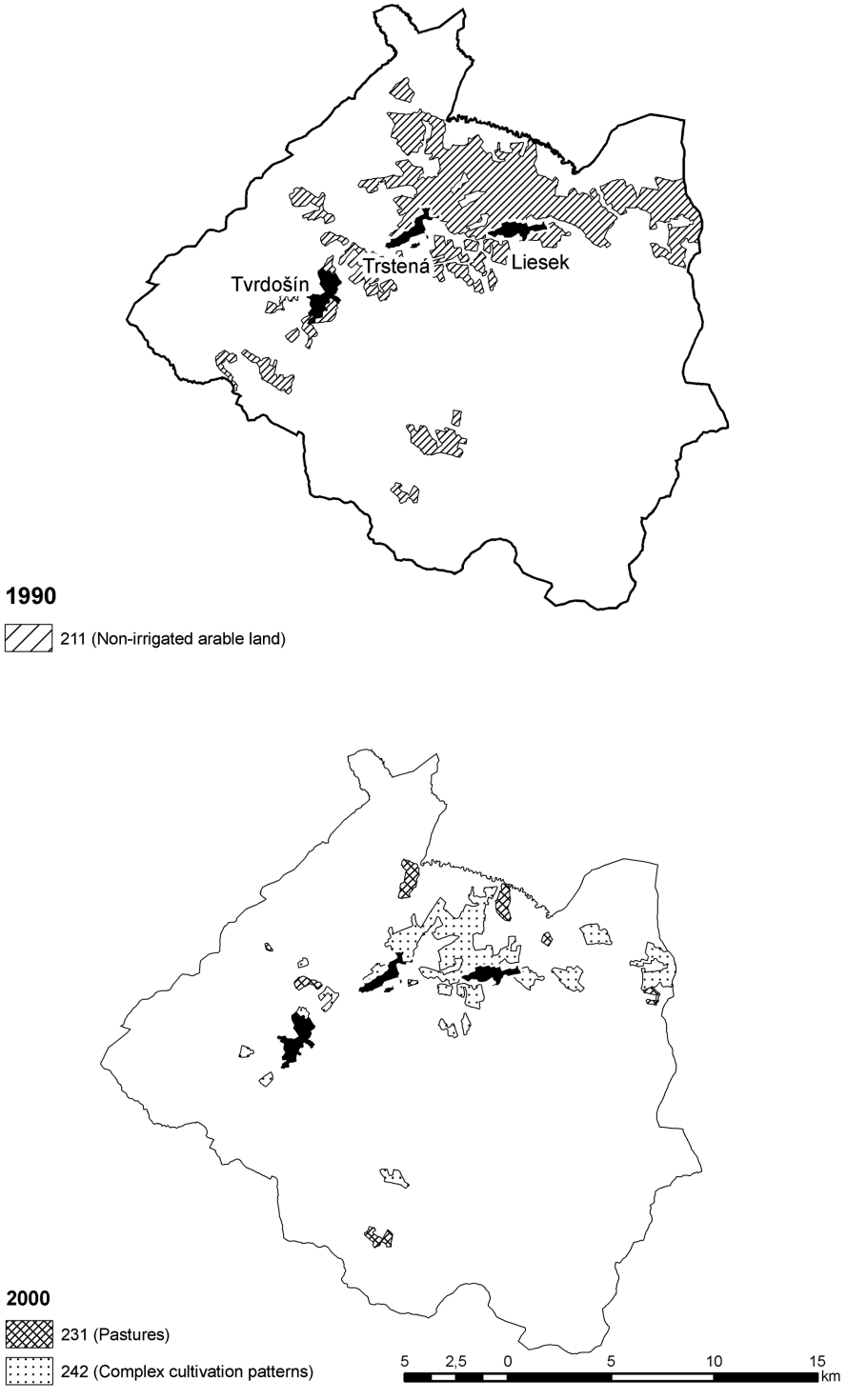

Figure 3. Occurrence of the transfer from the CLC class 211 to classes 231 and 242 in the district of Tvrdošín

Scope and occurrence of transfers from CLC class 211 (agricultural landscape) to class 231 (pastures)

This change type, connected with extensive farming, was identified above all in mountain and sub-mountain areas and in the lowland and basin landscapes of southern and south-eastern Slovakia (see Figure 1 and Table 2). Such changes, with the extent larger than 100 hectares, have been observed in the districts of: Tvrdošín (390.7 ha), Michalovce (381.6 ha – this district being located in the lowland landscape), Bardejov (359.4 ha), Námestovo (301.6 ha), Liptovský Mikuláš (269.2 ha), Zvolen (198.3 ha), Detva (196.7 ha), Kežmarok (193.1 ha), Stropkov (175.1 ha), Sabinov (163 ha), Stará Ľubovňa (150.8 ha), Brezno (131.4 ha), Zlaté Moravce (109.6 ha), Prievidza (108.8 ha), and Bánovce nad Bebravou (108.5 ha). The basic cause of the identified second distinct trend, consisting in conversion of arable land into meadows and pastures was the change of the agrarian policy after 1989. The modified policy of subsidies to agriculture, new situation on the agricultural product market in eastern and central Europe, introduction of market mechanism in the economy, etc., also led to the abandonment of land or change of arable land into grassland.

For example, the economically demanding cultivation of feedstuffs on arable land turned out to be inefficient in view of the possibility to raise cattle and sheep in a traditional manner – by grazing over a larger part of the year. The abandoned land overgrown by herbaceous formations was classified as the CLC class 231.

The issue of assessing the precision of results remains open. The CLC Technical Team carried out the preciseness check of the identified land cover changes. The applied method of checking the preciseness of the CLC2000 and CLC90/2000--changes data layers relied on visual assessment of about 8% of the territories of individual countries which participated in the I&CLC2000 Project. The verification units (10x10 km area), and parts of working units, were especially scrutinized. The position of verification units was determined on the basis of the following criteria: volume of land cover changes, diversity of the CLC class changes and diversity of the landscape types (Feranec *et al*. 2005). It is necessary to enhance the possibilities of obtaining relevant information through field checking and the use of topical field images obtained, for instance from the LUCAS (Land Use/Cover Area frame Survey) Project.

When comparing the CLC data layers with the national statistics, the existing differences, resulting from application of different methods in data acquisition, must be accounted for.

Conclusions

Making the CLC90, CLC2000 and CLC90/2000-changes data layers of 29 European countries (Büttner *et al*. 2004, for data and information concerning Slovakia visit http://atlas.sazp.sk) accessible has provided new possibilities for

analysis of trends, causes and consequences of natural and social processes, which take place in landscape and for assessment of its ecological stability at the all-European, national or regional levels. Such information constitutes input into different environmentally oriented projects and becomes an indispensable component for landscape management.

As far as the scope and significance are concerned, conversion of class 211 into class 231 (4,530.9 ha) and class 242 (13,111.7 ha) can be considered relevant when speaking about agricultural landscape.

A distinct enlargement of the area of the complex cultivation pattern (242) in the hinterland of rural settlements in the northern and central Slovakia is due to the restitution of farmland by original owners and its lease to private farmers.

Enlargement of the area of the CLC class 231 at the cost of the CLC class 211 is the consequence of the modified policy of subsidies to agriculture, introduction of market mechanism in the economy, etc. Occurrence of this change was observed in almost all districts of mountain and sub-mountain regions of Slovakia. This trend of grassland area enlargement at the cost of arable land conforms to the strategy of the *Rural Development Plan,* also supported by the EU.

The work here reported focused on application of the CLC90, CC2000 and CLC90/2000-changes data layers with participation of numerous European countries, so as to allow for the assessment of regional differences in the development of agricultural landscape in different natural and socio-economic settings of Europe.

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