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LAND USE CHANGES OF HISTORICAL STRUCTURES IN THE AGRICULTURAL LANDSCAPE AT THE LOCAL LEVEL — HRIŇOVÁ CASE STUDY

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Abstract

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The aim of this paper is to describe agricultural landscapes in the cadastral area of Hriňová and their development in the context of social and economic changes over the past 60 years. This area is characterized by the occurrence of historical structures of agricultural landscape (HSAL) which are important because they comprise various cultural, environmental and ecological aspects. The assessment of land use changes on the two scales of cadastral area and selected small localities highlights that the most important trend here is agricultural extensification. The results show that despite these changes in land use, the historical structures in the agricultural landscape represented by forms of anthropogenic relief remain a permanent part of this research area.

Key words: historical structures in the agricultural landscape, spatial pattern, landscape structure, forms of anthropogenic relief, land use.

Introduction

For the purpose of planning nature and landscape conservation, it is necessary to know the development of land use changes in order to identify the areas' conflicts with economic use. The spatial structure of the landscape, thus defining its shape and distribution, provides specific characteristics which enable characterization of any chosen part of the landscape.

Landscape is a mosaic where the mixture of local ecosystems or land uses is repeated in similar form over a kilometer-wide area (Forman, 1997), and it differs structurally in the distribution of species, energy and materials (Forman, Godron, 1986). At the same time, the land cover types on a regional scale remain close to the basic categories of the land use. Most landscapes have been influenced by anthropogenic use, and the resulting landscape mosaic is a mixture of natural and human-managed patches which vary in size, shape, arrangement, and which result from complex interactions between physical, biological and social forces (Turner, 1989). Wu and Hobbs (2002) identified land cover and land use as major research topics because these rank among the most important and challenging research areas in landscape ecology.

Anthropogenic impacts since the early 19th century and particularly during the 20th century, have considerably disturbed the state of equilibrium of the landscape and have resulted in rapid landscape change, in loss of diversity and ecological capacities and also in damage to historically valuable cultural landscapes (Petit, Lambin, 2002; Van Eetvelde, Antrop, 2004; Bastian et al., 2006; Demek et al., 2008). The rapidity and magnitude of landscape changes strongly accelerated population increase and a growth in urban areas (Antrop, 2005). The changes are exacerbated by changing values, policy and economics which have adversely affected the cultural landscape (Holl, Nilsson, 1999). The intensity of these combined factors on landscape mosaics has had significant impact on landscape stability. Bastian and Bernhadt, (1993) and Miller et al., (1997) consider that biotic components are the most sensitive indicators of such landscape changes.

Agricultural land has recently begun to be perceived not only as a source of food, but also its non-productive functions have become increasingly highlighted. Environmentally friendly use of agricultural land is paramount, and its significant biotic components such as non-forest woody vegetation must be preserved to maintain its cultural, environmental and ecological aspects (Deckers et al., 2005).

As already mentioned, the landscape has changed dramatically in the last 200 years. The extent of these changes can be significantly documented when the focus is placed on linear and point features of the landscape, which play an important part in maintaining the diversity of the landscape. Linear tree structures related to production began to emerge in the 18th and 19th centuries, forming boundaries, shelter and sources of wood and other products. Western Europe is characterized by hedgerows which contribute to the visual and cultural value of the landscape and to diversity in field and typical network patterns (Burel, Baudry, 1995). In the Czech Republic, hedgerow-defined field patterns called pluzinas date back to the Late Middle Ages. This term, in medieval Czech, means "agricultural land belonging to one village", thus defining its crop fields, meadows, pastures and roads (Gojda, 2000; Sklenička et al., 2009). Similar developments in agricultural landscape structure have now been recorded in Slovakia (Hreško et al., 2010). Transformation of the cultural landscape and land use changes of the agricultural landscape in Slovakia were studied by Boltižiar, Chrastina, 2008; Blažík et al., 2011; Muchová et al., 2010.

On the whole, traditional cultural landscape represents a specific, temporally limited and spatially shrinking subtype of landscape structures. These have a fragmentary nature, as they are remnants of the former continuous landscape. Such landscape elements create a mosaic of extensively used small-scale landscape features of arable lands and permanent agricultural crops. It also comprises permanent grasslands including meadows, grasslands and abandoned orchards which are currently unused areas with a low degree of succession, and referred to as Historical Structures of the Agricultural Landscape (HSAL). The traditional cultural landscape has an impact on a wide range of landscape features which determine their sustainable use (Štefunková, Dobrovodská, 2009). A characteristic feature of HSAL is the occurrence of Forms of Anthropogenic Relief (FAR), which improve the soil-relief features. These include terraces and graded bounds which ameliorate "de-skeletonized" soils during plowing, and the accumulation of stone heaps and mounds with varying degrees of earthing (Ružičková et al., 1999).

The studied area forms a specific type of settlement — the dispersed settlement (Petrovič, 2006), which was preserved during socialism and retains elements of the traditional cultural landscape. This area is interesting and specific in many ways, and ongoing research there is presented in several works (Oláh, 2003; Kunca et al., 2008; Oláh, Boltižiar, 2009).

The aim of this paper is to evaluate the development of land use in an area with specific HSAL on two levels. The first level determines the trends in landscape development of the entire Slovakian cadastral area of Hriňová, and the second provides detailed mapping of this area in four selected localities.

Study area

The specificity of the cadastral area of Hriňová city lies in maintaining the format of dispersed settlements with relatively original landscape structure. Maintainance of the traditional form of farming and unique landscape is due to the fact that this area was unaffected by agricultural collectivization following World War II.

The city of Hriňová lies in the northeastern part of the Zvolenská kotlina basin and is administratively part of the Banská Bystrica region and the Detva district. The model area is in the dispersed settlement situated on the deforested southern slopes of the Detvianske vrchy foothills and the western slopes of the Sihlianska planina plain in the area of Korytárky — Jasenovo. This cadastral area covers 12,643.84 hectares.

Four research areas which included all forms of anthropogenic relief were chosen for detailed mapping in the Hriňová cadastral area. In-depth research was conducted in the following research areas:

1. Hriňová–Blato (HB) — the mosaic of landscape elements here is created by arable land parcels and permanent grasslands which have varying degrees of use and several forms of anthropogenic relief,
2. Hriňová–Mesto (HM) — this locality is composed of mosaics of mostly fallow arable land modified into terraces together with permanent extensively-used sloped grasslands lacking anthropogenic relief forms,
3. Hriňová–Snohy (HS) — this area is currently dominated by extensively used permanent grasslands and small-scale landscape elements of arable land with graded bounds,
4. Hriňová–Krivec (HK) — this is an area dominated by mosaics of narrow-belt arable land and permanent grasslands with graded bounds and varying degrees of usage (Fig. 1).

Methods

Digitalization of the spatial data defining individual forms of land use was performed using the "on screen" method. It was conducted manually according to the analogue (visual) interpretation of maps and aerial orthophotos in the ArcView GIS environment.

Historical black and white (panchromatic) aerial photos from 1949 were utilized for the first period. These were provided by the Topographic Institute of the Slovak Army in Banská Bystrica. Unlike the processes used in historical maps, ortho-rectification here was performed in a digital photogrammetric system ("Orthobase" module of ERDAS IMAGINE 8.4 program) environment, using the affinity transformation method. Altitude values of a detailed digital model of terrain were acquired by digitalization of contour lines from topographic maps in the scale of 1:10 000. Orthophotos were created following triangulation of these photographs, and these were then transformed into orthophoto mosaics and interpreted by the comparison with topographic maps from 1956, in the scale of 1:25,000. Current land use in 2010 was interpreted using basic 1992—1993 maps of the Slovak Republic in the scale of 1:10,000 and from 2002/2003 orthophotos in the scale of 1:5,000 (Orthophotomaps © Geodis Slovakia, s.r.o, 2003; Aerial photograph and digital orthophotomaps © Eurosense s.r.o, 2003) verified by reconnaissance field survey). The secondary landscape structure of the Hriňová cadastral area was evaluated using the legend created for the Corine Land Cover project in 2000 (Feranec, Oťaheľ, 2001). The legend for mapping localities was modified and adjusted with identifiable units at a scale of 1:2,000 (Table 1).

Fig. 1. Location of the research area.

Interpretation of changes in land usage was based on expert assessment of all possible combinations of land cover changes identified while comparing the map layers from two time periods (Olschofsky et al., 2006). This transformation key was then used in an algorithm, which assigned a corresponding code for the type and pressure of the given change to each record in the spatial database. This resulted in the interpretation of land changes between 1949 and 2010.

The last step comprised evaluation of configuration indicators in individual time horizons. These reflect the spatial character and physical distribution of all objects in the landscape. Spatial analyses of the landscape were conducted using the specialized Patch Analyst 2.2 (McGarigal, Marks, 1995) statistical program and they were performed using the following landscape metrics: number of patches (NP), mean patch size (MPS), total edge (TE), mean patch edge (MPE), mean shape index (MSI), Shannon´s diversity index (SDI), Shannon´s evenness index (SEI).

T a b l e 1. Selected land-cover categories in the four localities — on a local scale.

Main category	Code	Sub-category
1 Forest and semi-natural areas	11 12 13 14 15	small woods solitary tree occurrence of forest trees which cover more than 50 % of the surface occurrence of forest trees which cover less than 50 % of the surface groups of scrub and trees
2 Pastures	21	grasslands
3 Agricultural areas	31 32 33 34	small-scale arable fields outfield gardens orchards
4 Transport units	41	field paths (Unpaved roads)
5 Traditional forms of anthropogenic relief	51 52 53 54 55	graded bounds bounds terraces rocky mounds with scrubs and trees muddy-rocky mounds with scrubs and trees

Results

When evaluating types of land use changes in the cadastral area of the city of Hriňová between 1949 and2010, besides unchanged parts, 8 types of changed usage were identified — deforestation, afforestation, agricultural intensification, agricultural extensification, urbanization, de-urbanization, overgrowth and flooding. However, the studied area may still be considered stable in terms of usage, as the major part of the territory retained its mainly forest-economic use. Some areas with extensive meadow grazing and small areas of arable land have preserved their same use (Table 2).

The second most extensive type of change was agricultural extensification, which was reflected in the south-western more intensively used part of the studied area. It concerned mainly transformations of small arable lands into permanent grasslands, and overgrowth of less accessible meadows into pastures. Agricultural extensification also quite significantly influenced isolated agricutural parts of the area. Agricultural extensification was identified in 1,403 ha which is 11.1% of the total cadastral area. The opposite trend of agricultural intensification took place in a much smaller area, where it mainly involved change of pastures into meadows and the transformation of meadows near houses into arable land.

In terms of size, the next trend was the afforestation area. This covered 392 ha (3.11% of the total area) and resulted from afforestation of marginal, less accessible and isolated pastures and meadows. Deforestation took place in only 40 ha (0.32%). This involved forests cut down near watercourses, and its effect was most apparent in vegetation on the bank of Slatina river.

Urbanization in this cadastral area was also a dominant trend in this landscape, especially in the central part of Veľký Slanec. This occurred in 265 ha (2.1% of the cadastral area) and the main factor here was development of industrial production in the city. To improve the accessibility of citizens to work, a lot of urban-type public housing was built in the following localities; Krivec I, Krivec II, Malý Slanec and Veľký Slanec. This created more dominant centres with infrastructure and services.

Although flooding was limited to a small area, its indirect impact is much more significant. The Hriňová reservoir on the Slatina river created a visually dominant element in this

T a b l e 2. Areas of individual types of land use changes in the Hriňová cadastral area.

Trends of landscape development	area (ha)	area (%)
Urbanization	265.86	2.10
De-urbanization	23.02	0.18
Agricultural intensification	410.99	3.25
Agricultural extensification	1403.42	11.10
Deforestation	40.86	0.32
Afforestation	392.99	3.11
Overgrowth	135.73	1.07
Flooding	52.62	0.42
No changes	9918.35	78.44
Total	12643.84	100.00

landscape. Concurrently, it limited economic use of the river above it, due to implementation of water resources protection.

Similar changes in land use were recorded during evaluation of these developmental trends in the studied localities. Comparisons between 1949 and 2010 confirmed that the most significant development trend was agricultural extensification by transformation of arable land into permanent grasslands with varying intensity of use. The worst decline in agricultural usage was noted in land lying fallow without use. This was recorded in the Hriňová—Mesto locality, resulting from abandonment of traditional land use after 1989 (Table 3). This was most likely due to worsening access for agricultural machinery combined with a decrease in economic profitability. The opposite trend occurred in the Hriňová — Krivec locality where conditions for more intensive use were created following land consolidation. This created graded bounds which reduced soil erosion. HSAL gained increased percentage of the total area, most likely as a result of creation and expansion of new rock and mud-rock mounds. However, extension of line structures in the immediate vicinity of unused parcels also had some effect.

Using the chosen indicators of the spatial structure of patches, evaluation was carried out to determine how land use changes were reflected between 1949 and 2010. The main indicator of land use changes showed a decrease in allocated polygons from 182 in 1949 to the current 153. These changes were then reflected in the evaluation of our selected landscape indexes. One of these was the calculation of mean patch size. The most significant increase in mean patch size (MPS) was recorded in the Hriňová–Snohy locality. The overall size increase in 2010 caused by historical blending of parts of estates, mainly near communications, was more than 300% compared to that in 1949. This was a change from 0.06 to 0.19 ha. An increase from 0.07 ha to 0.09 ha was also recorded in the Hriňová—Blato and Hriňová—Mesto localities, but this is partly due to the increased growth in area occurring in these localities (Table 4).

This change was also reflected in the total edge (TE) characteristic. As the number of patches diminished, their total perimeter also diminished. However, the decrease here was not as significant as in the mean patch size (MPS). We identified a 40% decrease in patch perimeter in the Hriňová—Snohy locality, a 20% decrease in Hriňová—Krivec and 2% decrease in Hriňová—Mesto. In contradistinction, a 7% increase was observed in Hriňová—Blato due to the decrease in mean patch size.

A significant increase in the size of estates is also confirmed by mean patch edge (MPE). In Hriňová—Snohy, this indicator rose from 143 m to 253 m, and this clearly identifies the agricultural intensification there. A minor increase was also recorded in Hriňová—Krivec and Hriňová—Blato. On the other hand, a decrease in mean patch edge was recorded in Hriňová—Mesto, most likely due to the increase in the number of patches in this locality.

The complexity of patch shapes was interpreted according to the mean shape index (MSI). The most regular patch shapes were recorded in Hriňová—Snohy, where their relatively oval shape became less regular between 1949 and 2010 (value of 2.20). This trend was also observed in Hriňová—Krivec and Hriňová—Blato. On the other hand, the increase in the number of patches in Hriňová—Mesto positively influenced a decrease in this value and the rounding of these parcels.

Richness, indicated by increased number of landscape elements in the studied localities, is also confirmed by Shannon´s diversity index (SDI).All localities exhibited an increase, with the most significant being the 31% increase in Hriňová—Blato. The highest increase in Shannon´s evenness index (SEI) was recorded in the locality of Hriňová—Snohy (+34%), and the greatest decrease occurred in Hriňová—Blato (-13%).

Comparison of previous parameters in relationship to FAR enables a more detailed insight into the upkeep and current use of these HSAL. The mean value of FAR (MPS) in Hriňová—Blato and Hriňová—Krivec increased; and it is interesting that the most significant increase in the number of FAR occurred in these two exact localities. In contrast, a decrease in mean size was recorded in Hriňová—Mesto and Hriňová—Snohy. FAR attained its highest values of 0.031 ha in 1949 and 0.029 ha in 2010 in Hriňová—Snohy, This was most likely due to the small number of FAR in this locality. Although the number of FAR increased in all localities, the patch perimeters (TE) did not increase everywhere, so the maximum TE was recorded in Hriňová—Blato where 48 FAR polygons had a total perimeter of 5,821 m (Table 5).

The number of FAR in a locality clearly differentiates the distribution of localities according to the mean patch edge (MPE). The lowest values were recorded in Hriňová—Blato at 121 m compared to the highest in Hriňová—Snohy at 315 m. With regard to the complexity of patch shapes, the mean shape index (MSI) confirmed the lowest value, and therefore the relatively most regular FAR shape, in Hriňová—Blato with the value of 2.61 in 2010. This was the result of several FAR with a regular oval perimeter. Other localities had more than twice these values. The least regular shapes were observed in the locality of Hriňová—Krivec, where an index value of 6.51 was recorded in 2010.

T a b l e 3. Class coverages in the studied areas (in %).

		Codes															
Localities	**Year**	**11**	**12**	**13**	**14**	**15**	**21**	**31**	**32**	**33**	**34**	**41**	**51**	**52**	**53**	**54**	**55**
Hriňová—Snohy	1949					0.19	61.52	37.04					1.25				
Hriňová—Snohy	2010			6.45			66.57	24.68					2.30				
Hriňová—Krivec	1949				9.55		41.03	47.81					1.61				
Hriňová—Krivec	2010						33.98	56.51		3.98	0.08	1.39	4.06				
Hriňová—Blato	1949						49.55	41.46					0.51	0.09		3.19	5.20
Hriňová—Blato	2010				5.27		39.50	38.40	1.25			0.45	0.74	0.38		5.83	8.18
Hriňová—Mesto	1949				5.94		33.39	55.04					0.54		5.09		
Hriňová—Mesto	2010	1.05	0.16	1.93		0.28	33.92	3.29	52.04	1.53			0.74		5.06		

T a b l e 4. Landscape metrics of the localities in two time horizons.

Localities	**Year**	**NP**	**MPS**	**TE**	**MPE**	**MSI**	**SDI**	**SEI**
Hriňová—Snohy	1949	38	0.066620	5469.33	143.93	1.674612	0.889587	0.641701
Hriňová—Snohy	2010	13	0.194736	3297.31	253.64	2.204099	1.197539	0.863842
Hriňová—Krivec	1949	38	0.074517	8322.06	219.00	3.428883	1.129810	0.814986
Hriňová—Krivec	2010	30	0.094389	6640.61	221.35	3.539416	1.345603	0.750995
Hriňová—Blato	1949	73	0.092121	13959.97	191.23	2.255102	1.399184	0.780900
Hriňová—Blato	2010	76	0.088485	15012.91	197.54	2.530502	1.832568	0.834037
Hriňová—Mesto	1949	33	0.076207	6486.30	196.55	2.886170	1.349498	0.838491
Hriňová—Mesto	2010	34	0.073965	6338.70	186.43	2.816005	1.671207	0.725796

Notes: NP —number of patches, MPS — mean patch size (in ha), TE — total edge (in m), MPE — mean patch edge (in m), MSI — mean shape index, SDI – Shannon´sdiversity index, SEI – Shannon´sevennes index.

T a b l e 5. Dynamics in the development of landscape metrics in Forms of Anthropogenic Relief (FAR) in these study areas.

Localities	Year	NP (FAR)	MPS	TE	MPE	MSI
Hriňová—Snohy	1949	1	0.031667	334.74	334.74	5.306370
Hriňová—Snohy	2010	2	0.029053	630.64	315.32	5.219925
Hriňová—Krivec	1949	6	0.007614	1130.51	188.42	6.174880
Hriňová—Krivec	2010	10	0.011477	2429.74	242.97	6.518069
Hriňová—Blato	1949	30	0.020165	3874.46	129.15	2.584058
Hriňová—Blato	2010	48	0.021192	5821.31	121.28	2.615854
Hriňová—Mesto	1949	10	0.014179	2185.59	218.56	5.216937
Hriňová—Mesto	2010	11	0.013264	2243.36	203.94	5.017807

Discussion

Historical structures of agricultural landscape (HSAL) have an irreplaceable role in landscape due to their exceptional historical and aesthetical value. The aim of this study is to assess the state of these structures, and their development over time since the end of World War II in the context of social and economic change. However, it must be noted that changes in landscape are not restricted only to land use and structures (landscape elements), but they also apply to the landscape as a whole, and they influence landscape processes and functions (Palang et al., 2006). Since human economic, social and political factors have played a major role in continual development of landscape structure, understanding the development of land use changes is necessary for planning nature and landscape conservation and in identifying conflicts arising in the economic use of these elements. These have become manifested at an increased rate due to significant changes in land ownership and use in all central and eastern European countries. As a result, developmental dynamics and the actual agricultural land structure significantly changed (Lerman, 2001; Olah, Žigrai, 2004; Skokanová et al., 2012). Špulerová et al. (2011) compiled a complex inventory and classification of traditional Slovak agricultural landscape structure. One of the most well-preserved traditional cultural structures in their suggested classification is areas with scattered settlements. This is confirmed in the traditional cultural structures represented by forms of anthropogenic relief in the studied areas which remain preserved today.

Several authors reported destruction and changes in agricultural activities which could create risks to the preservation of the traditional cultural landscape (Van Eetvelde, Antrop, 2004; Agnoletti, 2007; Špulerová, 2008; Mišovičová, Pucherová, 2008; Tomčíková, 2011; Jakab, Petluš, 2012 and Šolcová, 2013). Another factor potentially endangering the continuity of such areas is depopulation (Elbakidze, Angeltram, 2007). It is of utmost importance to find solutions to these problem, because research results confirm the irreplaceable role of HSAL (Deckers et al., 2005).

Moreira et al. (2006) observed changes in landscape use in Beira Alta in north-eastern Portugal. They found a decrease in arable cultivation followed by abandonment and the development of succession with gradual afforestation. However, sustained positives include the conservation of dry stone walls and local place names associated with the landscape. Kizos and Koulouri (2006) reported that expansion of forest areas, urbanization, deterioration and loss of cultural features such as terraces, hedgerows, stone walls and other agriculturally-related infrastructure can lead to decreased landscape diversity.

Based on our results, it can be stated that social and economic changes, and also important changes associated with EU accession, have led to these changes, Slovakia, as a whole, is at the crossroads, and rapid decisions must be made concerning the direction our country will take. Current choices include increased abandonment and a decrease in agricultural activity, or hopefully, support of agrarian funding schemes to reverse the effects the first two choices have already inflicted on our landscape. Correct decisions will ensure,the traditional cultural landscape and the preservation of their ecological systems (Forman, Bandry, 1984; Špulerová, Petrovič, 2011).

Conclusion

Following more than 20 years of social change, our foothill grassland ecosystems still remain endangered by dilapidation processes and abandonment of more remote but less productive grasslands. This has resulted from a combination of negative factors including; inappropriate economic conditions, legislative and administrative obstacles and loss of human ties to the traditional methods of land management.

Management changes have created conditions for an increase in biotopes which previously occurred only rarely. Such biotope habitats in the study area are fallow lands, extensive and abandoned grasslands, abandoned meadows and gardens in various succession stages, and the related increase in non-forest woody vegetation. However, in terms of biodiversity, this has proven to be a positive factor, for some groups of fauna and flora.

The key future task is to preserve the traditional way of using small-scale agricultural mosaics in the landscape in combination with various forms of anthropogenic relief. This relief includes stone heaps and mounds with terraces and graded bounds which significantly contribute to current preservation, and which can promote increased biological and landscape diversity in the long-term.

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