USING AN "INTERSECT" TOOL IN ARCGIS FOR ANALYSIS OF CHANGES IN THE SECONDARY LANDSCAPE STRUCTURE OF PODHAJSKA MUNICIPALITY

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Abstract: Observed area – Podhájska municipality is known for its thermal spa, which is the driving force in the development. The article deals with the analysis of changes in secondary landscape structure in Podhájska in the period between 1987 and 2014. Maps of secondary landscape structure were created by digitization of aerial imagery of the observed area in individual years and areas were identified where changes have occurred. They were defined as dynamic areas in Podhájska. Then we looked at the analysis of the changes types where we have used the "Intersect" tool in ArcGIS 10.1 and we have identified changes from group of landscape elements "x" to a group of landscape elements "y". With this way, we pointed out on the changes types in the current rural environment. Changes were observed at 6.58% of the territory in the whole observed period. The most significant changes became evident in expansion of agricultural land at the expense of forest vegetation, abandonment of specific forms of agriculture at the expense of the built-up territory and a decrease of agricultural land in extent of forest vegetation – overgrowing and abandonment of land.

Key Words: secondary landscape structure, rural landscape, aerial photos, intersect tool

INTRODUCTION

Rural area is often seen as an opposite of city, urban area. Šíp, Vystoupil (2005) define the rural area as a peripheral area what a city background creates and on which it is economically and administratively dependent. In the territorial system of division of labor rural area ensures agricultural production, small services and recreation. After the transition to a market economy, privatization and restructuring of companies, rural area was facing to difficulties – rural agricultural decline or depopulation, and therefore rural area needs to be revitalized through the diversification. After 2000, there is a gradual revival of rural development, the revitalization, new construction of houses and creating of new poles of development.

A thermal spa is such a pole of development in Podhájska that encourages the development of tourism in the municipality. The first borehole in Podhájska was implemented in 1973. The borehole was conducted south of the municipality with the intention to use water as a heating medium for greenhouses. Water with temperature about 80°C containing iodine, what colors the water to brown, began churning out from the depth of 1900m. These events contributed to the fact that local people built two swimming pools in the area the next months. The development of the thermal spa is recorded in time of the transition of ownership to the municipality in 1991. In 2003, a complete reconstruction of the borehole and the winter pool was made (Oremusová 2009). Opening of new Aquamarin wellness center in 2012 was another sign of the development. The development of tourism also affects the landscape structure. Woods (2005) argues that mainly agriculture, the impact of human activity on the rural areas, rural landscape and land use is researched in terms of geography in the context of rural area. The utility of this view of the rural landscape lies mainly in emphasis to spatial differences and exploring the landscape and its interaction with the human factor. A suitable method for analysing these changes is an analysis of secondary landscape structure within periods. For example Sviček (2000), Jančovič, Petrovič (2012) dealt with detecting of land cover changes

interpreting an aerial photographs of mostly agricultural landscape in selected areas during different time.

MATERIAL AND METHODS

The observed territory – Podhájska municipality is the center of Termal microregion. There is a likelihood of dynamic changes of landscape structure due to existence of the thermal spa and the diversification of economic activities.

Panchromatic (black and white) aerial photos of year 1987 provided by Topography Institute of Colonel Jan Lipsky in Banska Bystrica (TICJL) and colourful orthophotos of 2003 were used to analyse changes in secondary landscape structure of Podhájska. The newest images were used from a web portal mapy.cz where aerial photos of whole Slovakia are in very good quality resolution and were recorded in the years 2012–2014. For this reason, we reported outputs at the newest secondary landscape structure that particular range of years in the map. The appropriateness of the use of aerial imagery to identify changes in landscape shows Boltižiar (2008) and he states accurate projection of the Earth's surface and providing amount of quantitative, but mainly qualitative information about individual objects in landscape, whose dynamics can be observed in different time period, for the greatest priority. Aerial photographs are also used for monitoring landscape changes by Feranec (2012), who considers satellite technologies as an inseparable part of exploring a dynamically changing world. Land use can be interpreted on orthophotos in different ways. The methodology Corine Land Cover is widespread interpretation in European countries (Feranec et al. 1996). By monitoring changes in the rural landscape affected by natural or human factors deal with e.g. Vojteková (2013), Šolcová (2012) and Malenová (2007).

Georeferencing, digitization and subsequent vectorization of groups of landscape elements in software ArcGIS 10.1 in the three observation periods were the next step in the processing of aerial photos. We observed eight groups of landscape elements based on the definition by Vojteková (2013), who proceed it from a methodology of Ružička (2000) and combined it with the methodology of Corine Land Cover (Feranec et al. 1996, Ružička 2000). The result takes into consideration in large measure human-geographical and landscape-ecological approaches: 1. Elements of forest vegetation, 2. Elements of meadows and pastures vegetation, 3. Elements of agricultural land, 4. Elements of bedrock and substrate, 5. Elements of water courses and water bodies, 6. Elements of urban and recreational areas, 7. Elements of technical structures, 8. Elements of transportation.

Several methods were developed to analyse the changes in the landscape structure in ArcGIS, which deals Singh (1989) in detail with. In our study, we used the tool "Intersect" in ArcToolbox (Analysis Tools→Overlay→Intersect) what the intersection of the existing shapefiles (in our case, two referenced years) creates. A new layer emerges with the attribute table with data from both shapefiles. Tool "Intersect" has used to analyse changes in landscape structure also e.g. Mackenzie (2009), Benini et al. (2010), Chirico et al. (2006) and Coughlan (2013). It is possible to sort out the polygons in attribute table with the same group of landscape elements in both study years in the newly created shapefile formed by using the tool *Intersect*. Using the tool *Select by Attributes*, we enter the formula what selects the polygons with the same code in both study years, i.e. areas where is no change.

Subsequently we exported selected polygons into a new shapefile and new shapefile appears that show us the areas where was a change from one group to another group of landscape elements in the two studied years. Because using the function of *Intersect* we connected two attribute tables and we could identify the type of the change, i.e. changes from which to which group of landscape elements has occurred. These indicators were expressed by a percentage, so we could identify a character of differentiation of rural space. We calculated the size of all existing polygons (areas) to analyze the type of the changes. After that we calculated the percentage of group of landscape elements in year x transformed to group of landscape elements y to a total area of changed landscape structure in Podhájska, over a period of years x–y.

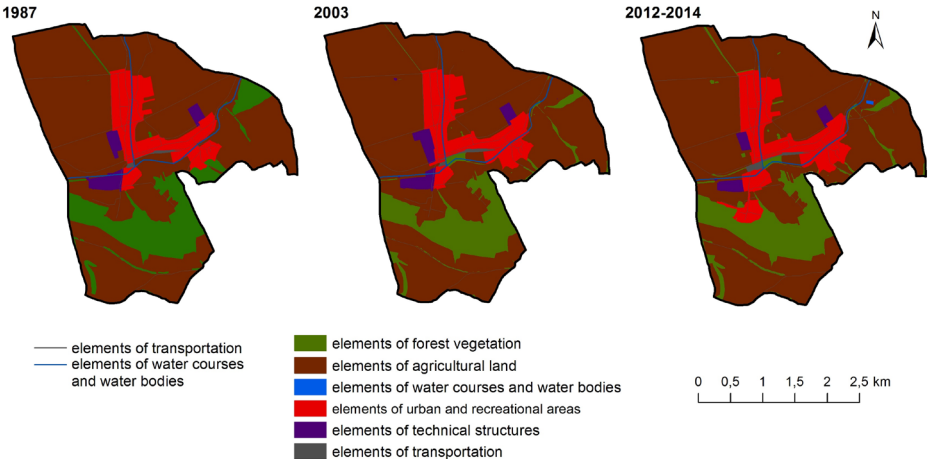
RESULTS AND DISCUSSION

Secondary landscape structure of Podhájska municipality

By digitalizing aerial photographs we created maps of secondary landscape structure of Podhájska in 1987, 2003 and 2012–2014 (see Figure 1). Only 6 of the 8 groups of landscape elements were identified – a group of meadow and pasture vegetation and elements of bedrock and substrate were not identified.

Changes from 1987 to 2003 reflected mainly on loss of forest vegetation at the expense of an increase of elements of agricultural land. This phenomenon is particularly noticeable to the east and southeast of the urban area. More noticeable changes were seen in the period between 2003 and 2012 (2014), when the transformation of agricultural land into built-up area occurred. This phenomenon is consequence of permanently increasing importance of tourism in the village, where boom in building-up of accommodation facilities was near the swimming pool in Podhájska. Gardens, vineyards, and crofts were located to the south of the swimming pool in the past. Agricultural land was transformed into the built-up area with a majority of tourist accommodation. That resulted in the decline of agricultural functions at the expense of the increase of tourism importance in Podhájska.

Figure 1 Secondary landscape structure of Podhájska municipality

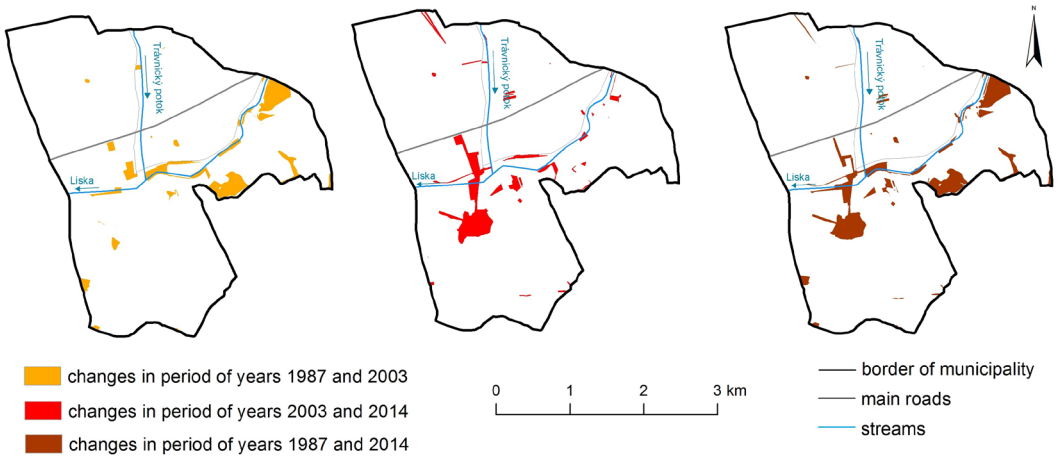


In Podhájska, new water surface arose, the Gergeľ pond with carps. It is also possible to talk about the transformation of agricultural land to a facility intended for recreational purposes.

Identification of localisation changes in landscape

By using a tool *Intersect* in ArcGIS 10.1 and by subsequent selection by attributes we can identify areas in Podhájska, which underlies to changes the most and the other, which remained in the observed period unchanged (see Figure 2). First map in Figure 2 shows the changes between 1987 and 2003. The changes were localized to a greater extent in periphery of the municipality and there essentially were changes in the unbuilt area and agricultural land.

Figure 2 Areas where changes were identified within observed period



Map in the middle (Figure 2) shows the changes that took place in the period 2003–2012 (2014). There are already noticeable changes in the area close to urban areas. This resulted in a revival of the municipality especially in the area of thermal swimming pool, where new parking places, accommodation and camping were built. This resulted in new recreational, tourist area in the village.

In terms of overall changes, i.e. between 1987 and 2012 (2014), we can assess that the southern part of Podhájska is much more dynamic than the northern part of the village. It can be assumed that in this part of the village is expected much more dynamic development in the future. The village was then notionally divided into the two parts – the northern and southern part, while the northern part performs traditional residential and agricultural function, which was typical for rural areas especially in the past and the southern part is progressing and there is visible a diversification of functions towards the development of tourism. It would be appropriate to create a diversification plan for the northern part to avoid disparities in development of the village.

Identification of changes type

From 1987 to 2003, it was changed 4.29% of the area of Podhájska. From Table 1 it is visible detailed analysis of the types of changes to groups of landscape elements. The biggest changes can be seen in the deforestation and subsequent land use for agricultural purposes (50.3%). On the other hand, the opposite effect of the conversion of agricultural land to forest vegetation is noticeable (26.8%). New building-up and transformation of agricultural land into built-up area were also observed. In this period, a disposing of technical objects and their conversion into agricultural land were observed, too (3.41%). Other changes can be considered as less important because of small areas.

Table 1 Type of changes in secondary landscape structure within period 1987–2003 (%)

1987 \ 2003		Group of landscape elements							
		1	2	3	4	5	6	7	8
Group of landscape elements	1	-	x	50.3	x	x	<0.01	0.11	x
	2	x	-	x	x	x	x	x	x
	3	26.8	x	-	x	x	11.7	6.8	x
	4	x	x	x	-	x	x	x	x
	5	x	x	x	x	-	x	x	x
	6	0.14	x	0.78	x	x	-	x	<0.01
	7	x	x	3.41	x	x	0.02	-	x
	8	x	x	x	x	x	<0.01	x	-

Legend: 1 – elements of forest vegetation, 2 – elements of meadows and pastures vegetation, 3 – elements of agricultural land, 4 – elements of bedrock and substrate, 5 – elements of water courses and water bodies, 6 – elements of urban and recreational areas, 7 – elements of technical structures, 8 – elements of transportation, x – unchanged

Table 2 Type of changes in secondary landscape structure within period 2003 to 2012–2014 (%)

2003 \ 2014		Group of landscape elements							
		1	2	3	4	5	6	7	8
Group of landscape elements	1	-	x	6.10	x	x	0.23	x	0.13
	2	x	-	x	x	x	x	x	x
	3	20.31	x	-	x	1.91	35.90	0.15	1.82
	4	x	x	x	-	x	x	x	x
	5	x	x	x	x	-	x	x	x
	6	1.80	x	5.09	x	x	-	x	x
	7	1.78	x	12.32	x	0.03	9.89	-	1.88
	8	x	x	x	x	x	x	x	-

Legend: 1 – elements of forest vegetation, 2 – elements of meadows and pastures vegetation, 3 – elements of agricultural land, 4 – elements of bedrock and substrate, 5 – elements of water courses and water bodies, 6 – elements of urban and recreational areas, 7 – elements of technical structures, 8 – elements of transportation, x – unchanged

In the period from 2003 to 2012(2014), it was changed only 3.53% of the total area of municipality. From the point of view of change types (Table 2) it is visible more than one-third share of changes (35.9%), when the agricultural area has changed to built-up area and recreational areas.

This phenomenon was particularly striking south from the swimming pool, where the former vineyards, gardens were transformed into an area with accommodation facilities – e.g. Apartment Monty***, Sunny apartment, pension 3Galeria and other.

About one fifth of the territory (20.31%) was under influence of the succession and it was changed from agricultural land to forest vegetation or areas growing with shrubs. Also, there was a revitalization of the old technical objects and their transformation into agricultural land (12.32%) or a group of residential elements and recreational areas (9.89%). A small part of the changed territory (6.10%) was transformed from forest to agricultural land. In comparing the secondary landscape structure in 1987 and 2012 (2014), 6.58% of the total territory of Podhájska was changed. It should be noted, that some areas that have changed in the period to 2003, in the next reporting period changed back to the original group of landscape elements. This means that the sum of the changes in the first reporting period and in the second reporting period is not identical to the overall change. Throughout the whole observed period three essential processes appear (Table 3):

- expansion of agricultural land at the expense of forest vegetation (31.74%)
- abandonment of specific forms of agriculture (vineyards, gardens, etc.) at the expense of an increase of the built-up territory (25.98%)
- a decrease in area of agricultural land in extent of forest vegetation – overgrowing and abandonment of land (25.54%)

Table 3 Type of changes in secondary landscape structure within period 1987 to 2012–2014 (%)

1987 \ 2014		Group of landscape elements							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Group of landscape elements	1	-	x	31.74	x	1.03	0.34	x	x
	2	x	-	x	x	x	x	x	x
	3	25.54	x	-	x	0.02	25.98	0.08	1.72
	4	x	x	x	-	x	x	x	x
	5	x	x	x	x	-	x	x	x
	6	1.06	x	1.54	x	x	-	x	0.33
	7	0.60	x	4.74	x	x	5.28	-	x
	8	x	x	x	x	x	x	x	-

Legend: 1 – elements of forest vegetation, 2 – elements of meadows and pastures vegetation, 3 – elements of agricultural land, 4 – elements of bedrock and substrate, 5 – elements of water courses and water bodies, 6 – elements of urban and recreational areas, 7 – elements of technical structures, 8 – elements of transportation, x – unchanged

There was also a small change when the agricultural and forest land transformed into water - building a pond. A group of technical elements, mainly industrial and agricultural building, was transformed mainly to agricultural land or inhabited areas.

CONCLUSION

Podhájska started a new phase of the development because of geothermal borehole from 1973 and the subsequent building-up of the thermal spa. The decline of primary agricultural functions after the transition to a market economy has forced rural municipalities to find new industries that would help the progress and revitalization of rural areas. Based on the using of aerial photos, followed by their digitization, making maps of the secondary landscape structure we identified localities, in which a change of function or use was observed within the time horizon 1987–2003, 2003–2012 (2014) and an overall change in the whole observed period, i.e. 1987–2012 (2014). From 1987 to 2003, 4.29% of the Podhájska has changed its character. The biggest changes can be seen in the deforestation and subsequent land use for agricultural purposes (50.3%). On the other hand, the opposite effect to the conversion of agricultural land to forest and shrubby vegetation is striking (26.8%). In the period 2003 to 2012–2014, only 3.53% of the municipality has changed. In this period mainly the transformation of agricultural land to a group of residential elements and recreational areas has occurred. This phenomenon was particularly striking south from the swimming pool, where the former vineyards, gardens were transformed into an area with accommodation facilities. In comparing to the secondary landscape structure during the entire period, a change was observed at 6.58% of the territory of the village. From the overall point of view we identified three main types of changes - the

expansion of agricultural land at the expense of forests vegetation, abandonment of specific forms of agriculture at the expense of an increase of built-up territory and overgrowing of agricultural land and its succession. In Podhájska the growing importance of tourism in the landscape structure has reflected and it can be assumed that a similar trend can be expected in the future.

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REFERENCES

Benini L., Bandini V., Marazza D., Contin A. 2010. Assessment of land use changes through an indicator-based approach: A case study from the Lamone river basin in Northern Italy. *Ecological Indicators*, 10(1): 4–14.

Boltižiar M. 2008. Využitie výsledkov diaľkového prieskumu Zeme a historických máp pri hodnotení zmien využitia kultúrnej krajiny. In: *Inovačné učebné texty z geografie*. Nitra: FPV UKF, 2008. 327 s.

Coughlan M.R. 2014. Farmers, flames, and forests: Historical ecology of pastoral fire use and landscape change in the French Western Pyrenees, 1830–2011. *Forest Ecology and Management*, 312: 55–66.

Feranec J., Oťahel P., Pravda J. 1996. Krajinná pokrývka Slovenska identifikovaná metódou Corine land cover. *Geographia Slovaca*, 11(1): 1–95.

Feranec J. 2012. *Meniace sa Slovensko očami satelitov*. 1st ed. Bratislava: VEDA.

Chirici G. et al. 2006. Earth Observation Techniques and Geographic Information Systems as Tools for assesing land use/cover changes in a landscape context. In: *The Conservation of Cultural Landscapes*. Oxford: CABI, pp. 57–70.

Jančovič P., Petrovič F. 2012. Trendy vývoja kultúrnej krajiny medzi mestami Piešťany a Hlohovec. *Životné prostredie*, 46(1): 34–37.

Mackenzie J. 2009. Land-Use/Land Cover Transitions in Delaware, 2002–2007. Working paper, College of Agriculture and Natural Resources, University of Delaware, Newark, 2009.

Malenová P. 2007. Sledovaní vývoje využití území s pomocí GIS. In: *Venkovská krajina* [online]. May, 18–20, 2007, Hostětín, Czech republic, pp. 90–94. [2015-09-08]. Available from: hostetin.veronica.cz/sites/default/files/0098_vk2007_final.pdf

Oremusová D. 2009. *Geografické aspekty regionálneho rozvoja mikroregiónu Termál*. 1st ed. Nitra: FPV UKF.

Ružička M. 2000. The principles and criteria of landscape-ecological method LANDEP. *Ekológia*, 19(2): 18–22.

Singh A. 1989. Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing* [online]. 10(6): 989–1003. [2015-08-21]. Available from: http://www.tandfonline.com/doi/abs/10.1080/01431168908903939

Sviček M. 2000. *Detekcia zmien krajinnej pokrývky analógovou interpretáciou čiernobielych leteckých snímok.* 1st ed. Bratislava: VÚPOP.

Šíp J., Vystoupil J. 2005. Metodika analýzy hodnoty území venkovského prostoru v intencích trvale udržitelného rozvoje cestovního ruchu jako základní nástroj nové rajonizace CR. In: *Cestovní ruch, regionální rozvoj a školství-trvale udržitelný rozvoj a turismus.* 2005, Jihočeská univerzita, Tábor, Czech republic, pp. 24–30.

Šolcová L. 2012. *Vývoj krajiny s disperzným typom osídlenia v Novobanskej štálovej oblasti*. 1st ed. Nitra: FPV UKF.

Vojteková J. 2013. *Trendy vývoja banskej krajiny na hornom Ponitrí*. 1st ed. Nitra: FPV UKF v Nitre.

Woods M. 2005. *Rural geography: Processes, Responses and Experiences in Rural Restructuring*. 1st ed. London: SAGE.