LANDSCAPE CHANGES IN SELECTED SUBURBAN AREA OF BRATISLAVA (SLOVAKIA)

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Abstract

An excellent example of high-intensity changes in the landscape are the suburban areas of big cities, especially those parts located in close proximity to areas of protected landscape. The biggest changes in the landscape structure can be observed there mainly due to location of new building areas. The main objective of the study is to determine from the case study of Bratislava the level and nature of changes in the landscape of selected suburban area. Study area is located at the northern border of Bratislava partly within Protected Landscape Area of Malé Karpaty.

On the basis of the identification and evaluation of changes in landscape structure in different time periods is determined the indicator of landscape changes and types and intensity of changes in the landscape in the selected suburban area of Bratislava. The studies are based on the changes of percentage of main elements in the secondary landscape structure manifested by extent of urbanization level, resignation from land cultivation, forestation and other changes in the landscape.

Key words: landscape changes; driving forces; landscape changes indicator; land-use and land-cover changes; Slovakia.

Introduction

Landscape is a dynamic interaction of natural and cultural aspects where effects of changing social needs become visible. Its characteristic feature is changeability under the influence of different forces called „driving forces of landscape change“ (Bürgi et al., 2004, Schneeberger et al., 2007) or „key processes“ (Marucci, 2000). They can be divided into five groups: cultural, socioeconomic, political, technological and natural. Synthesis of the changes in spatial structure taking place in the past creates unique character of each landscape (Krajewski, 2012). Its current condition has been created for ages as the result of the relationship between nature and man. At the very beginning the main reason of the changes was the development of settlement and the need for new cultivation land, further industrial revolution, the development of technical infrastructure, building technology and tourism. Current rural landscape condition is still mostly the effect of creating new land for agricultural production in last 200 years (Hernik, 2011). Therefore, one has to remember that any landscape research should be preceded by determining basic trends of landscape change. Spatial and ecologic features of landscape make it subject of interest of different groups of scientists – geographers, landscape ecologists, landscape architects or economists. It has been studied for a long time with different scientific methods in many countries for example in Spain (Serra et al., 2008), Switzerland (Herpserger, Bürgi, 2009), Brazil (Bertolo et al., 2012), Austria (Kraussmann et al., 2003) or United States (Brown, Schulte, 2011). However, there is still the need for further study of past landscape changes because of better understanding the reasons of current changes and the importance of it for sustainable landscape management (Antrop, 2006).

In recent years we can see intensification of landscape changes as a result of strong socio-economic forces for example changes in agriculture, transport and industry (Antrop, 2004). It was also recognized by the Council of Europe and in 2000 the European Landscape Convention was established to give the base for landscape protection in European countries. The signatories of the Convention consider the landscape as important part of quality of life and key element of cultural heritage. Increase of negative impacts on landscape in last ten years is particularly visible in Central Europe because of new possibilities which have been given by the membership of European Union. Current economic development connected with better technologies, more rich society and phenomenon of urban sprawl is the reason of increased land demands and negative impacts on the landscape in suburban areas. Most of the people want to live relatively close to the city in attractive landscape. That's why the discussion of landscape changes is particularly important in relation to areas with great landscape beauty where there are strong processes of urbanization. As excellent example of high-intensity changes in the landscape are those parts of suburban areas of big cities which are located in close proximity to areas of protected landscape. These parts are attractive locations for residential development.

Materials and methods

Study area

The main objective of the study was to determine from the local-scale case study of Bratislava the level and types of changes in the landscape of selected suburban area located in attractive landscape in last ten years (from 2004 to 2014). The research should give some useful information about landscape changes indicator (LCI) which shows the scale of landscape change in different periods of time and types of changes observed in selected suburban area. The study area (Tab.1) – Zahorska Bystrica – was chosen because of diversified landscape structure where we can observe still growing population. It is located at the northern border of Bratislava partly within Protected Landscape Area of Malé Karpaty (Fig.1). Eastern part is mountainous and covered by forest. In the central part there is building area surrounded by flat agricultural land which dominate also in western part of study area.

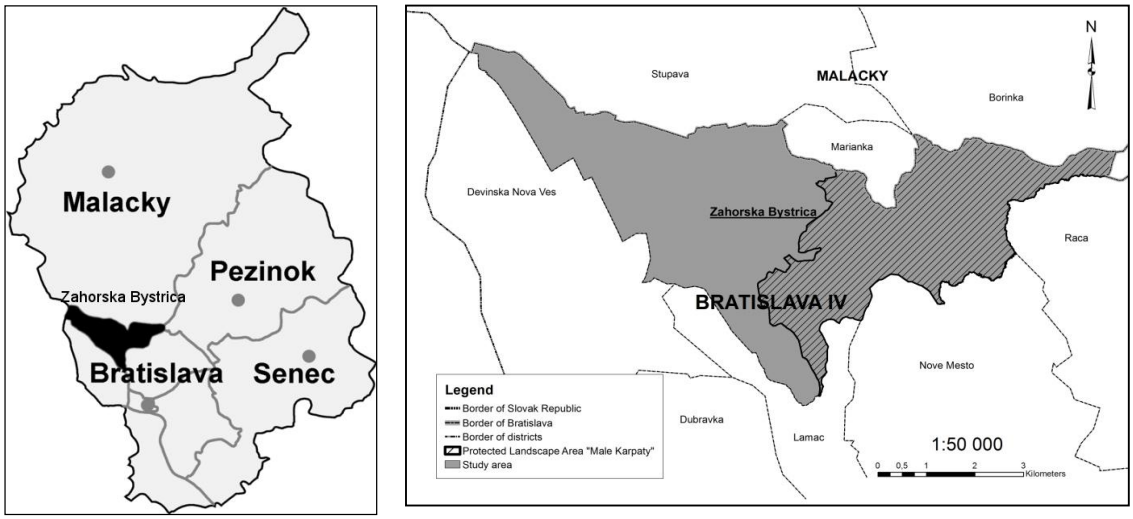

Fig. 1 Location of study area.

Tab. 1 Basic information about study area. Source: www.datacube.statistics.sk

Name of study area	Area [ha]	Number of inhabitants	% of protected landscape area	Landscape character
Zahorska Bystrica	3,229.78	2,321 (2004) 3,071 (2009) 3,999 (2014)	42.9%	Eastern part – mountainous, forested; central part – building area, western part – flat arable land

Methodology of assessing landscape changes indicator

Landscape is a synthesis and physiognomic effect of changes taking place in spatial structure of the land. Therefore, assessment of landscape changes should be carried out on the basis of analysis the elements creating present and past spatial structure reconstructed from available ortophotomaps or cartographic materials. It will help to answer the question which period of time was crucial for landscape changes. The intensity of this phenomenon is defined by landscape change indicator (LCI). The essence of used method of relative data deviation is to compare the values obtained by quantitative area analysis of each element creating spatial structure in selected period of time, with value from analysis previous period of time called reference criterion. Deviation from the reference criterion gives information about changes of spatial structure components. A summary of all values allows determine the indicator of landscape changes.

Methodology of assessing landscape changes indicator of study area was divided into four phases:

1) The first phase includes creating the maps in ArcGIS showing current and past spatial structure in 3 different time periods. On the basis of ortophotomaps and field inventory study area were divided into 15 components with different spatial functions:
    1) highways and expressways;
    2) main roads;
    3) local roads;
    4) single-family housing area;
    5) multi-family housing area;
    6) service area;
    7) industry area;
    8) sport and leisure area;
    9) forest and forest succession area;
    10) meadows and pastures;
    11) large arable land;
    12) small arable land;
    13) old orchards;
    14) allotment gardens;
    15) closed quarry.
2) The second step is to create the database concerning the area of each element of spatial structure for each analyzed time interval. The maps created in first step form the basis for database.
3) The third phase consists of determining the level of percentage deviation between the reference criterion and data from next time interval, for each element of the spatial structure. The percentage for the reference criterion = 0, and the change from initial value by 1%, with reference to whole area of research, is equal to the deviation of +1 or -1.
4) The last step consists of summing the absolute values of obtained level of the deviation for all analyzed components of the spatial structure in all time sections, under the

assumption that both increase and decrease of the value indicates the changeability of landscape. Resulting value is an indicator of landscape changes level (LCI).

Assessing character of landscape changes

Analysis of components creating spatial structure in three different time periods made possible the assessment of landscape changes. Character of them was the basis of division into types and subtypes of landscape changes. In the first type – *transformations inside built-up area* – were grouped all transformations from single-housing and sport and leisure area to multi-housing area. In this category two subtypes were determined:

I1 – transformation from sport and leisure area to multi-family housing area;
I2 – transformation from single-family housing area to multi-family housing area.

The second type of changes – *increase of housing area* – represent transformations from large and small arable land, meadows and pastures, old orchards and allotment gardens to single and multi-housing area. Under increase of built-up area type there are seven subtypes:

H1 – transformation from meadows and pastures to multi-family housing area;
H2 – transformation from small arable land to multi-family housing area;
H3 – transformation from small arable land to single-family housing area;
H4 – transformation from meadows and pastures to single-family housing area;
H5 – transformation from old orchards to single-family housing area;
H6 – transformation fon from large arable land to single-family housing area;
H7 – transformation from allotment gardens to single-housing area.

The third type of changes – increase *of service and industry area* – is characterized by transformations from large arable land, meadows and pastures to service and industry area. This category contains three subtypes:

C1 – transformation from large arable land to service area;
C2 – transformation from meadows and pastures to service area;
C3 - transformation from large arable land to industry area.

The fourth type of changes – *internal transformations of agricultural land* – is represented by transformations between large and small arable land, meadows and pastures and old orchards area. Under this category four subtypes were identified:

A1 – transformation from large arable land to meadows and pastures;
A2 – transformation from small arable land to meadows and pastures;
A3 – transformation from old orchards to meadows and pastures;
A4 – transformation from small arable land to large arable land;

The fifth type of changes – *transformations of forested area* – consists only one subtype –

F1 – transformation from meadows and pastures to forest and forest succession area.

The sixth t;ype of changes are *transformations of transport system.* Two subtypes were identified in this category:

T1 – increase of highways and expressways;
T2 – increase of main and local roads.

Results and discussion

Maps prepared in ArcGIS show spatial structure of study area in 2004, 2009 and 2014 (Fig. 2). The dates cover the period of last ten years after becoming Slovakia a member of European Union. Analyses of landscape change indicator were performed for two 5-year periods – from 2004 to 2009 and from 2009 to 2014. Detailed information about area of each component of spatial structure and changes in percentage is given in Table 2.

Analyses of spatial structure components in three different periods of time – 2004, 2009 and 2014 (Tab. 2) show that the systematic reduction of area covered by large arable land and old orchards, steadily increasing single housing area and amount of local roads are characteristic of the study area. In the first of the analyzed time periods – from 2004 to 2009 – more changes can be observed than in the other one. At this time significantly decreased area of old orchards, large and small arable land and meadows and pastures. A lot of new single-family, multi-family and service buildings were built, process of forest succession has began on a large area. Landscape changes indicator for this period of time is 6.18.

Tab. 2 Landscape changes indicator (LCI) in 2004-2009 and 2009-2014

Spatial structure component	Area in 2004 [ha]	Area in 2009 [ha]	Area in 2014 [ha]	% in 2004	% in 2009	% in 2014	2004-2009	2009-2014
Highways and expressways	6.00	6.00	10.29	0.19	0.19	0.32	0.00	0.13
Main roads	8.94	8.94	9.59	0.28	0.28	0.30	0.00	0.02
Local roads	14.61	17.78	20.86	0.45	0.55	0.65	0.10	0.10
Single-family housing area	138.85	165.49	179.81	4.30	5.12	5.57	0.82	0.44
Multi-family housing area	0.37	4.91	5.82	0.01	0.15	0.18	0.14	0.03
Service area	12.54	30.15	30.9	0.39	0.93	0.96	0.55	0.02
Industry area	31.69	30.36	34.05	1.01	0.94	0.98	0.04	0.11
Sport and leisure area	2.66	1.92	1.92	0.06	0.06	0.06	0.02	0.00
Forest and forest succession	1,498.08	1,545.94	1,546.48	46.38	47.86	47.88	1.48	0.02
Meadows and pastures	208.85	198.25	197.03	6.49	6.14	6.17	0.33	0.03
Large arable land	1,034.61	1,017.98	1,004.63	32.03	31.52	31.11	0.55	0.41
Small arable land	96.37	71.24	70.67	2.98	2.21	2.19	0.78	0.02
Old orchards	97.17	52.83	41.06	3.01	1.64	1.27	1.37	0.36
Allotment gardens	75.66	75.66	74.34	2.34	2.34	2.30	0.00	0.04
Closed quarry	2.35	2.35	2.35	0.07	0.07	0.07	0.00	0.00
						LCI = 6,18		**1,67**

The second time interval – from 2009 to 2014 – is characterized by much less changes. At this time increased the length of highways and expressways and single-family and multi-family housing area at the expense of area covered by old orchards and large arable land. Landscape changes indicator for this period of time is 1.67.

The second part of research was represented by analyses of landscape changes types in 2004-2014 (Tab. 3). The most frequently observed transformations were those from meadows and pastures to single-family housing area (H4) and from large arable land to meadows and pastures (A4) but the biggest area of change is represented by transformations from old orchards to meadows and pastures (A3) and from meadows and pastures to area with forest succession process (F1).

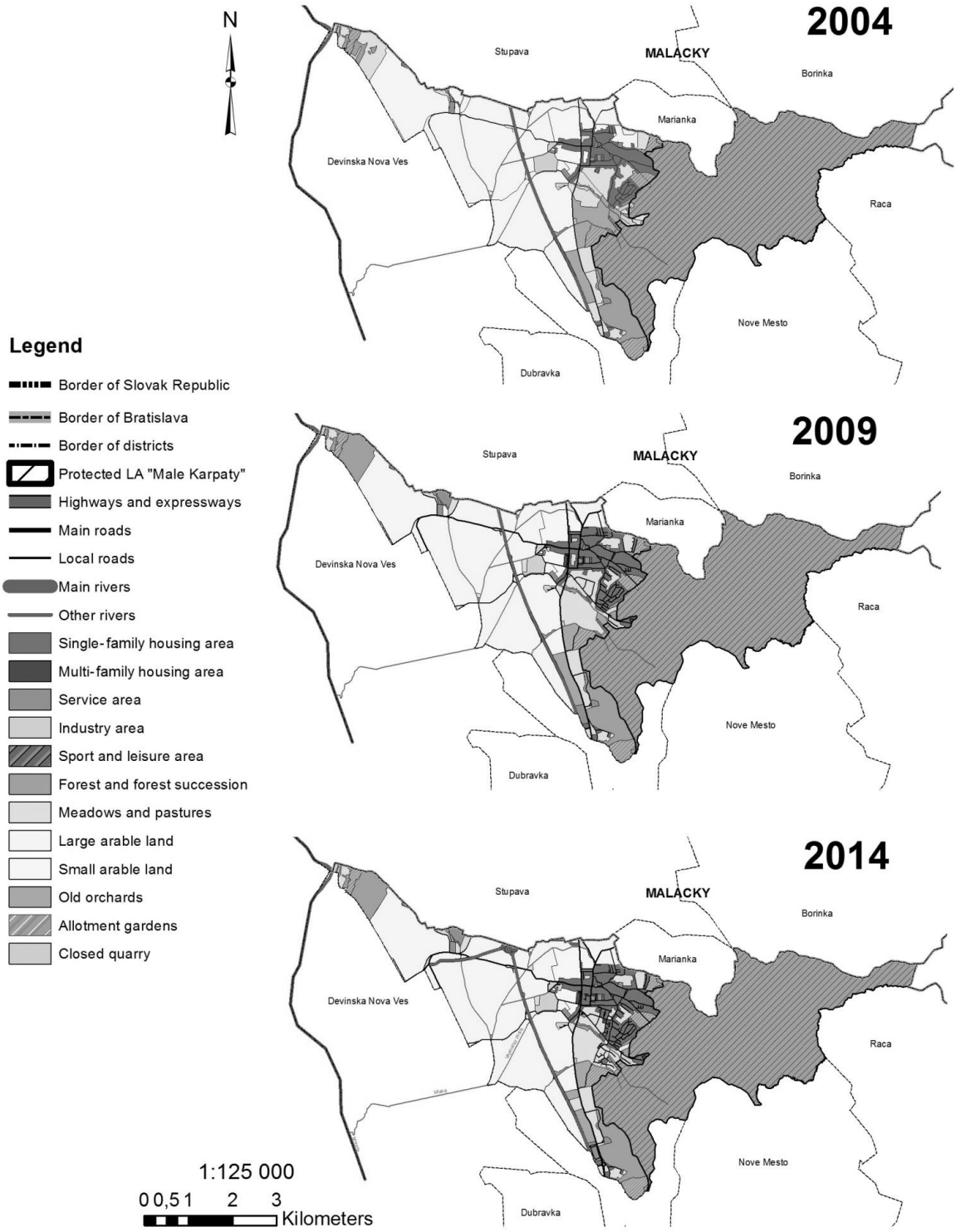

Fig. 2 Maps of spatial structure in 2004, 2009 and 2014.

Tab. 3 Type of landscape changes of the study area.

Type of change	Area of change [ha]	% of study area	Number of polygons
I1	0.74	0.02	1
I2	0.55	0.02	1
H1	3.68	0.11	1
H2	3.22	0.10	1
H3	13.07	0.40	3
H4	26.47	0.82	10
H5	0.90	0.03	1
H6	4.38	0.14	4
H7	1.31	0.04	1
C1	8.27	0.26	1
C2	9.74	0.30	2
C3	0.98	0.03	1
A1	15.94	0.49	8
A2	10.07	0.31	2
A3	51.66	1.60	2
A4	5.15	0.16	1
F1	46.73	1.45	4
T1	4.29	0.13	15
T2	6.90	0.21	64

Conclusions

The presented case study identifies a level of changes in two 5-years periods of time – from 2004 to 2009 and from 2009 to 2014. Different transformations scale of analyzed components of spatial structure allows to observe that landscape changes indicator is much bigger in first time interval. But this indicator gives general information about scale of landscape changes without any information about quality of changes. Only identification of types and subtypes of landscape transformations allows to assess changes from this point of view. Knowledge about level and character of landscape transformations is especially important for decision- making connected with management and future planning of landscape from the point of view of European Landscape Convention implementation

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