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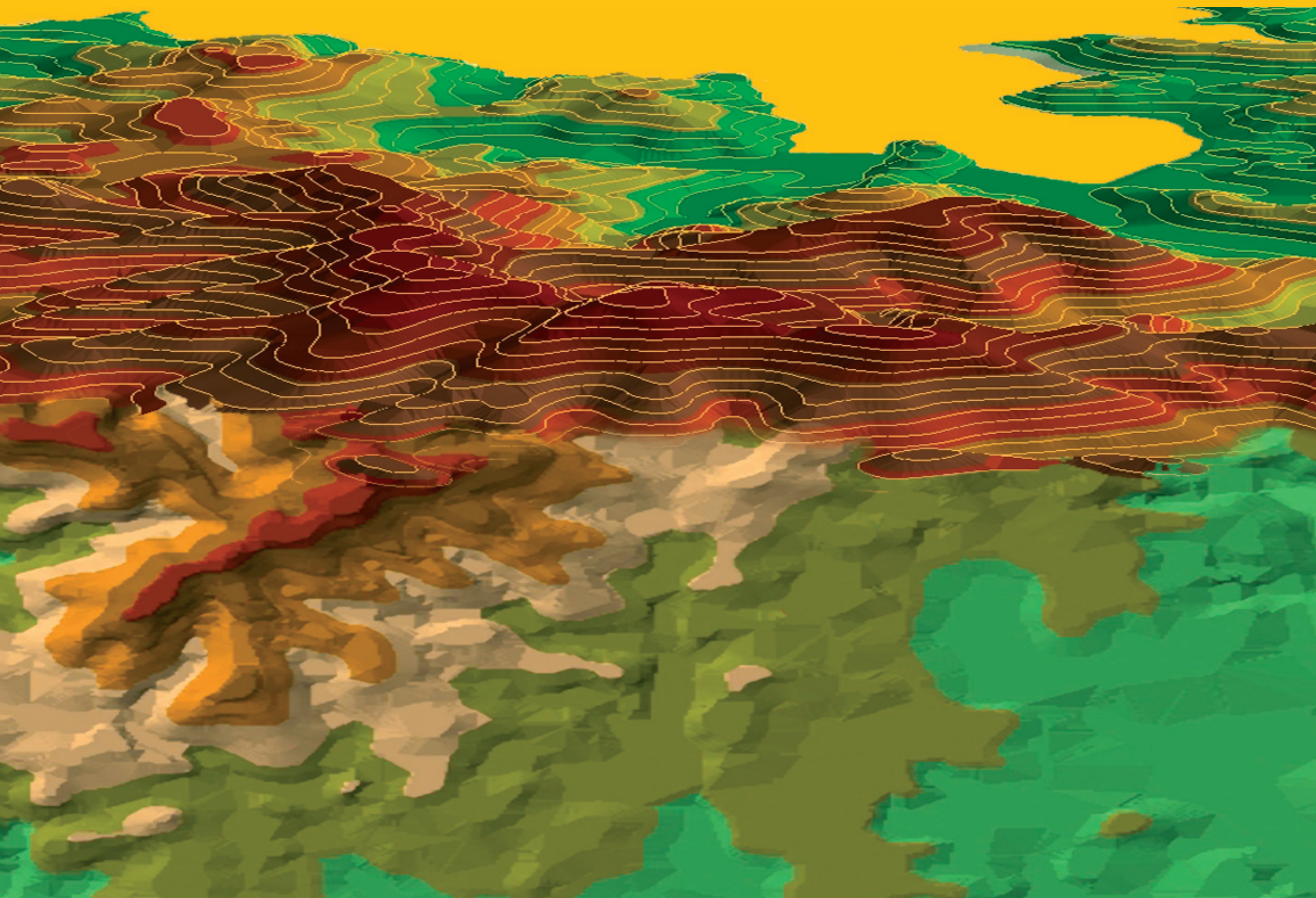

Fig. 8: AS2 type segment of the Smrečianka brook (Photo: I Tomčíková, 2011)

Fig.13: CS1 type segment of the Smrečianka brook (Photo: I. Tomčíková)

Illustrations related to the paper by I. Tomčíková

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Articles:

CAN WE COMBINE STRUCTURAL FUNCTIONALITY AND LANDSCAPE SERVICES ASSESSMENTS IN ORDER TO ESTIMATE THE IMPACT OF LANDSCAPE STRUCTURE ON LANDSCAPE SERVICES?

Hana SKOKANOVÁ

Abstract

This paper investigates two methods of assessing structural functionality and landscape services, and the potential of their joint application in order to estimate the impact of landscape structure in terms of structural functionality on landscape capacity to provide various services. The methods were tested in three different landscape types of the Czech Republic. The results showed that linking these two methods might help in estimating the impact of landscape structure on some landscape services in landscape types with a prevalent valuable matrix, but are dependent on landscape metrics defining individual functionality groups.

Shrnutí

Je možno zkombinovat hodnocení funkčnosti krajiny s hodnocením krajinných služeb pro odhadnutí dopadu struktury krajiny na její služby?

Tento článek zkoumá dvě metody hodnotící funkčnost struktury krajiny a služby krajiny a potenciál jejich propojení pro odhad dopadu struktury krajiny z hlediska její funkčnosti na kapacitu krajiny poskytovat různé služby. Metody byly testovány ve třech různých typech krajiny České republiky. Výsledky ukázaly, že propojení těchto dvou metod by mohlo pomoci k odhadu dopadu struktury krajiny na její některé služby v typech krajiny s převládajícím cenným prostředím, ale že tyto výsledky jsou závislé na krajinných metrikách, které definují jednotlivé funkční skupiny.

Keywords: *landscape assessment, structural functionality, landscape services, landscape metrics, Czech Republic*

1. Introduction

Landscape is an extremely complex concept of a holistic nature (Naveh, Lieberman, 1994; Antrop, 2000) as it consists of both natural and human-induced components with various interlinks. Present landscapes have been strongly influenced by human activities: namely by urbanization, industrialization, and intensive agriculture which can heavily impact landscape quality in terms of ecological functions and processes, biodiversity, the capacity to provide numerous services useful for humans, etc.

A scientifically sound guidance is needed for planners to address ecological problems associated with urbanization, industrialization or intensive agriculture and to conserve ecosystems in order to halt the loss of biodiversity. Landscape metrics have been widely used as a quantitative and objective tool for planners to lay out reliable planning guidance. They can be used to indicate ecosystem degradations or disturbances requiring special attention in some regions (Su et al., 2012).

Landscape structure reflects both the natural settings and the impacts of human activities through the centuries (Skokanová, Eremiášová, 2013). It significantly influences ecological functions and processes (see e.g. Tischendorf, 2001; Tscharntke et al., 2002; Dauber et al., 2003) and its key role in the assessment of landscape quality, especially biodiversity and visual quality, has been pointed out in many studies (Kuiper, 1998; Hokit et al., 1999; Weinstoerffer and Girardin, 2000; Bock et al., 2005; Dramstad et al., 2006). In recent decades, landscape structure has very often been a topic of scientific research, which yielded a large amount of papers (Kuttner et al., 2013). Many indices were proposed for the analysis of landscape structure to capture landscape patterns in relation to their function (Forman and Godron, 1986). The spatial configuration of landscape elements expressed by landscape metrics indirectly reflects structural functionality, which can be interpreted as a degree of connectivity of landscape elements, and is also referred to as landscape functionality (Kuttner et al., 2013; Skokanová, Eremiášová, 2013).

Besides the assessment of structural functionality, reflecting the spatial configuration of landscapes, we can also assess what goods and services a landscape can provide. Ecosystem services are quantified and valued by ecosystem service assessments that are typically trans-disciplinary (Seppelt et al., 2012). The assessment of ecosystem service values should be useful for ecological planners (van der Horst, 2011), given its capacity to combine ecological processes and economic outcomes (Wainger et al., 2010). In order to be widely applied, the data set and methods used for assessing ecosystem services must be easily accessible and low-cost (Su et al., 2012). One of the basic concepts for the assessment of ecosystem services was introduced in the Millennium Ecosystem Assessment (MEA, 2005). It provides a basic framework for assessing the interaction between ecosystems and humans, and how these can be measured, evaluated, and strengthened for future well-being (Hermann et al., 2013). There is an increasing amount of work dealing with mapping, classification and valuation of ecosystem services (e.g. de Groot et al., 2002; Wallace, 2007; Sherrouse et al., 2011), as the issues represent key elements required for integrating this concept into decision-making processes (Burkhard et al., 2009; Hermann et al., 2013). The mapping of ecosystem services can be based on land use/land cover classes (Burkhard et al., 2009; Potschin, 2009; Lautenbach et al., 2011), or habitats (Haines-Young and Chopping, 1996; Haines-Young, Potschin, 2008), which are spatially explicit, represent distinct ecological units, and thus could be seen as "bundles" of the services they can deliver (Hermann, Schliefer and Wrbka, 2011).

When dealing with the landscape scale, it might be more appropriate to use the term "landscape services" (Termorshuizen, Opdam, 2009), as they are associated with people's local environments, and are related more to human and cultural patterns, unlike ecosystem services that may be related more to natural processes and conservation (Hermann et al., 2013). The capacity for providing services within an ecosystem is believed to be not homogenously distributed across landscapes, but rather dependent on spatial and temporal interactions between different components (Ng et al., 2013; Syrbe, Walz, 2012; Willemen et al., 2008). Despite this knowledge, works joining ecosystem services and spatial patterns are rather rare (Frank et al., 2012; Su et al., 2012). A possible approach to account for spatial patterns and their impact on landscape structure-related ecosystem services might be the use of landscape metrics (Feld et al., 2007). Examples of this approach can be found in studies published by Kong et al. (2007), Frank et al. (2012), Su et al. (2012) or Syrbe and Walz (2012). The latter group of authors used landscape metrics to identify the impact of landscape structure on ecosystem services, while Ng et al. (2013) focused on landscape connectivity, since they believe that not taking into consideration this criterion may lead to a failure in properly accounting for the spatial variability of ecosystem services caused by the dynamics in the landscape configuration (Ng et al., 2013).

This article presents results from the assessment of structural functionality, landscape services, and their mutual relationship in three different landscape types occurring in the Czech Republic. In particular the following questions are posed: Are there any relationships between structural functionality and landscape services? Namely, can we combine the proposed assessments in order to estimate the impact of landscape structure expressed by structural functionality on landscape services? If so, where would this finding be most valid?

The assessment of structural functionality is based on statistical analysis of landscape metrics, since structural functionality in this article is understood as a degree of connectivity of landscape elements (see above). The assessment of landscape services is based on the use of an expert-driven capacity matrix, showing relationships between landscape elements and selected landscape services.

2. Materials and methods

2.1 Sample sites

Ten sample sites, on average between 350 and 400 ha in size, were selected (Fig. 1). Their selection was based on two criteria: they included parts of protected areas, and the total area of sealed surfaces did not exceed 10% of the total area of each sample site.

The sample sites were categorised into three groups, according to their landscape type (LT):

1. Alluvial forested LT (1,036.10 ha) – situated in wide river valleys (150–300 m above sea level) with quaternary sediments (loess, sand, and gravel), fluvisols, and warm to mild climate. Floodplain forests with ash, oak or elm, as well as wet meadows, are also common in this LT. Settlements occur to a greater extent in two of the case studies belonging to this LT;

2. Hilly agricultural LT (1,281.93 ha) – situated in hilly regions at lower elevations (180–300 m a.s.l.) with calcareous clays and sands, chernozems, and warm and dry climate. The prevalent land use is mainly vineyards or arable land, but dry grasslands and oak or oak-hornbeam woodlands occur in protected areas; and
3. Upland meadow forested LT (1662.58 ha) – situated in uplands at higher elevations (300–780 m a.s.l.) with flysh formations (rotation of sand stones and clay stones, usually in calcareous forms), cambisols, and mild climate. Oak-hornbeam or beech forests predominate, but mesophile meadows are also widespread. Settlements occur to a greater extent in two of the case studies belonging to this LT.

2.2 Landscape element maps

Orthophotos from 2009, provided by the Ministry of the Environment of the Czech Republic, with a resolution of 1 m, were used to create landscape element maps (Skokanová, Eremiášová, 2013). Landscape elements in this article represent the smallest mappable homogenous units, and are equal to patches in the sense of Forman and Godron (1986). The photos were manually vectorized in ArcGIS software (ESRI, 1999–2008), and landscape elements were delimited. They were then assigned a code that reflected land cover categories, type and intensity of usage, as well as the ecological stability of the depicted elements. The classification of land cover categories was based on methods tested in the Czech Republic (Pellantová, 1994; Vondrušková, 1994) and Slovakia (Petrovič, 2005; Pucherová, 2007).

Ecological stability (similar to hemeroby – see Steinhardt et al., 1999) was used as one of the measures of quality of the landscape elements. It was based on both a digital layer of biotope mapping in the Czech Republic, which was created when the network of NATURA 2000 sites was established, and on field surveys conducted in 2010 and 2011. The classification of ecological stability was based on the concept of Míchal (1994), who defines ecological stability as the ability of an ecological system to sustain itself despite the influence of disturbing elements, and to reproduce its substantial characteristics in conditions of external disturbance. Each landscape element was given a degree of ecological stability from 0 to 5. A detailed description of the levels is available in Skokanová, Eremiášová (2012).

In total, 83 types of landscape elements were distinguished, falling into the broad categories of arable land, permanent grassland, permanent crop, forest, water area, sealed area, and other areas.

2.3 Structural functionality

For calculating structural functionality, the resulting landscape element map was rasterized with a pixel size of 1.5 m. This rasterized layer served for

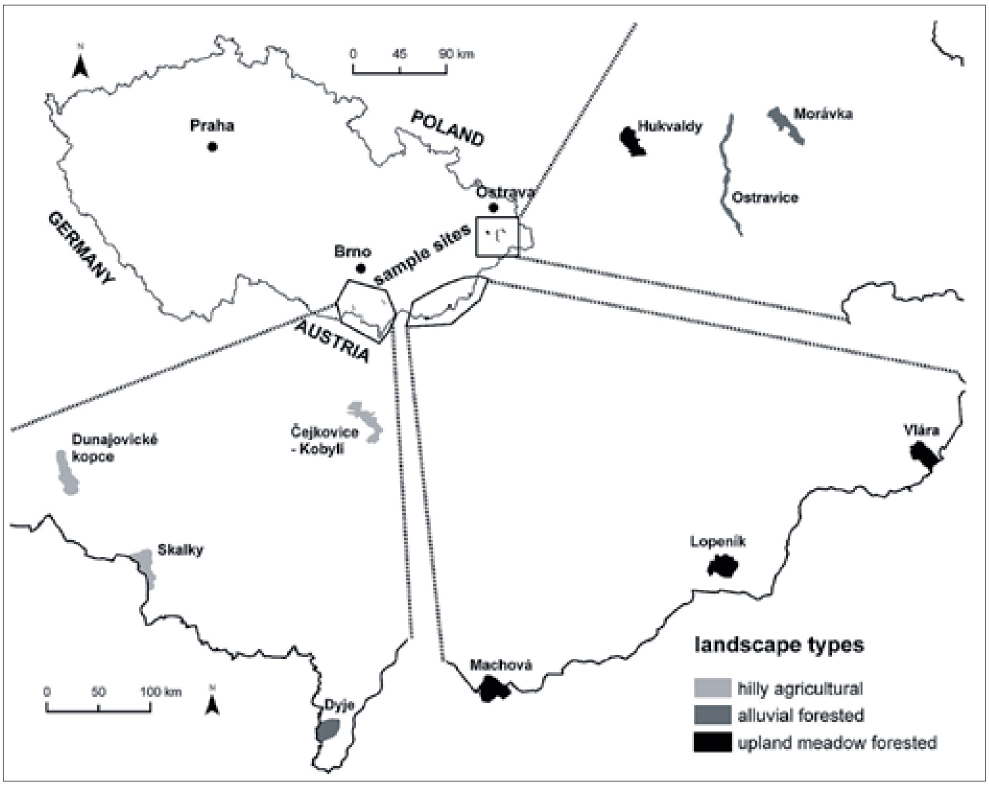

Fig. 1: Location of sample sites in terms of landscape types

calculating landscape metrics of landscape elements important for the assessment of functionality. Calculation of landscape metrics was carried out using the Fragstats 3.3 programme (McGarigal et al., 2002). Relevant metrics for structural functionality assessment were selected in several steps (for more detail, see Kuttner et al., 2013): first, highly correlated metrics (correlation coefficients of ± 0.8) were selected using the Kendall-Tau method. These were then transformed in order to approximate a Gaussian distribution, and were pooled into six functionality groups reflecting different ecological processes: connecting corridors, dissecting corridors, valuable matrix, disturbed matrix, artificial matrix, and stepping stones (Kuttner et al., 2013; Skokanová and Eremiášová, 2013). Connecting corridors are represented by linear landscape elements that provide connectivity for organisms between other landscape elements (e.g. rivers, tree lines, grassland strips along roads). Dissecting corridors are, on the other hand, artificial linear structures such as roads, railroads, and pipelines. Landscape elements of higher ecological quality, and thus higher conservation value, are recorded in the valuable matrix, whereas landscape elements which are highly anthropogenically influenced belong to the disturbed matrix. The artificial matrix consists of landscape elements with dominant sealed surfaces, such as settlements, industrial areas, and waste dumps. The final functionality group, stepping stones, represents landscape elements that can serve as proxy habitats: examples include abandoned mining sites, fallow land, parks, groups of trees, etc.

For each functionality group a principal component analysis was performed to reveal metrics, which explained the structure in the data to the greatest degree. Predefined relationships between landscape metrics and structural functionality were used for the normalisation of selected metrics (Table 1). These relationships were based on statistical results and were supported by literature (e.g. Cushman et al., 2008; Schindler et al., 2008; Farig, 2003). A positive relationship was defined for cases where increasing values of landscape metrics led to increasing functionality; a negative relationship was defined for cases where increasing values of landscape metrics led to decreasing functionality.

The functionality of landscape elements was calculated as the mean of all normalised indices belonging to the respective functionality group. It was subsequently divided into five functionality categories (very low, low, medium, high, very high) according to the quintile values to derive areal statistics.

2.4 Landscape services

The assessed landscape services were adopted from de Groot (2006). In total, 20 individual sub-services were distinguished and grouped into five main services:

Landscape metrics	Connecting corridors	Dissecting corridors	Valuable matrix	Disturbed matrix	Artificial matrix	Stepping stones
Aggregation index (AI)			+	–		
Mean patch area (AREA_MN)	+	–	+	–		+
Class area (CA)	+	–	+		–	+
Connectance index (CONNECT)	+	–				+
Mean contiguity index (CONTIG_MN)					–	
Mean core area (CORE_MN)			+	–	–	
Area weighted Euclidean nearest-neighbour distance (ENN_AM)	–	+	–	+	+	–
Mean fractal dimension index (FRAC_MN)	+	–		+	+	
Largest patch index (LPI)			+			
Landscape shape index (LSI)	+	–				
Patch density (PD)	+	–				+
Mean proximity index (PROX_MN)	+	–	+	–	–	+
Area weighted mean shape index (SHAPE_AM)	+	–	+	+		+

Tab. 1: Relationships between functionality groups and landscape metrics in terms of structural functionality (Kuttner et al., 2013). Note: + indicates a positive relationship (i.e. increasing structural functionality with increasing metrics); – indicates a negative relationship (i.e. decreasing structural functionality with increasing metrics)

regulation, habitat, provision, information, and carrier. Regulation services relate to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life-supporting systems through biogeochemical cycles, and maintain a healthy ecosystem at different scale levels (de Groot, 2006). This group includes sub-services such as climate regulation, disturbance prevention, water regulation, water supply, soil retention, soil formation, nutrient regulation, and pollination. Habitat services provide refuge and reproduction habitat for wild plants and animals. They are defined in terms of the minimum critical biotope size needed for a related species. The sub-services of refugium and nursery belong in this group. The provision services are targetting the supply of natural resources (Hermann et al., 2013), while information services include all services contributing to the maintenance of human health, such as opportunities for reflection, spiritual enrichment, recreation, and aesthetic experience. Provision services are in this case represented by food, raw materials, genetic resources, and medicinal resources. Recreation, science, and education were selected for information services. Finally, carrier services describe the capacity of landscapes to provide a suitable substrate for most human activities. As such, we can put sub-services of habitation, cultivation, transportation, and waste disposal into this group. Definitions and examples of the mentioned sub-services are included in de Groot (2006) and Hermann et al. (2013).

The assessment of potential landscape services was based on the use of a capacity matrix (according to Haines-Young, Potschin, 2008; Burkhard et al., 2009), where landscape services were related to a specific landscape element. The relation expressing the capacity of the landscape element to provide a certain landscape service was assessed on a scale from 0 (no relevant link) to 5 (very high relevant link) by expert evaluations from different disciplines of ecology. Values from the capacity matrix were taken from Herman et al. (2013), who used broad habitat types (Essl et al., 2002) as basic units, and adapted for the landscape elements accordingly.

To receive one single value for each sub-service per sample site, mean values of all landscape elements service values were separately calculated for individual sub-services. These were then extrapolated to LT levels by calculating mean values for the related sample sites per LT. Consequently, the main service values were obtained by calculating mean values of the specific subservices on the LT level.

Possible relationships between mean functionality and individual landscape services of the landscape elements at the landscape level were tested using Spearman's rank correlation coefficients in the STATISTICA programme (Statsoft, 2004).

3. Results

3.1 Structural functionality

The highest structural functionality was calculated for the upland meadow forested LT, while the hilly agricultural LT showed the lowest values of structural functionality. Slightly higher mean functionality was noted for the alluvial forested LT.

In general, the valuable matrix (median = 55.62) and the connecting corridors (median = 42.44) showed the highest values of mean functionality, while the dissecting corridors (median = 48.91) turned out to be lower, but still higher than the disturbed matrix (median = 45.86), artificial matrix (median = 31.62), and stepping stones (median = 41.28), as clearly shown in Figure 2a. While these observations were valid for both the alluvial forested and the upland meadow forested landscape types (see Figure 2b and d), functionality groups in the hilly agricultural LT tended to behave differently. The differences were typical mainly for the artificial matrix and dissecting corridors – the former showing the highest values of mean functionality and the latter showing the lowest values of mean functionality (Fig. 2c).

The areal distribution of the functionality categories followed a similar pattern as the mean functionality in the functional groups (Tab. 2): Landscape elements such as forests, meadows, and watercourses, belonging to the functionality category "very high", spatially dominated in both forested landscape types. On the other hand, landscape elements from the disturbed matrix (arable land, permanent crops) representing the "very low" functionality category covered more than 50% of the hilly agricultural LT.

3.2 Landscape services

Capacity values of landscape elements to provide main landscape services, i.e. regulation, habitat, provision, information, and carrier, in different landscape types are shown in Fig. 3. As is obvious from this figure, there are only slight differences between the landscape types. Overall, the upland meadow forested LT tended to show higher values for all main services, with the exception of carrier services (Fig. 3c), while the hilly agricultural LT showed the lowest values for all main services, with the exception of provision and regulation services (Fig. 3b). In the alluvial forested LT, carrier services were higher, and provision with regulation services lower than in the other two LT (Fig. 3a).

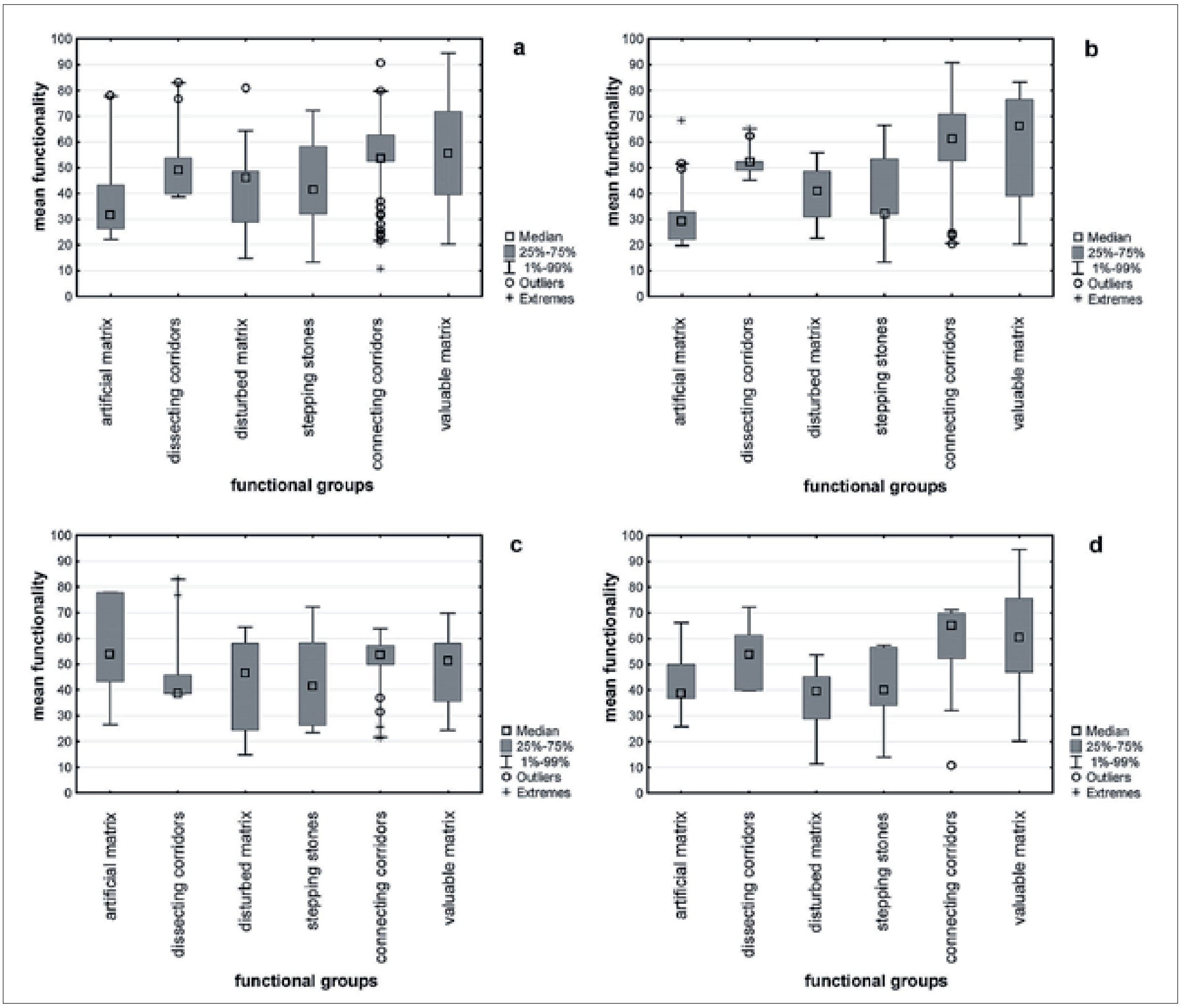

Fig. 2: Mean functionality in functionality groups – overall (a), alluvial forested LT (b), hilly agricultural LT (c), and upland meadow forested LT (d)

	Very low	Low	Moderate	High	Very high
Alluvial forested LT	4.7	13.3	10.2	5.5	66.3
Hilly agricultural LT	57.1	23.7	6.6	9.2	21.9
Upland meadow forested LT	5.9	1.8	7.0	6.7	79.4

Tab. 2: Area percentage of functionality categories ("very low" to "very high") in the individual landscape types

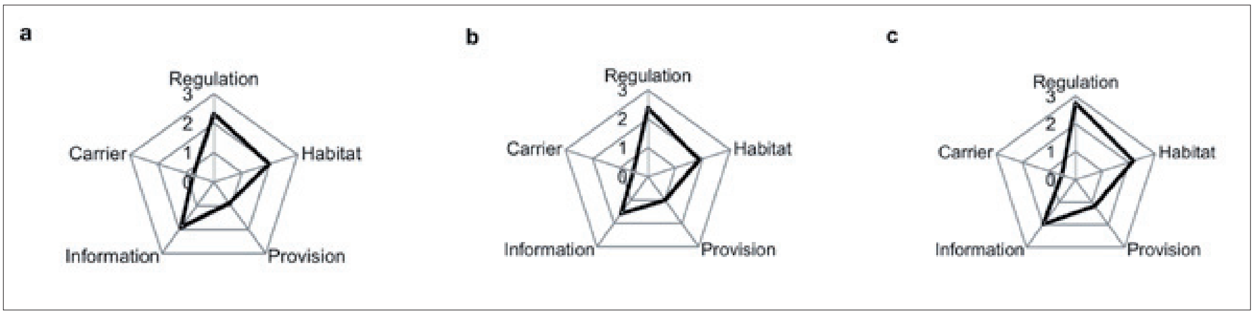

Fig. 3: Capacity values to provide main landscape services in the alluvial forested LT (a), hilly agricultural LT (b), and upland meadow forested LT (c)

Regulation and habitat services dominated in all landscape types. The highest values were calculated for the upland meadow forested LT. This resulted from a high number of patches of oak-hornbeam and beach forests, as well as herb-rich meadows with higher capacities of the services. A high number of patches of forests and meadows also provided higher capacities for food and medicinal resources from the provision services, and played an important part in the recreation sub-service, which belongs to the information services.

Predominant agricultural use in terms of large and numerous patches of arable fields, vineyards, and intensive orchards in the hilly agricultural LT was reflected in the higher capacity to provide the cultivation sub-service belonging to carrier services. However, since the other sub-services in this group showed very small values, the carrier services group as a total recorded only low values. The number of agricultural patches together with more valuable landscape elements in the form of forest and steppe was also reflected in the higher values of regulation services, namely soil formation, water regulation (Fig. 4), soil retention and nutrient regulation, and habitat services, namely refugium sub-services.

The highest values of carrier services shown in the alluvial forested LT were caused by the concentration of interconnected settlements in the river valleys, which resulted in rather high values of habitation and transportation sub-services. On the other hand, the predominant floodplain forests together with wet meadows provided higher regulation (especially disturbance prevention, pollination, and climate regulation sub-services), information (recreation sub-service), and habitat services than was the case of the hilly agricultural LT.

3.3 Relationships between structural functionality and landscape services

Spearman's correlation coefficients revealed a significant relationship between structural functionality and the majority of landscape services, especially in the upland meadow forested LT (19 out of 20 sub-services were significantly correlated within the range from – 0.288 to + 0.494: see Tab. 3) and in the alluvial forested LT (17 out of 20 sub-services were significantly correlated within the range from – 0.499 to + 0.540). In the hilly agricultural LT, significant correlations were found only for 14 subservices and the values ranged from – 0.139 to + 0.288.

It is clear from Tab. 3 that the correlations were rather weak for all landscape types, and only the alluvial forested LT showed a slightly stronger relationship between structural functionality and landscape services, especially regulation, habitat, and provision services. Positive correlations, i.e. increases in the values of mean functionality resulting in the increase of landscape services, were typical for regulation services, habitat services, provision services, and information services in both the alluvial forested and upland meadow forested landscape types. Negative correlation, i.e. landscape services decreasing with increasing structural functionality, was related to the carrier services in both forested LTs and to the majority of sub-services in the hilly agricultural LT.

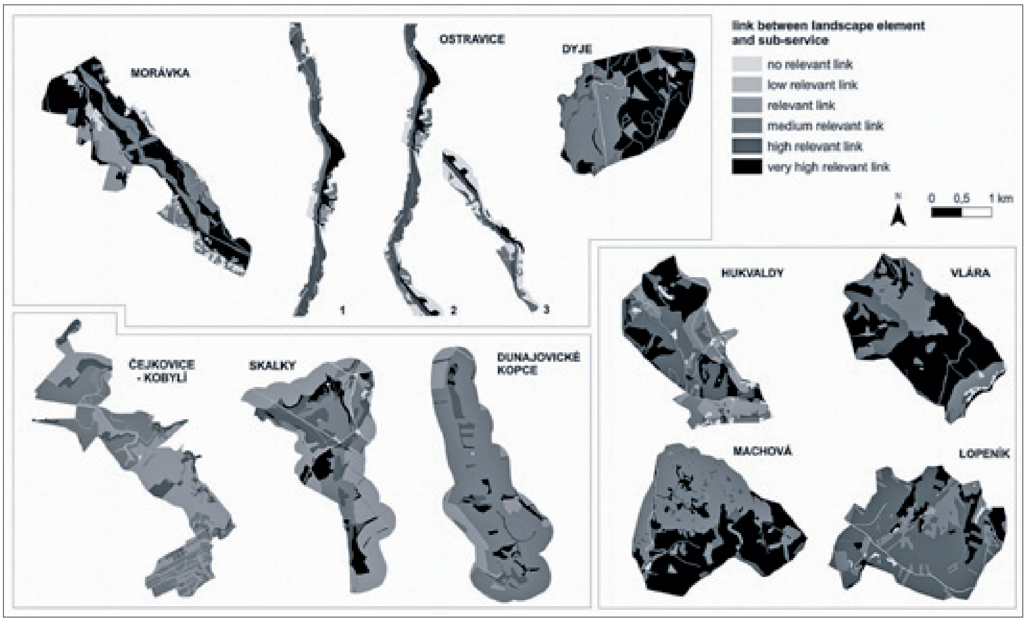

Fig. 4: Water regulation service maps for the alluvial forested LT (upper left), hilly agricultural LT (lower left), and upland meadow forested LT (right)

Landscape service	Landscape sub-service	Alluvial forested LT	Hilly agricultural LT	Upland meadow forested LT
Regulation services	climate regulation	0.005	**– 0.138**	**0.092**
	disturbance prevention	**0.473**	0.001	**0.454**
	soil formation	**0.471**	0.009	**0.364**
	water regulation	**0.472**	**– 0.144**	**0.357**
	soil retention	**0.442**	– 0.049	**0.305**
	nutrient regulation	**0.514**	– 0.030	**0.415**
	pollination	**0.370**	**0.372**	**0.094**
	water supply	**0.472**	0.037	**0.381**
Habitat services	refugium	**0.428**	0.048	**0.190**
	nursery	**0.501**	**0.180**	**0.319**
Provision services	food	**0.540**	– 0.019	**0.439**
	medicinal resources	**0.410**	**0.174**	**0.494**
	raw materials	**0.415**	**– 0.254**	**0.154**
	genetic resources	**0.425**	**0.137**	**0.108**
Information services	science and education	**0.361**	**– 0.181**	**0.419**
	recreation	**0.290**	**– 0.077**	**0.323**
Carrier services	cultivation	– 0.041	**– 0.132**	**– 0.153**
	habitation	**– 0.499**	0.058	**– 0.288**
	transportation	**– 0.349**	– 0.001	**– 0.264**
	waste disposal	0.011	**0.083**	– 0.010

Tab. 3: Spearman correlation coefficients between structural functionality and landscape services in the alluvial forested LT, hilly agricultural LT, and upland meadow forested LT (significant correlations ($p < 0.05$) are marked in bold)

4. Discussion

The presented methods for assessing structural functionality and landscape services have their advantages and disadvantages, which are discussed in more detail below.

4.1 Structural functionality

For assessing structural functionality, landscape elements were pooled into functionality groups. Distinguishing these groups is very clear, regarding connecting and dissecting corridors – in both cases they are represented by linear elements of long and narrow shapes, while connecting corridors are represented by natural or man-adjusted (e.g. regulated rivers) landscape elements, and dissecting corridors are represented by strictly man-made landscape elements. Also, the artificial matrix is clearly distinguished, since it contains only sealed surfaces. Distinguishing between the valuable matrix and the disturbed matrix is based on the intensity of their usage, reflected also in their degree of ecological stability: while landscape elements in the disturbed matrix are intensively used by man (e.g. large-scale intensive vineyards), human impact and the use of landscape elements in the valuable matrix (e.g. semi-natural meadows) is rather low. As such, if the human impact on landscape elements in the valuable matrix significantly increases, resulting in the decrease of natural species (their presence is less than 30%), these elements might be reclassified as a disturbed matrix. On the other hand, if the human impact decreases, landscape elements in the disturbed matrix will first be reclassified as stepping stones. They can be reclassified as a valuable matrix in the end, when the impact of humans will have significantly ceased. This process can be reflected for example in the increased presence of natural species.

The most problematic group to distinguish is represented by stepping stones. Landscape elements of this group can be considered as a step between the disturbed matrix and the valuable matrix, where the intensity of human impact is lower, but still higher than in the valuable matrix, since humans have been affecting the elements for a very long time (decades or even centuries). They include, for example, abandoned orchards, or they were originally made by humans but later left to natural processes (e.g. ponds). The presence of natural species in this group is rather low. Stepping stones are important parts in the landscape, because they support species dispersal by decreasing inter-patch distances and providing habitat shelter (Kuttner et al., 2013).

Since the calculation of structural functionality strongly depends on the relationship of the functionality groups with respect to the landscape metrics (Kuttner et al., 2013), it is essential to pool the landscape elements into the correct groups. This can be achieved by applying the above-mentioned rules, which are applicable in different regions of the world. Because this approach needs additional information that is not easily obtainable (e.g. information about the degree of ecological stability or naturalness), the classification by Kuttner et al. (2013), who used CORINE Land Cover classes, can be applied instead.

Calculating structural functionality using the methodology presented here might be biased by the fact that landscape metrics, due to their high number, are often correlated to each other (Wagner and Fortin, 2005; Uuemaa et al., 2009), leading to difficulties in interpretation of the results. Therefore, selecting the most suitable metrics is quite challenging. This can be overcome by various statistical analyses, e.g. factor analysis, principal components analysis and cluster analysis, as was the case in Riiters et al. (1995), Cushman et al. (2008), Schindler et al. (2008) or Kuttner et al. (2013). These analyses make it possible to identify independent components of landscape structure and to group them (Uuemaa et al., 2009).

Besides the landscape metrics, functionality values can be greatly influenced by the number and spatial extent of landscape elements. This was typically the case for the artificial matrix in the hilly agricultural LT, where this functionality group covered the smallest area and had the smallest number of landscape elements, resulting in unbalanced values of the corresponding metrics, hence high functionality values. Similar results were also noted in the Austrian-Hungarian borderland case studies (Kuttner et al., 2013).

A major disadvantage of the current assessment might be seen in the transformation, normalization and aggregation of indices, which may lead to a loss of transparency of the applied method. However, the steps are justifiable: the transformation of input indices was carried out in order to approximate a Gaussian distribution as a necessary precondition for the principal components analysis, which was used to select the most suitable indices explaining relationships within the functionality groups. Further normalization was used to adjust values to a common scale in order to calculate the resulting values of functionality for the given landscape element. It was used because different methods were applied in the transformation of indices: logarithmic, square root, and arcsine square root. Final values of mean functionality per landscape element, which are achieved by averaging the values of normalized indices, reflect the complexity of structural functionality expressed by relevant landscape indices.

The advantages of calculating structural functionality on the basis of landscape metrics lay in simplicity, transparent selection of the landscape metrics, and general applicability. As such, this method might serve as a general guide for both landscape managers and nature conservation authorities for selecting areas suitable for nature conservation and landscape protection (Skokanová, Eremiášová, 2013).

4.2 Landscape services

The methodology used for the assessment of potential landscape services can be regarded as simple and generally applicable. Since it does not require intensive new data collection, it can be used especially in regions with limited or incomplete data on specific landscape services (Hermann et al., 2013). The application of a capacity matrix with expert driven values has also been successfully used in other studies (Haines-Young and Potschin, 2008; Burkhard et al., 2009; Hermann et al., 2013). It enables a rapid service assessment and supplies a good overview to see the first trends for landscape service provision (Burkhard et al., 2009). Using a relative five-step scale in assigning capacity values to landscape elements enables a comparison of different capacities to deliver individual sub-services by harmonizing different indicators. It also offers the opportunity to avoid value-laden units, such as monetary terms (Hermann et al., 2013), which are usually quite difficult to establish (see e.g. Seják et al., 2010).

A major drawback of this methodology might be seen in assigning capacity values to landscape elements by expert judgement, which can be subjective. This can be to some extent overcome by incorporating additional data from a field survey, reflecting for example the intensity of usage or ecological quality in the definition of landscape elements, as was the case of this study. Incorporating additional data in the definition of landscape elements also overcomes the problem of distinguishing land cover classes only on the basis of maps derived from orthophotos or satellite imagery. Another approach was shown in the work of Hermann et al. (2013), who defined landscape elements as broad habitat types but revised initial values of the capacity matrix by qualifiers derived from field surveys.

The capacity to provide some landscape sub-services (e.g. pollination, recreation, water regulation) can be strongly influenced by the spatial and functional position of landscape elements, neighbour effects, landscape element size, etc., as shown in the studies by Lautenbach et al. (2011) or Ng et al. (2013). Other services, such as soil formation or water supply are expected to depend primarily on land use composition (Lautenbach et al., 2011). Hermann et al. (2013) weighted potential capacities by area, assuming that the area of a landscape element has an impact on the provision of a service (e.g. a large forested area can affect climate more than a small one). Despite the fact that the methodology used in this project for landscape services assessment largely stems from their work, this step was avoided, because their proposed procedure (re-categorization of area-weighted values by 20th-percentiles) did not consider the occurrence of very few large patches in opposition to many small ones, leading to biased results.

The rather small and insignificant differences between landscape services within and between the landscape types were caused by the aggregation of relevant sub-services into main landscape services, which resulted in a loss of information. This obstacle seems to be the main drawback of the methodology, but it can be partly rectified by weighting individual sub-services, based on the need of landscape managers to stress particular sub-services.

4.3 Relationships between structural functionality and landscape services

Statistical analyses confirmed to some degree that landscapes with higher structural functionality could have a higher capacity to provide landscape services. However, this assertion was valid predominantly for the alluvial forested and upland meadow forested LTs, due to a higher occurrence of valuable landscape elements with a higher share of natural species that significantly influence many of the landscape sub-services: this includes, among others, disturbance prevention, water regulation, and water supply, soil formation, nutrient regulation, genetic resources, raw materials, medicinal resources, science, and education (Yapp et al., 2010). This assertion is most likely influenced by the positive relationship between structural functionality and the majority of landscape metrics related to this functionality group (see Tab. 1). Positive relationships between the landscape/ecosystem services and the landscape metrics that characterize the valuable matrix have also been reported in other studies: Lautenbach et al. (2011) found, for example, that food, recreation, and water regulation were affected by the size of the respective patch; Bodin et al. (2006) reported similar findings for pollination; and Frank et al. (2012) identified significant relationships between genetic resources and the nursery and shape index.

Negative relationships between structural functionality and many landscape sub-services in the hilly agricultural LT correspond to the prevalence of the disturbed matrix in this landscape type, and consequently indirectly point to the relation between sub-services, namely those from the provision and information services, and the respective landscape metrics. The relationships between functionality groups and landscape metrics also explain the negative outcome for habitation (typical of the artificial matrix) and transportation (typical of the dissecting corridors) sub-services in both forested LTs.

Because the relationships were only significant for some landscape services and in some landscape types, aggregating landscape metrics in order to deliver structural functionality values gives fuzzy results, and might be used only for some landscape services. It seems that combining only landscape metrics with landscape services can give a clearer picture about the importance of spatial configuration on estimating, evaluating, and maintaining landscape services (see Syrbe, Walz, 2012; Su et al., 2012; Lautenbach et al., 2011; or Frank et al., 2012), and therefore might be a better solution for landscape planners and managers.

5. Conclusion

This paper investigates two methods for assessing structural functionality and landscape services, and the potential of their joint application in order to estimate the impact of landscape structure in terms of structural functionality on landscape capacity to provide various landscape services.

The main advantage of the methods lies in the fact that all assessed criteria are spatially embedded and can be simply visualized, and therefore give a clear idea about potentials, possible conflicts and limits in landscape planning and management. Also, their relative simplicity and limited need for detailed data meet the requirement to be easily accessible and low-cost. The especially transparent sampling and selection procedures of landscape metrics used to define functionality groups ensures general applicability to other regions, and can be used in other landscape metric-related research questions.

Separately, the assessments can be used as supportive tools in nature conservation and landscape planning – especially the assessment of structural connectivity, combined with tools incorporating species and other ecologically decisive driving factors, can, among other things, contribute to the delimitation of ecological networks or protected areas. The assessment of landscape services might help in evaluating sensitive regions, which was also demonstrated in the study published by Hermann et al. (2013). Another advantage of this assessment is in evaluating multiple services in one procedure, and thus capturing a more realistic picture of heterogeneous landscapes.

The results of the statistical analyses showed that linking structural functionality to landscape services might, to some extent, help in estimating the impact of landscape structure on some landscape services in landscape types with the prevalent valuable matrix, as were the cases of the upland meadow forested landscape type and the alluvial forested landscape type. However, the relation between these attributes very likely depends on the relationship between landscape metrics and structural functionality defined for the individual functionality groups. Therefore, a combination of individual landscape metrics with landscape services would probably provide better insights on how landscape structure can influence landscape services.

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References:

ANTROP, M. (2000): Background concepts for integrated landscape analysis. Agriculture, Ecosystems & Environment, Vol. 77, p. 17–28.

BOCK, M. et al. (2005): Spatial indicators for nature conservation from European to local scale. Ecological Indicators, Vol. 5, p. 322–338.

BODIN, Ö., TENGÖ, M., NORMAN, A., LUNDBERG, J., ELMQVIST, T. (2006): The value of small size: loss of forest patches and ecological thresholds in Southern Madagascar. Ecological Applications, Vol. 16, p. 440–451.

BURKHARD, B., KROLL, F., MÜLLER, F., WINDHORST, W. (2009): Landscapes' capacities to provide ecosystem services - a concept for land-cover based assessment. Landscape Online, Vol. 15, p. 1–22.

CUSHMAN, S. A., MCGARIGAL, K., NEEL, M. C. (2008): Parsimony in landscape metrics: strength, universality and consistency. Ecological Indicators, Vol. 8, p. 691–703.

DAUBER, J. et al. (2003): Landscape structure as an indicator of biodiversity: matrix effects on species richness. Agriculture, Ecosystems & Environment, Vol. 98, p. 321–329.

de GROOT, R. (2006): Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. Landscape and Urban Planning, Vol. 75, p. 175–186.

de GROOT, R. S., WILSON, M. A., BOUMAND, R. M. J. (2002): A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics, Vol. 41, p. 393–408.

DRAMSTAD, W. E., TVEIT, M. S., FJELLSTAD, W. J., FRY, G. L. A. (2006): Relationships between visual landscape preferences and map-based indicators of landscape structure. Landscape and Urban Planning, Vol. 78, p. 465–474.

ESRI, Inc. (1999-2008): ArcMap 9.3. Redlands, CA.

ESSL, F., EGGER, G., ELLMAUER, T., AIGNER , S. (2002): Rote Liste der gefährdeten Biotoptypen Österreichs: Konzept. UBA-Monographien, Umweltbundesamt, Wien. 40 pp.

FARIG, L. (2003): Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics, Vol. 34, p. 487–515.

FELD, C. K. et al. (2007): Assessing and monitoring ecosystems – indicators, concepts and their linkage to biodiversity and ecosystem services. The RUBICODE Project. 108 p. [online] available at: http://www.rubicode.net/rubicode/RUBICODE_Review_on_Indicators.pdf

FORMAN, R. T. T., GODRON, M. (1986): Landscape Ecology. John Willey and Sons, Inc., New York, NY, USA. 619 pp.

FRANK, S., FÜRST, C., KOSCHKE, L., MAKESCHIN, F. (2012): A contribution towards a transfer of the ecosystem service concept to landscape planning using landscape metrics. Ecological Indicators, Vol. 21, p. 30–38.

HAINES-YOUNG, R., CHOPPING, M. (1996): Quantifying landscape structure: a review of landscape indices and their application to forested landscapes. Progress in Physical Geography, Vol. 20, p. 418–445.

HAINES-YOUNG, R., POTSCHIN, M. (2008): England's Terrestrial Ecosystem Services and the Ecosystem Approach. Full Technical Report. 89 pp.

HERMANN, A. et al. (2013): Assessment framework for landscape services in European cultural landscapes: An Austrian Hungarian case study. Ecological Indicators. (In press).

HERMANN, A., SCHLEIFER, S., WRBKA, T. (2011): The concept of ecosystem services regarding landscape research: A review. Living Reviews in Landscape Research, Vol. 5, p. 1–37.

HOKIT, D. G., STITH, B. M., BRANCH, L. C. (1999): Effects of landscape structure in Florida scrub: A population perspective. Ecological Applications, Vol. 9, p. 124–134.

KONG, F., YIN, H., NAKAGOSHI, N. (2007): Using GIS and landscape metrics in the hedonic price modeling of the amenity vaule of urban green space: A case study in Jinan City, China. Landscape and Urban Planning, Vol. 79, p. 240–252.

KUIPER, J. (1998): Landscape quality based upon diversity, coherence and continuity: Landscape planning at different planning-levels in the River area of The Netherlands. Landscape and Urban Planning, Vol. 43, p. 91–104.

KUTTNER, M., HAINZ-RENETZEDER, C., HERMANN, A., WRBKA, T. (2013): Borders without barriers – Structural functionality and green infrastructure in the Austrian–Hungarian transboundary region of Lake Neusiedl. Ecological Indicators, Vol. 31, p. 59–72.

LAUTENBACH, S., KUGEL, C., LAUSCH, A., SEPPELT, R. (2011): Analysis of historic changes in regional ecosystem service provisioning using land use data. Ecological Indicators, Vol. 11, p. 676–687.

MCGARIGAL, K., CUSHMAN, S. A., NEEL, M., ENE, E. (2002): FRAGSTATS: spatial pattern analysis program for categorical maps. [online] Available at: http://www.umass.edu/landeco/research/fragstats/fragstats.html

MEA (2005): Ecosystems and Human Well-Being: Synthesis Report. Island Press, Washington, DC., 155 pp.

MOSER, B., JAEGER, A. G., TAPPEINER, U., TASSER, E., EISELT, B. (2007): Modification of the effective mesh size for measuring landscape fragmentation to solve the boundary problem. Landscape Ecology, Vol. 22, p. 447–459.

MÍCHAL, I. (1994): Ekologická stabilita. Veronica, Brno. 275 pp.

NAVEH, Z., LIEBERMAN, A. (1994): Landscape ecology, Theory and Applicaton. Springer-Verlag, USA, New York. 356 pp.

NG, C. N., XIE, Y. J., YU, X. J. (2013): Integrating landscape connectivity into the evaluation of ecosystem services for biodiversity conservation and its implications for landscape planning. Applied Geography, Vol. 42, p. 1–12.

NOVÁKOVÁ, J., SKALOŠ, J., KAŠPAROVÁ, I. (2006): Krajinná ekologie. Skripta ke cvičením. Lesnická práce, Kostelec nad Černými Lesy. 31 pp.

PELLANTOVÁ, J. [ed.] (1994): Metodika mapování krajiny pro potřeby ochrany přírody a krajiny ve smyslu zákona ČNR 114/92 Sb. ČÚOP Praha – Výzkumné a monitorovací pracoviště v Brně, Praha. 34 pp.

PETROVIČ, F. (2005): Vývoj krajiny v oblasti štálového osídlenia Pohronského Inovca a Tribeča. Ústav krajinnej ekológie SAV, pobočka Nitra, Bratislava. 209 pp.

POTSCHIN, M. (2009): Land use and the state of the natural environment. Land Use Policy, Vol. 26, p. S170–S177.

PUCHEROVÁ, Z. [ed.] (2007): Druhotná krajinná štruktúra (Metodická príručka k mapovaniu). UKF v Nitre, Nitra. 124 pp.

RIITERS, K. H. et al. (1995): A factor analysis of landscape pattern and structure metrics. Landscape Ecology, Vol. 10, p. 29–39.

SEJÁK, J. et. al. (2010): Hodnocení funkcí a služeb ekosystémů České republiky. Fakulta životního prostředí UJEP v Ústí nad Labem, Ústí nad Labem. 198 pp.

SEPPELT, R. et al. (2012): Form follows function? Proposing a blueprint for ecosystem service assessments based on reviews and case studies. Ecological Indicators, Vol. 21, p. 145–154.

SHERROUSE, B. C., CLEMENT, J. M., SEMMENS, D. J. (2011): A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. Applied Geography, Vol. 31, p. 748–760.

SCHINDLER, S., POIRAZIDIS, K., WRBKA, T. (2008): Towards a core set of landscape metrics for biodiversity assessments. A case study from Dadia National Park, Greece. Ecological Indicators, Vol. 8, p. 502–514.

SKOKANOVÁ, H., EREMIÁŠOVÁ, R. (2012): Changes in the secondary landscape structure and the connection to ecological stability: the cases of two model areas in the Czech Republic. Ekológia (Bratislava), Vol. 31, p. 33–45.

SKOKANOVÁ, H., EREMIÁŠOVÁ, R. (2013): Landscape functionality in protected and unprotected areas: Case studies from the Czech Republic. Ecological Informatics, Vol. 14, p. 71–74.

STATSOFT, Inc. (2004): STATISTICA Cz, version 10.0. Available at www.statsoft.cz.

SU, S., XIAO, R., JIANG, Z., ZHANG, Y. (2012): Characterizing landscape pattern and ecosystem services value changes for urbanization impacts at an eco-regional scale. Applied Geography, Vol. 34, p. 295–305.

SYRBE, R.-U., WALZ, U. (2012): Spatial indicators for the assessment of ecosystem services: Providing, benefitting and connecting areas and landscape metrics. Ecological Indicators, Vol. 21, p. 80–88.

STEINHARDT, U., HERZOG, F., LAUSCH, A., MÜLLER, E., LEHMANN, S. (1999): Hemeroby index for landscape monitoring and evaluation. In: Hyatt, D.E., Lenz, R.J. [eds.]: Environmental indices – System analysis approach. EOLSS Publ., Oxford, pp. 237–254.

TERMORSHUIZEN, J., OPDAM, P. (2009): Landscape services as a bridge between landscape ecology and sustainable development. Landscape Ecology, Vol. 24, p. 1037–1052.

TISCHENDORF, L. (2001): Can landscape indices predict ecological processes consistently? Landscape Ecology, Vol. 16, p. 235–254.

TSCHARNTKE, T., STEFFAN-DEWENTER, I., KRUESS, A., THIES, C. (2002): Characteristics of insect populations on habitat fragments: A mini review. Ecological Research, Vol. 17, p. 229–239.

VAN DER HORST, D. (2011): Adoption of payments for ecosystem services: an application of the Hägerstrand model. Applied Geography, Vol. 31, p. 668–676.

VONDRUŠKOVÁ, H. [ed.] (1994): Metodika mapování krajiny. SMS Hradec Králové, Praha. 55 pp.

WAGNER, H. H., FORTIN, M. J. (2005): Analysis of landscapes: concepts and statistics. Ecology, Vol. 86, p. 1975–1987.

WAINGER, L. A., KING, D. M, MACK, R. N., PRICE, E. W., MASLIN, T. (2010): Can the concept of ecosystem services be practially applied to improve natural resource managament decisions? Ecological Economics, Vol. 68, p. 978–987.

WALLACE, K. J. (2007): Classification of ecosystem services: Problems and solutions. Biological Conservation, Vol. 139, p. 235–246.

WEINSTOERFFER, J., GIRARDIN, P. (2000): Assessment of the contribution of land use pattern and intensity to landscape quality: use of a landscape indicator. Ecological Modelling, Vol. 130, p. 95–109.

WILLEMEN, L., VERBURG, P. H., HEIN, L., van MENSVOORT, M. E. F. (2008): Spatial characterization of landscape functions. Landscape and Urban Planning, Vol. 88, p. 34–43.

YAPP, G., WALKER, J., THACKWAY, R. (2010): Linking vegetation type and condition to ecosystem goods and services. Ecological Complexity, Vol. 7, p. 292–301.

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DEVELOPING A STRATEGY FOR THE PROTECTION OF TRADITIONAL AGRICULTURAL LANDSCAPES BASED ON A COMPLEX LANDSCAPE-ECOLOGICAL EVALUATION (THE CASE OF A MOUNTAIN LANDSCAPE IN SLOVAKIA)

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Abstract

Traditional agricultural landscapes (TALs) in Slovakia are mosaics of small-scale arable fields and permanent agricultural cultivations resulting from continuous succession over centuries. The objective in this paper is to develop a strategy for the protection and management of TAL in the Liptovská Teplička cadastral area, which has mountainous arable land and grassland TALs. Driving forces, threats and other trends related to these TALs were identified, based on the valuation of land-use changes, socio-economic and demographic phenomena and on biodiversity and sociological research. The strategy was oriented towards optimal multi-functional utilization and management of the investigated landscapes.

Shrnutí

Rozvoj strategie ochrany tradičních zemědělských krajin založené na komplexním krajinně-ekologickém hodnocení (na příkladu horské krajiny na Slovensku)

Tradiční zemědělská krajina je tvořena mozaikovou strukturou extenzívně využívaných maloplošných prvků orné půdy a trvalých kultur, které se tu vytvořily plynulou sukcesí trvající několik století. Cílem studie bylo vypracovat strategii pro ochranu a management tradiční zemědělské kraji v katastrálním území Liptovské Tepličky, které představuje typ tradiční horské polně-luční zemědělské krajiny. Výzkum byl zaměřený na změny využívání krajiny, hnací síly, ohrožení a trendy tradiční zemědělské krajiny. Návrh strategie je zaměření na optimální multifunkční využití a návrh managementu pro studované území.

Keywords: *traditional agricultural landscape, management, measures, biodiversity, Slovakia*

1. Introduction

Traditional agricultural landscapes (TALs) are described as landscapes where traditional sustainable agricultural practices are currently carried out and biological diversity is conserved (Harrop, 2007). TALs in Slovakia comprise a mosaic of small-scale arable fields and permanent agricultural cultivations, including grasslands, vineyards and high-trunk orchards originating from continuous succession over centuries (Štefunková, Dobrovodská, 1998). They are significant as unique islands of species-rich plant and animal communities. History has recorded many successive and even devastating landscape changes, which have barely left any TAL relics today (Benayas and Bullock, 2012; Marini et al., 2011). These changes are regarded as a menacing adverse development because they have engendered loss of diversity, coherence and identity characteristics of TALs, which are rapidly vanishing (Antrop, 2005a; Supuka, Stepankova, 2006). Traditional land-use systems in Europe have mainly persisted in upland and remote areas where physical constraints have prevented agricultural modernisation (Plieninger et al., 2006). The Slovak TAL inventory has determined the area of delimited TALs at 42,085 ha, and this comprises merely 0.9% of the entire territory of Slovakia (Špulerová et al., 2011). However, these areas are currently not subject to special protection and trends in declining management and abandonment are quite apparent.

On the other hand, these landscapes are significant not only from the biodiversity viewpoint, but they also have irreplaceable ecological, cultural and historical values, beneficial for society. For example, they play an important role in water retention and soil erosion control – both important with respect to climate change.

It is only in recent decades that the link between traditional European agricultural landscapes and biodiversity has been investigated and the importance of European agri-biodiversity recognized (Pedroli et al., 2007). Case studies involving multidisciplinary investigation of TALs, landscape history, forces driving the land-shaping system and land management methods have been analyzed, together with landscape preservation strategies. These are of great value from both nature and heritage conservation perspectives (Kizos et al., 2010; Petanidou et al., 2008; Cullotta and Barbera, 2011; Petit et al., 2012, and others). Interest in maintaining the integrity of traditional landscapes also emerged from the European Landscape Convention (ELC, 2000), following realistic threats of the loss of traditional landscapes.

The concept of High Nature Value (HNV) agricultural areas was developed within the Common Agricultural Policy (EU/1257/99). This ensued from a project for the European Environment Agency, focused on the identification of High Nature Value (HNV) farmland (Andersen et al., 2003; EEA/UNEP, 2004). The following three types of HNV farmland were defined (Paracchini et al., 2006):

1. (I) Farmland with a high proportion of semi-natural vegetation;
2. (II) Farmland with a mosaic of low intensity agriculture and natural and structural elements; and
3. (III) Farmland supporting rare species or a high proportion of European or World populations.

Although the HNV concept has not been effectively implemented in the current Slovak policy, national authorities have already created an expert platform to identify HNV indicators and the extent of HNV farmland (Plassmann, 2013).

The first attempt to identify HNV farmland in Slovakia was based on remote sensing data and information on species and habitat type distribution listed in the Annexes of the Habitat directive (Halada et al., 2011). In the Slovak Agricultural Agency spatial attention is currently concentrated only on type I – species rich grassland. Extensively utilized mosaics of TALs together with structural elements such as Forms of Anthropogenic Relief (FAR) represented by stone walls, terraces and mounds, and natural elements including field margins, hedgerows, patches of woodland or scrub and small rivers, form the type II Farmland with a mosaic of low intensity agriculture. Type II allocation is based on indicators and results from the Slovak countryside TAL inventory of 2009–2011 (Špulerová et al., 2011). This utilized a combination of land cover and farming system approaches with research on biodiversity.

The main aim of the research reported here is to highlight the significance of TALs, their biodiversity and threats, and to propose the most suitable management plan through studying the Liptovská Teplička pilot area. This area was selected because it reflects actual land use and management approaches, natural, socio-economical conditions and TAL protection and management strategies. TALs in this Liptovská Teplička cadastral area consist of characteristic mosaics of small strip fields and balks in a preserved cultural-historical landscape.

2. Materials and methods

Research into a cultural landscape is based on holistic principles, which integrate scientific disciplines. The trans-disciplinary landscape concept is based on the following five landscape dimensions; spatial entity, mental entity, temporal dimension, the inter-relationship of nature and culture, and systemic landscape properties (Tress and Tress, 2001). The landscape is studied as a hierarchical structure to reduce its extreme complexity to more comprehensive entities. The most important task in landscape studies is to define a scale indirectly derived from map surveys and resolution sampling (Antrop, 2005b). Intensive interaction between decision makers, researchers and landscape users is required in TAL studies. Scientific principles are utilized to understand the processes and spatial ecological structures and to restore, maintain and create traditional land use systems (Vos and Meeks, 1999). Developing instruments for practice and policy making such as scenario studies, monitoring systems and implementation of expert management systems, are highly recommended (WLO, 1998).

It is essential to understand the spatial and temporal intersection and interaction of landscape socio-economic, abiotic and biotic systems, in order to determine the current trends and threats to agrarian landscape heritage preservation, and to define TAL scenarios and management strategies. Herein we present a methodological approach to develop a strategy for TAL protection based on a complex landscape ecological assessment (Tab. 1). We were inspired by LANDEP methodology (Ružicka and Miklos, 1990) and by other methods and case-studies based on multidisciplinary integration and multi-scale approaches (Cullotta and Barbera, 2011; Ellis et. al., 2009; Van Eetvelde and Antrop, 2004).

Landscape scale/ landscape system	**Landscape – ecological analysis**		
	Abiotic conditions	Biotic conditions	Socio-economic and cultural conditions
Cadastral area	• Geology • Soils •Geomorphology •Hydrology	• Potential vegetation •Natural – semi-natural biotopes	• Past and present land cover/land-use • Socio-economic negative and positive impact •Landscape heritage features • Demographic structure • Sociological research
Selected TAL sites	• Geological substrate • Soils	• Zoological inventory of selected fauna groups • Phyto-coenological inventory	• Land cultivation • Traditional techniques • Forms of anthropogenic relief
	Landscape - ecological synthesis and evaluation		
Selected TAL sites	• Biodiversity and ecological value • Cultural-historical value		
Cadastral area	• Land-use trends • Cultural-historical value of TAL • Ecological value of TAL • Driving forces and threats to TAL • Elaboration of 3 scenarios and consultation with stakeholders		
	Proposals		
Cadastral area	**• Practical management measures of TAL**		
	• Strategy for sustainable utilization and protection of TAL		

Tab. 1: Methodology of complex landscape-ecological evaluation to develop a protection strategy for traditional agricultural landscapes

The complex landscape-ecological evaluation consisted of an analysis of landscape conditions at cadastral area level (landscape meso-scale) and selected TAL site levels (micro-scale). Landscape synthesis and assessment resulted in a strategy and practical measures for TAL management.

The landscape analysis at the cadastre level was focused not only on natural landscape components, land-cover/land-use and socio-economic conditions, but also included a TAL demographic and cultural heritage analysis and sociological research. The analysis of socio-economic conditions was based on the following:

1. Identification of human interaction with natural resources with positive impact (such as legislative measures for nature protection, protection of natural, cultural and historical resources, and also ecologically significant landscape elements currently lacking legislative protection); and
2. Those with negative impacts, thus posing threats to TALs and other natural resources

Demographic conditions were evaluated on the basis of population age structure, population movements, economic structure, employment and unemployment, and educational, ethnic and religious population structure. The sociological research on farmers and stakeholders perceptions of TALs was implemented by semi-structured interviews with five key stakeholders (mostly local farmers and decision makers) and from a questionnaire survey of local inhabitants, the latter involving 5% of permanent residents, with 230 respondents. The interviews were focused on the identification of underlying driving forces in landscape change, and agricultural policy effects on farmer's livelihoods and farm management. The questionnaire survey provided quantitative data on farmers and their farming practices. The total sample was divided into recent farmers in the 2000s, farmers from the 1970s, 1980s and 1990s, non-farmers, potential farmers from farming families, and other remaining respondents (Lieskovský et al., 2013).

Phyto-sociological sampling was performed on all non-forest habitats within the cadastre area, with a detailed fauna and flora inventory for selected TAL sites with different types of traditionally managed agricultural plots and FARs. The following fauna groups indicated habitat ecology; Mollusc (*Molusca*), Millipedes (*Diplopoda*), Beetles (*Coleoptera*), Birds

(*Aves*), Grasshoppers (*Orthoptera*) and Butterflies (*Lepidoptera*). Soil analysis, FAR inventory, cultivation type and agricultural technique were analyzed for selected TAL sites.

Landscape-ecological synthesis and evaluation consisted of identifying TAL localities, and land use trends assessment at the cadastral level. TAL sites comprised areas with preserved continuity of agricultural use, and their distribution in the study areas was identified through a comparison of current and historical maps depicting the state of land use in three time horizons (Štefunková et. al., 2013).

Biodiversity and cultural-historical values were assessed in monitoring plots with different types of TAL structures. The biodiversity assessment centred on the evaluation of species abundance, habitat diversity and vulnerability of species, based on vegetation and zoological surveys and existing ecological conditions. The cultural and historical value was determined by using a range of preservation and traditional cultivation techniques and original land terracing with FARs.

The main driving forces and threats to TALs were identified from knowledge of abiotic, biotic and socio-economic landscape conditions, from the results of the sociological research, and from past and current land use trends. Knowledge of biodiversity and cultural and historical value of the TAL sites was also included for this purpose.

Modelling scenarios: Three visual scenarios were derived from photomontages. These were based on the identified land-use changes, driving forces and TAL threats and trends, (software Adobe Photoshop 7.0). They depicted TAL disintegration trends, traditional TAL management maintenance and TAL abandonment. These scenarios were then discussed with local stakeholders.

The outcome provided a strategy for TAL protection and management consisting of practical management measures for different TAL types, and strategic development goals focused on key TAL objectives and based on sustainable development principles.

3. Results

3.1 Complex landscape-ecological evaluation of the pilot area

This research was performed in the Liptovská Teplička cadastre situated in a small basin surrounded by mostly steep (12°–17°) or moderate slopes in the Low Tatra Mts. (Fig. 1) at altitude ranges from 846–1,429 m a.s.l. Natural conditions comprise a wide spectrum of geological bedrocks (predominantly limestone and dolomites), related soils, relief segmentation and varied micro-climatic conditions. Goral settlers colonized the village with preserved typical wooden architecture in the 17th century. Specific FARs were created during the period of terrain modification for agricultural production. This landscape has a strip-like structure of small-scale plots, which create an attractive framework in the forested Low Tatra Mts. The area has sub-regions with a specific combination of natural and cultural diversity and high landscape visual quality.

The current dominant landscape structure encompasses grasslands differentiated by land use activity including intensively or extensively utilized meadows or pastures, some of which are tessellated or have lengthwise mounds. Extensively utilized meadows of grass-covered former arable fields cover the largest area of this grassland. The semi-natural meadows comprise small remnants of former mountain hay meadows, which, together with haylofts, retain the typical mountain landscape features existing before collectivisation. The most important landscape interventions linked to the establishment of an agricultural committee and collectivization began in 1975. Meadows situated in remote areas from settlements were transformed into pastures. The depression of agriculture continued until 1991, when re-privatization of agricultural land was connected with extensive agricultural development and the commencement of organic farming. Currently, most agricultural land is cultivated by the Agricultural Cooperative of Liptovská Teplička, which has leased land from private owners, and adopted organic farming since 1996 on the entire agricultural land area. They currently cultivate approximately 1,275 ha of farmland, 60 ha of which is arable land; meadows and pastures represent the remainder.

Traces of preserved traditional agriculture remain in five different types of TAL mosaic under different management intensity and with the presence of various FARs (Fig. 1). The different FAR types such as balks, terraces and mounds result from improved topography-soil quality, and these are either further directly cultivated and improved by stone removal or remain uncultivated (Fig. 2). Depending on the proportion of the soil/stone content, the FARs are categorized in three groups: muddy, muddy-rocky and loamed-rocky (Fig. 3).

TALs often create specific living conditions for biota of high biodiversity and also support many rare and endangered species. The biodiversity assessment herein centred on species richness in natural and semi-natural habitats and on habitats conditioned by anthropogenic activities such as FARs. More than 200 plant species

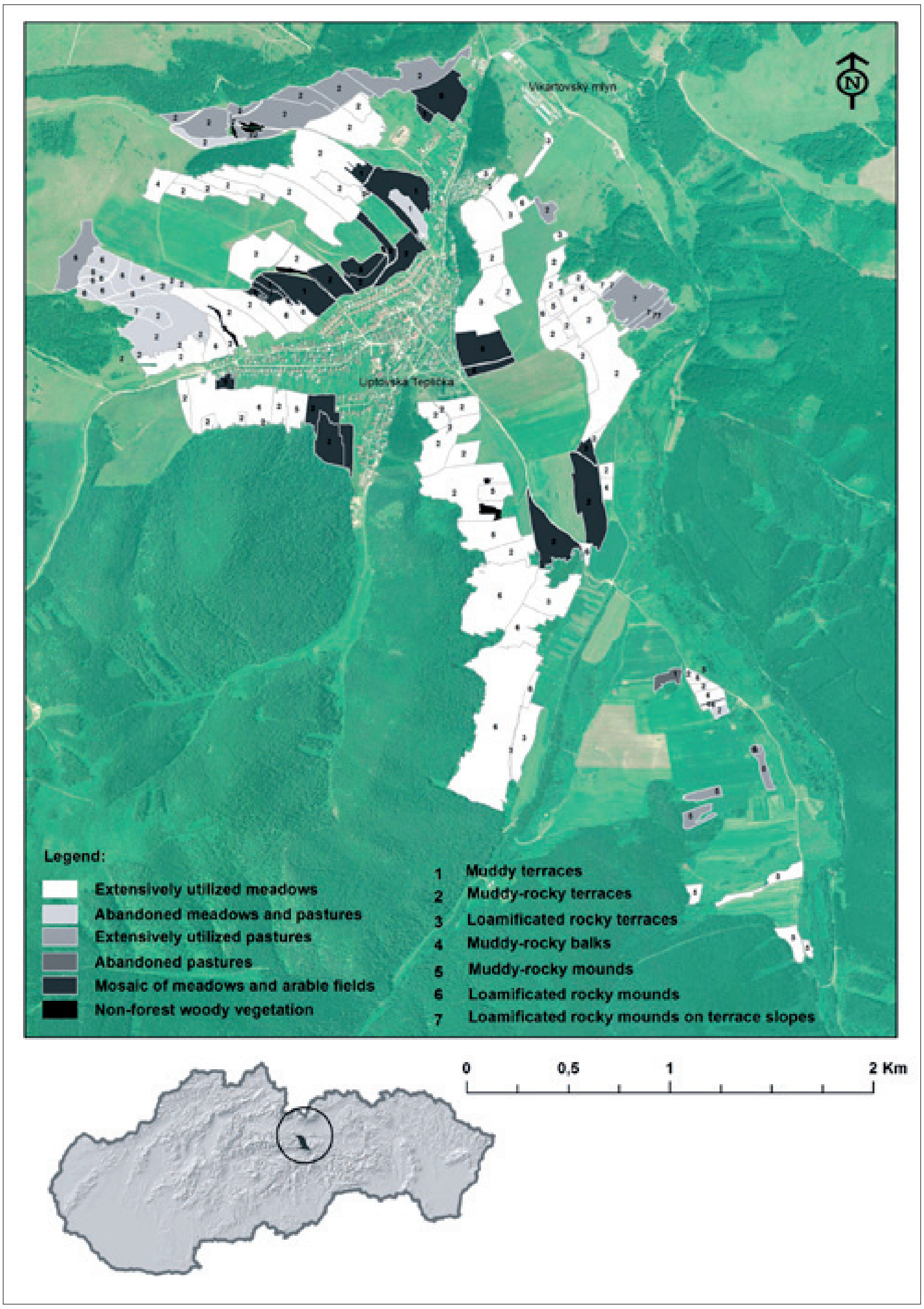

Fig. 1: Distribution of different types of traditional agricultural landscapes with the presence of Forms of Anthropogenic Relief in the Liptovska Teplička cadastral area

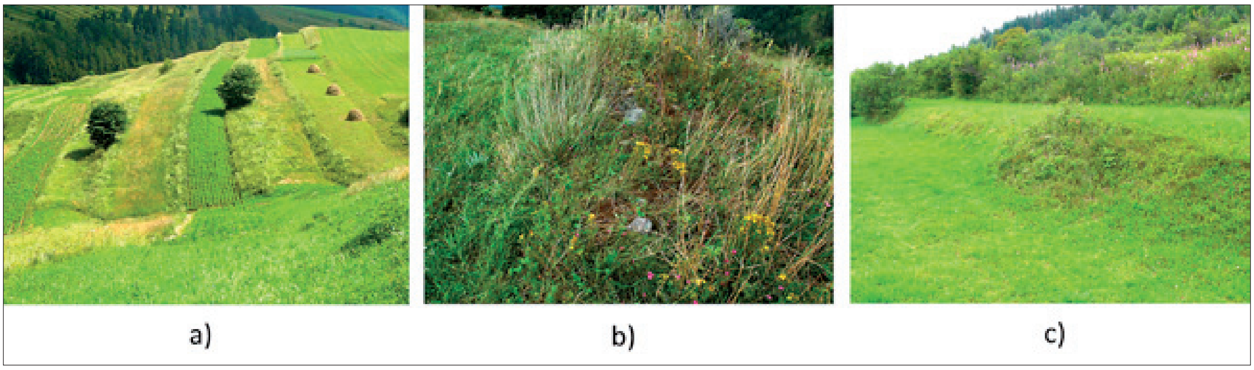

Fig. 2: Forms of Anthropogenic Relief: a) Terraces, b) Mounds, c) Mounds on terrace slopes

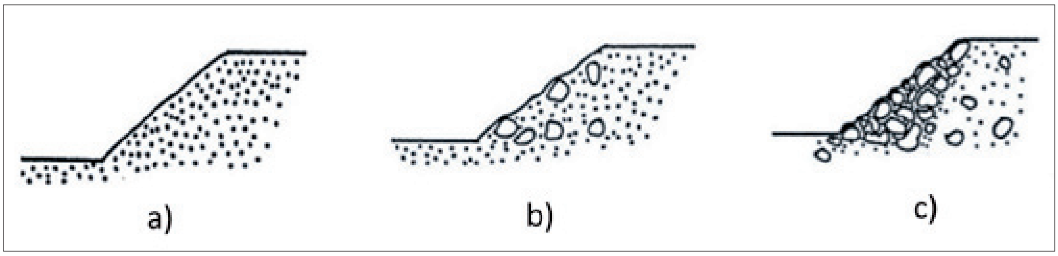

Fig. 3: The stone and soil content of the Form of Anthropogenic Relief: a) muddy, b) muddy-rocky, c) loamy-rocky terraces

were recorded on grassland habitats, including several endangered and/or protected species (Ružičková, Dobrovodská, 2006).

The TAL dominant structure here is extensively used meadows with either muddy-rocky terraces or rocky mounds. The species composition is affected by environmental conditions and management intensity with the highest abundance recorded for semi-natural species, rich mesophilous meadows connected to humid mountain areas. However, pastures affected by collectivisation are characterized by low species abundance. Extensive agriculture and organic farming affected the extent of species richness of grass-covered former arable fields. Grass-covered terraces and mounds show high species richness increased by the occurrence of regionally rare species untypical of meadows and usually connected with rocky habitats. The research results for selected animal groups revealed their current status and favourable conditions for diversity (Dankaninová, Gajdoš, 2011).

The village of Liptovská Teplička had a population of 2,359 in 2009, and statistics show a positive trend in population increase in the large rural settlement area (http://portal.statistics.sk). In terms of age structure, 60% of the population is in the productive age group and 25% in pre-productive age, while only 15% is in the post-productive age group. A greater part of economically active residents work in manufacturing (195), forestry, logging and related services (185), and in agriculture and tourism (70). Although they work in nearby cities, such as Poprad in the High Tatra Mts., and often travel abroad for a better job, there is no direct evidence of labour migration (Moyzeová, 2012).

The assessment of positive and negative socio-economic phenomena indicates very high environment quality in the study area, as this area is part of the Low Tatra National Park and Natura 2000 sites. Ecologically important landscape segments include wetlands, cultural-historical landscape features and historic urban structures, and the landscape is unaffected by significant negative socio-economic impacts (Moyzeová, 2012).

3.2 Driving forces

Landscapes are the result of many layers of past natural processes and human interventions (Brandt et al., 1999). Driving forces involved in TAL maintenance and other observed landscape changes are identified as follows:

- Natural conditions and geographic location for TAL existence: steep or moderate slopes and relatively high altitude (Fazekašová et al., 2013). Stony soils formed less favourable conditions for agriculture, leading to the creation of FAR. A broad spectrum of geological bedrocks from limestone to flysh sandstone influence high species richness and habitat diversity;
- Long tradition in extensive land management with traditional extensive agricultural technological features is preserved;
- Family relationships, religion, a positive relationship with the land, knowledge of specific local conditions and ability to work in them, are decisive;
- Historical diligence of local people, their common sense and ability to use rational approaches in developing their native region;
- Favourable population age structure with a dominance of working-age population and migration of middle-aged and younger generations from work or study outside the region, creates an opportunity to employ these age groups in the agricultural sector; and
- Preservation of folk traditions and high cultural and historical consciousness of the population, together with favourable environmental conditions and no significant negative impacts on environmental components, are a prerequisite for the development of economic activities in the region, particularly activities related to rural tourism.

3.3 Threats to traditional agricultural landscapes

The main threats to TALs were determined by comparing conflicts between the current ecosystem status and the main potential and actual drivers. The future of TALs is threatened mainly by:

- Inappropriate economic conditions for successful TAL agricultural management caused by low profitability management, high input, low income, low market prices for products, poor trade opportunities and an inappropriate competitive environment;

- Lack of human resources is a consequence of the gradual ageing of farmers and the younger generation's loss of interest in traditional management;
- Intensive pressure of owners and developers for changing agricultural land into built-up areas and other land use, while not preserving traditional architecture;
- Insufficient legislative support for TALs protection fails to provide adequate protection for valuable landscape structures, low support from grant schemes, as well as administrative barriers to obtaining sufficient resources;
- Weak support of national agricultural policies for preservation and development of traditional farming;
- Poor TAL publicity and diminished appreciation of both their value and ecosystem services they provide for society;
- Insufficient research and monitoring of TAL changes with the accompanying lack of awareness about threats to TALs.

These all result in diminishing traditional land use, including subsequent land abandonment, grassland overgrown by shrubs and spreading synanthropic species.

3.4 Modelling scenarios

The preservation of TALs depends on human activity and specifically on agricultural management. The future development of agricultural landscapes depends on trends in land use and the institution of conditions which prevent possible threats. Although an ecologically stable and visually beautiful heterogeneous landscape attracts people more than homogeneous areas (Palang et al., 2000), final outcomes appear influenced by economic decisions (Penker, Wytrzens, 2005), human driving forces often producing negative results (Dramstad, Fjellstad, 2011). One positive aspect of landscape planning exists in the visual presentation of landscape and in consequent choices of future landscape evolution. Such visualization is supported by modern research methods, which allow a relatively rapid modelling of basic conditions throughout the country (Jakab, Petluš, 2012). Our research focuses on the major drivers: economic development, land abandonment and agro-environmental policies. Three main scenarios for the agricultural landscape are developed in this study area (Fig. 4 – see cover p. 4):

- A disintegrating trend in TALs, with the gradual extinction of the mosaic, when threats become actuality through economic development pressures; the trend in this scenario is tourism development with built-up areas. This occurs in winter tourism development where the most valuable terraced fields surrounding the village are destroyed due to the construction of ski facilities. Further economic development involves agricultural intensification unrelated to the existing severe natural conditions, as occurred during agricultural collectivization.
- The maintenance of traditional TAL management with optimal land-use when threats are minimized. This scenario provides favourable conditions for biodiversity support in agricultural management and ensures optimal utilization of agri-environmental schemes. Although the current agricultural cooperative utilizes an agri-environmental scheme, it only supports biodiversity in species-rich grasslands without considering the tessellated landscape pattern and more difficult management conditions.
- This scenario depicts land abandonment linked to rural landscape depopulation, which occurs as the local population's interest in traditional management wanes. Here, the most valuable TAL structures become the most threatened because of their low productivity and difficult management. These include terraces and mosaics of small arable fields and grasslands.

Answers to the questionnaire provided by local stakeholders revealed that respondents perceive two main threats to the extinction of TALs – intensive agricultural land use and land abandonment. However, their levels of concern for these two threats differ (Baránková et al., 2011).

4. Strategy for the protection and management of TALs

TAL protection and management strategies were developed from analytic, synthetic and evaluation research results. This comprised two elements: strategic development goals and a proposal for TAL practical management measures.

4.1 Strategic Development Goals

It is necessary to provide effective management in order to protect and sustain TAL use because agriculture is not a permanent job for more than 70% of farmers who also work outside the village (Bezák, Dobrovodská, 2012). Current farmers have a strong link to their land, but this is unsustainable for the long-term TAL protection and maintenance, and we therefore define the following seven strategic objectives:

1. To ensure sustainable development and improved human resources in TAL management and protection by implementing the following measures:

- Increasing public awareness and fostering the population's positive attitude to TAL;

- Strengthening education and training focused on local specifics and values; to encourage the younger generation to respect the landscape and its historical and landscape values, and to promote the significance and benefits of ecological management;
- Encouraging farmers to develop and continue their family farming traditions, to further develop pride in the specifics of their countryside and to ensure the transfer of TAL management knowledge and experience from generation to generation; and
- Creating a motivational environment for young people to remain in their village and to continue in traditional land management.

2. To support appropriate socio-economic conditions for TAL management, tourism and regional development utilizing the following measures:

- Strengthening grant and subsidy schemes for TAL management and protection and adapting them to small private farmers' needs;
- Creating a favourable environment for economic marketing of produce by increasing market prices, by ensuring a favourable competitive environment and by increasing domestic sales wherever possible;
- Strengthening tourism development in the community by developing appropriate support services, this especially means to foster traditional regional folk festivals and present folk crafts; and
- Increasing local government support by funding schemes for traditional management activities.

3. To strengthen the promotion of the cultural-historical landscape and natural TAL values by implementing the following measures:

- Enhancing public awareness of TAL values;
- Promoting natural and cultural values of a specific rural region, this can be achieved by editing promotional material, promoting regional professional events, publicizing on websites and cooperating with regional government travel agencies, tourist information centres and tourist facilities in the village and its surrounds;
- Organizing additional local promotional events, excursions and field trips aimed at increasing awareness of folk customs and traditions and arousing people's positive attitude to TALs; and
- Extending the existing nature trails and advertising them on billboards extolling TAL values.

4. To eliminate threats to TALs by implementing the following:

- Ensuring appropriate management of farming sites vulnerable to erosion and landslide processes;
- Eliminating negative disturbances during bird nesting seasons;
- Preventing TAL abandonment;
- Eliminating illegal landfill and creation of wild dumps that threaten not only the landscape, but also the aesthetic quality of TALs;
- Reducing or completely eliminating the application of fertilizers and other chemicals;
- Reducing the pressure of developers to construct buildings, which conflict with traditional architecture;
- Following essential environmental principles in organic farming, including eliminating soil and water pollution from the application of pesticides and reducing damage from over-loaded vehicles;
- Excluding activities likely to contaminate water sources such as intensive grazing and the application of liquid and solid organic fertilizers, namely in areas with significant groundwater resources; and
- Proposing assessment policies to ensure that management practices follow the legislation enacted for the assessment of environmental impacts.

5. To strengthen the protection of TALs by implementing the following measures:

- Applying management policy, which protects TALs in spatial planning documents, and particularly in land-use planning documentation;
- Initiating gradual legislative protection for TALs by declaring them significant landscape features and protected areas, and including them in a network of territorial systems of ecological stability so that appropriate management can support their conservation and protection;
- Proposing a possible inclusion of TALs in grassland and pasture land, and promoting architectural elements ratification in UNESCO cultural heritage sites;
- Reconciling conservation interests in nature and natural resources with those serving individual farmers' needs; and
- Reconciling the protection of TALs with conflicting activities of socio-economic development, particularly in the development of sports and recreational activities such as ski tracks and related services.

6. To provide TAL research and monitoring.

7. To apply appropriate management practices in TAL areas by implementing the following important measures:

- Fostering the respect of typical settlement form and structure, characterized by (1) the ethno-cultural and socio-economic region, (2) natural-climatic zones, (3) the districts' valuable cultural, historical and social phenomena, and (4) potential economic advantages for the entire community by fostering the progressive development of appropriate summer and winter tourism activities, especially those focused on cultural, cognitive and agro tourism.

4.2 Practical management measures for traditional agricultural landscapes

The proposal for TAL practical management measures focuses on the optimal land use of habitats in different TAL types. This is necessary for their general favourable conservation status and for habitat biodiversity conservation, in particular. The proposal is based on the analysis of TAL landscape structure and typology, and on biotic and abiotic conditions, in conjunction with the biodiversity assessment and evaluation of TAL ecological and cultural-historical values. A model for the practical management of TAL sites in the entire pilot study area was designed from our research results on the monitored plots.

The practical management design covers the following types of TAL structures:

a) extensively utilized areas of (1) pastures with muddy terraces, (2) calcareous grasslands with rocky mounds, (3) silicaceous grasslands with rocky mounds, and (4) grasslands with muddy-rocky terraces; and
b) intensively utilized areas of (5) grasslands and (6) large-block arable fields, plus mosaics of (7) grasslands and arable fields with muddy terraces, and (8) grasslands and arable fields with muddy-rocky mounds, together with semi-natural meadows.

Management measures are focused on the optimal use of the area, with emphasis placed on the area's natural and cultural values. The measures considered the needs, limitations and optimal execution time required for management activities such as mowing, grazing, tree removal, and use of organic fertilizers.

5. Discussion and conclusion

The strategy for the protection and management of TALs herein is oriented towards

1. Optimal multifunctional utilization and management of TAL traditional and sustainable development in the investigated landscapes;
2. Landscape biodiversity maintenance through the application of an agro-environmental scheme; and
3. Potential of TALs for tourism development.

The ecological management proposal encourages not only valuable habitat protection, but it ensures a positive impact on the health of local inhabitants and visitors by reducing stress phenomena from air, soil and water pollution, together with the provision of healthy organic products.

Liptovská Teplička is the highest situated village with traditional agriculture in Slovakia, where meadows and pastures have been developed since Goral colonization. The rugged topography, steep slopes and shallow rocky soils encouraged the local population to maintain maximum use of their agricultural land in the formation of characteristic TALs. This produced a narrow mosaic strip of arable land plots, grasslands and FAR. The rugged topography prevented excessive land reclamation during the collectivization period (Dobrovodská, 2006), and agricultural intensification was recorded on only 1.56% of this territory (Špulerová, Dobrovodská, 2010). Land use change evaluation revealed a declining trend in grasslands. This was previously due to land use changes from grassland to cropland, but is currently caused by abandonment and subsequent succession (Bezák, 2009; Kandrík, Oláh, 2010). Here, the main agricultural landscape organization is the Liptovská Teplička Agricultural Cooperative, which introduced organic farming in 1996. The TAL biodiversity assessment proves that the current management is favourable and well accepted. The results indicate that TALs are important stabilizing elements in agricultural land, and their presence and traditional utilization significantly increase biodiversity in these areas. The superiority of TAL biodiversity over intensely cultivated areas was confirmed in all TAL structures and also on FAR, so these may be classified as islands of species-rich habitats providing refuge in the landscape matrix.

The current state of TALs in the Liptovská Teplička pilot area is quite favourable, so for the ongoing TAL preservation we recommend maintaining the current and proposed management measures and principles of the Agricultural Cooperative Liptovská Teplička's organic farming, ably supported by agri-environmental schemes. TALs are already rare in Slovakia and adequate attention is essential for these less accessible and remote marginal areas with extreme natural conditions. It is imperative that these TALs are classified as significant landscape features and important local bio-centres because of their dual benefits for society and the environment.

Implementation of the Common Agricultural Policy has provided greater financial support to recommence agricultural activities after joining the European Union. Nevertheless, concern remains about biodiversity maintenance in mountain grassland communities, where access is limited and specific extensive management is still required (Bezák, Halada, 2010). On the other hand, in order to establish support for TAL in existing instruments, there has to be contrived inclusion of both agricultural heritage and bio-diversity in existing international regulatory objectives for TAL preservation (Harrop, 2007). Therefore, it is essential that new instruments and policy documents directly supporting TAL clearly define this aspect as a prime goal of conservation policy, and ensure TAL definition and inclusion in the national agri-environmental grant scheme.

The natural and cultural-historical landscape value reflects the relative importance of landscape in sustaining biodiversity, and the preservation of this value demands ongoing development strategies formulated for landscape planning on a landscape-applicable scale (Wrbka et al., 2004). A successful example of a funded development strategy was illustrated in the monitoring of an agri-environmental scheme of hay meadows in Switzerland. There, financial subsidies were justified and highly rewarded by increased species richness of vascular plants, grasshoppers and wild bees. The species richness in this hay meadow agri-environment scheme far surpassed species richness on untreated control meadows (Knop et al., 2006).

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References:

ANDERSEN, E. et al. (2003): Developing a High Nature Value Farming area indicator. Report to the European Environment Agency, Copenhagen.

ANTROP, M. (2005a): Why landscapes of the past are important for the future? Landscape and Urban Planning, Vol. 70, p. 21–34.

ANTROP, M. (2005b): From holistic landscape synthesis to transdisciplinary landscape management. In: Tress,B., Tress, G., Fry, G., Opdam, P. [eds.]: From Landscape Research to Landscape Planning: Aspects of Integration, Education and Application, Wageningen UR Frontis Series, No. 12, Springer Science + Business Media, p. 27–50. Available at: http://library.wur.nl/frontis/landscape_research/03_antrop.pdf

BARÁNKOVÁ, Z., DOBROVODSKÁ, M., ŠTEFUNKOVÁ, D., BABICOVÁ, D., MOYZEOVÁ, M., PETROVIČ, F. (2011): Participation of local people on identifying the landscape values and future development in historical agricultural landscapes. Ekológia (Bratislava), Vol. 30, No. 2, p. 216–228.

BENAYAS, J. M. R., BULLOCK, J. M. (2012): Restoration of Biodiversity and Ecosystem Services on Agricultural Land. Ecosystems, Vol. 15, No. 6, p. 883–899.

BEZÁK, P. (2009): Driving forces and pressures of the landscape and biodiversity change in Slovakia. In: Geography and sustainable development: proceedings. Macedonian Geographical Society, Skopje, p. 9–18.

BEZÁK, P., DOBROVODSKÁ, M. (2012): Stakeholders´ perception of traditional agricultural landscape and its management (3 Slovak case studies). In: Forum Carpaticum 2012: from Data to Knowledge, from Knowledge to Action. ILE SAS Nitra, p. 204–205. Available at: http://uke.sav.sk/fc/fc_2012/Download/FC2012_Conference_Abstracts.pdf

BEZÁK, P., HALADA, Ľ. (2010): Sustainable management recommendations to reduce the loss of agricultural biodiversity in the mountain regions of NE Slovakia. Mountain Research and Development, Vol. 30, No. 3, p. 192–204.

BRANDT, J., PRIMDAHL, J., REENBERG, A. (1999): Rural land-use and dynamic forces – analysis of ‘driving forces’ in space and time. In: Krönert R., Baudry J., Bowler I. R., Reenberg A. [eds.]: Land-use changes and their environmental impact in rural areas in Europe. UNESCO, Paris, France, p. 81–102.

CULLOTTA, S., BARBERA, G. (2011): Mapping traditional cultural landscapes in the Mediterranean area using a combined multidisciplinary approach: Method and application to Mount Etna (Sicily; Italy). Landscape and Urban Planning, Vol. 100, p. 98–108.

DANKANINOVÁ, L., GAJDOŠ, P. (2011): Hodnotenie biodiverzity pavúčích spoločenstiev v historických štruktúrach poľnohospodárskej krajiny Liptovská Teplička. In: Krumpálová, Z. [ed.]: 9. arachnologická konferencia: Východná, 14.–18.9.2011. KEE UKF v Nitre, p. 16–17.

DOBROVODSKÁ, M. (2006): The development of relations between man and landscape in a historical mountain agricultural landscape of Slovakia. Ekológia (Bratislava), Vol. 25, suppl. 1, p. 38–48.

DRAMSTAD, W. E., FJELLSTAD, W. J. (2011): Landscapes: Bridging the gaps between science, policy and people. Landscape and Urban Planning, Vol. 100, p. 330–332.

ELLIS, E. C. et al. (2009): Estimating long-term changes in China‘s village landscapes. Ecosystems, Vol. 12, No. 2, p. 279–297.

EEA/UNEP (2004): High nature value farmland. European Environmental Agency and UNEP regional office for Europe. Office for official publications of the European Communities, Luxembourg. Available at: http://www.eea.europa.eu/publications/report_2004_1 European landscape convention, Florence, 20.X.2000, Council of Europe Treaty Series No. 176 (2004)

EU/1257/99: COUNCIL REGULATION (EC) No. 1257/1999 of 17 May 1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) and amending and repealing certain Regulations.

FAZEKAŠOVÁ, D., BOLTIŽIAR, M., BOBUĽSKÁ, L., KOTOROVÁ, D., HECL, J., KRNÁČOVÁ, Z. (2013, in press): Development of soil parameters And changing landscape structure in conditions of cold mountain climate (Case Study LiptovskÁ Teplička) In: Ekológia (Bratislava), roč. 32, Vol. 2.

HALADA, Ľ., HALABUK, A., GAJDOŠ, P. (2011): Poľnohospodárska krajina s vysokými prírodnými hodnotami. Životné prostredie: revue pre teóriu a starostlivosť o životné prostredie, Vol. 45, No. 1, p. 12–16.

HARROP, S. R. (2007): Traditional agricultural landscapes as protected areas in international law and policy. Agriculture, Ecosystems & Environment. Vol. 121, No. 3, p. 296–307.

JAKAB, I., PETLUŠ, P. (2012): Development of a Program Tool for the determination of the Landscape Visual Exposure Potential. In: Models of the Ecological Hierarchy: From Molecules to the Ecosphere. Elsevier B.V. Amsterdam, p. 375–390.

KANDRÍK, R., OLAH, B. (2010): Land use development in the central part of the Spiš region (Slovakia) since the 18th century. Moravian Geographical Reports, Vol. 18, No. 4, p. 10–20.

KIZOS, T., DALAKA, A., PETANIDOU, T. (2010): Farmers' attitudes and landscape change: evidence from the abandonment of terraced cultivations on Lesvos, Greece. Agric Hum Values, No. 27, p. 199–212.

KNOP, E., KLEIJN, D., HERZOG, F., SCHMID, B. (2006): Effectiveness of the Swiss agri-environment scheme in promoting biodiversity. JOURNAL OF APPLIED ECOLOGY. Vol. 43, No. 1, p. 120–127.

LIESKOVSKÝ, J., KANKA, R., BEZÁK, P., ŠTEFUNKOVÁ, D., PETROVIČ, F., DOBROVODSKÁ, M. (2013): "Driving forces behind vineyard abandonment in Slovakia following the move to a market-oriented economy." Land Use and Policy, No. 32, p. 356–365.

MARINI, L., KLIMEK, S., BATTISTI, A. (2011): Mitigating the impacts of the decline of traditional farming on mountain landscapes and biodiversity: a case study in the European Alps. Environmental science & policy, Vol. 14, No. 3, p. 258–267.

MOYZEOVÁ, M. (2012): Pozitívne socioekonomické javy a kvalita životného prostredia (na príklade obce Liptovská Teplička). Ekologické štúdie, Vol. 3, No. 1, p. 20–27.

PALANG, H., ALUMÄE, H., MANDER, Ü. (2000): Holistic aspects in landscape development: a scenario approach. Landscape and Urban Planning, Vol. 50, p. 85–94.

PARACCHINI, M. L., TERRES, J. M., PETERSEN, J. E., HOOGEVEEN, Y. (2006): Background document on the methodology for mapping High Nature Value Farmland in EU 27. EC JRC, EEA, 32 pp.

PEDROLI, B., VAN DOORN, A., DE BLUST, G., PARACCHINI, M. L., WASCHER, D. BUNCE, F. [eds.] (2007): Europe's living landscapes. Essays on exploring our identity in the countryside. LANDSCAPE EUROPE / KNNV.

PENKER, M., WYTRZENS, H. K. (2005): Scenarios for the Austrian food chain in 2020 and its landscape impacts. Landscape and Urban Planning, Vol. 71, p. 175–189.

PETANIDOU, T., KIZOS, T., SOULAKELLIS, N. (2008): Socioeconomic Dimensions of Changes in the Agricultural Landscape of the Mediterranean Basin: A Case Study of the Abandonment of Cultivation Terraces on Nisyros Island, Greece. Environmental Management, Vol. 41, p. 250–266.

PETIT, C., KONOLD, W., HÖCHTL, F. (2012): Historic terraced vineyards: Impressive witnesses of vernacular architecture. Landscape History Vol. 33, No. 1, p. 5–28.

PLASSMANN, M. (2013): The high nature values farming concept throughout EU 27 and its maturity for financial support under the CAP. HNV and CAP task 1 Report for Slovakia. DAPHNE – Institute of Applied Ecology Slovakia.

PLIENINGER, T., HÖCHTL, F., SPEK, T. (2006): Traditional land-use and nature conservation in European rural landscapes. Environmental science & policy, No. 9, p. 317–321.

RUŽICKA, M., MIKLOS, L. (1990): Basic premises and methods in landscape ecology planning and optimization. In: Zonneveld, I. S., Forman, R. T. T. [eds.]: Changing landscape, an ecological perspective. Springer-Verlag, p. 233–260.

RUŽIČKOVÁ, H., DOBROVODSKÁ, M. (2006): Druhovo bohaté trávne porasty v chotári obce Liptovská Teplička – produkt intenzívneho a polointenzívneho hospodárenia. In: Novák, J., Macejková, Ľ., Stankovičová, Ľ. [eds.]: Podtatranské pažite: zborník referátov zo sympózia. SPU Nitra, p. 44–49.

SUPUKA, J., STEPANKOVA, R. (2004): Characteristic and marks of cultural landscape of Slovakia. Ekológia (Bratislava). Vol. 23, Suppl. 1, p. 333–339.

ŠPULEROVÁ, J., DOBROVODSKÁ, M. (2010): Significance of landscape diversity of historical agricultural landscape structures on the example of Liptovská Teplička study area. In: Nováček, P., Huba, M. [eds.]: Udržitelný rozvoj – stav a perspektivy v roce 2010: Sborník z konference. Olomouc, UP Olomouc, p. 241–251.

ŠPULEROVÁ, J., DOBROVODSKÁ, M., LIESKOVSKÝ, J., BAČA, A., HALABUK, A., KOHÚT, F., MOJSES, M., KENDERESSY, P., PISCOVÁ, V., BARANČOK, P., GERHÁRTOVÁ, K., KRAJČI, J., BOLTIŽIAR, M. (2011): Inventory and classification of historical structures of the agricultural landscape in Slovakia. Ekológia (Bratislava), Vol. 30, No. 2, p. 157–170.

ŠTEFUNKOVÁ D., ŠPULEROVÁ, J., DOBROVODSKÁ M., MOJSES M., PETROVIČ F. (2013): Traditional agricultural landscapes – a model of detailed land use mapping, Tájökológiai Lapok, Vol. 11, No. 1, p. 1–21.

ŠTEFUNKOVÁ, D., DOBROVODSKÁ, M. (1998): Kultúrno-historické zdroje Slovenska a ich význam pre trvalo udržateľný rozvoj. In: Izakovičová, Z., Kozová, M., Pautditšová, E. [eds.]: Implementácia trvalo udržateľného rozvoja. Bratislava, ÚKE SAV, p. 104–111.

TRESS B., TRESS G. (2001): Capitalising on multiplicity: a transdisciplinary systems approach to landscape research, Landscape and Urban Planning, Vol. 57, No. 3–4, p. 143–157.

VAN EETVELDE, V., ANTROP, M. (2004): Analyzing structural and functional changes of traditional landscapes – two examples from Southern France. Landscape and Urban Planning Vol. 67, No. 1–4, p. 79–95.

VOS, W., MEEKES, H. (1999): Trends in European cultural landscape development: perspectives for a sustainable future. Landscape and Urban Planning, Vol. 46, p. 3–14.

WLO (1998): A new identity for landscape ecology in Europe. A research strategy for the next decade: outlines formulated at the European congress Landscape ecology: things to do, 6–10 October 1997, Amsterdam.

WRBKA, T., PETERSEIL, J., SCHMITZBERGER, I., STOCKER-KISS, A. (2004): Alpine farming in Austria, for nature, culture or economic need? New Dimensions of the European Landscape Book Series: Wageningen ur frontis series, Vol. 4, p. 165–177.

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ZONES AND SEGMENTS AS TAXA USED IN THE HIERARCHICAL CLASSIFICATION OF RIVERINE LANDSCAPES: A CASE STUDY OF THE SMREČIANKA BROOK, SLOVAK REPUBLIC

Ivana TOMČÍKOVÁ

Abstract

A river is a highly complex structure and the constituent of landscape and catchment basin from which it drains water. In the holistic concept, a river is defined in mutual interactions with its surroundings as a spatial system – the riverine landscape. As a product of fluvial processes, the riverine landscape has a regular spatial hierarchical structure, which is determined by the structure of its morphology, substrate, biota, land cover and socioeconomic structures. The aim of this paper is to verify the river landscape hierarchical classification and to identify the so-called higher taxa – zones and segments in the Smrečianka valley. The main data sources were hydrological maps at 1:50 000, topographic maps at 1:10 000 and 1:25 000, GIS database levels, geological maps at 1:50 000, and the boundaries were specified by a field survey.

Shrnutí

Zóny a segmenty jako taxony v hierarichické klasifikaci říční krajiny: případová studie – vodní tok Smrečianky, Slovenská republika

Řeka je složitý systém, součást krajiny a povodí, kterou protéká a ze které odvádí vodu. V holistickém chápání se řeka ve svých vzájemných interakcí se svým okolím definuje jako prostorový systém – říční krajina. Říční krajina jako produkt fluviálních procesů má zákonitou prostorovou hierarchickou strukturu determinovanou strukturou její morfologie, substrátu, bioty, krajinné pokrývky a socioekonomických struktur. Cílem příspěvku je charakterizovat hierarchickou klasifikaci říční krajiny a identifikovat tzv. vyšší taxony – zóny a segmenty vodního toku Smrečianky. Základním zdrojem údajů byly vodohospodářské mapy v měřítku 1:50 000, topografické mapy v měřítku 1:10 000 a 1:25 000, databázové vrstvy GIS, geologické mapy v měřítku 1:50 000.

Key words: *riverine landscape, River Landscape Hierarchical Classification, spatial variability, zone, segment, Smrečianka brook, Slovak Republic*

1. Introduction

Rivers have always been a strategic phenomenon for humanity. People have always desired to tame the streams and use them as a source of energy, material, food and transport, and to develop the land around them into towns, forests or fields. A river is a complex system, an integral part of the landscape and river basin, from which it drains water. In the holistic perception of the word, river is understood in its mutual interactions with its environment, and it is defined as a spatial system, riverine landscape, a hydro-system. For its complex character, the methodology and methods of hydrology, fluvial geomorphology, hydrobiology, hydroecology, landscape ecology, economy, sociology and legislation are applied, which gives us an appropriate tool for integrated management, protection, or revitalization of the riverine landscape (Lehotský, 2006).

The aim of this report is to verify the riverine landscape hierarchical classification and to identify the so-called higher taxa – zones and segments – in the Smrečianka brook. My main sources were hydrological maps 1:50 000, topographic maps 1:10 000 and 1:25 000, GIS database levels, geological maps 1:50 000, with boundaries specified by a field survey.

2. Theoretical and methodological bases

The riverine landscape presents a geographic entity, a taxon of landscape structures, situated in the valley bottom, or large-scale landscape depression, which is a 'product' of fluvial processes (Lehotský, 2006). In our understanding, river landscape is not identical with the morphologically perceived type of fluvial relief. It is understood in the narrower sense and represents a relief type, which was formed by the activity of streams along with water-initiated slope processes.

Riverine landscape is a spatial entity, which has been defined not long ago in physical geographic works, or was commonly presented as the lowest, non-structured, homogenous entity within the terrestrial landscape types. Even in the field of landscape ecology, the riverine landscape is presented and perceived as in physical geography or only ecologically, i.e. as a bio-corridor.

According to Lehotský (2005), the riverine landscape has a complex structure and consists of a hydrogeomorphological substrate basis, soil, a lower layer of air, biota and landscape cover structures. In terms of its lateral dimension and generally speaking, a riverine landscape is morphologically differentiated to include the stream channel with its bed and banks, the flood plain and the transitional upland fringe.

With its defined position within the drainage basin, a riverine landscape can be perceived through the optics of hierarchy. As a product of complex processes, it has its regular spatial and hierarchical structure, basically determined by the biophysical pattern as a consequence of climatic and hydrological processes.

A number of hierarchical classifications linking the catchment and channel have been proposed as a tool for effective river investigation and management (Frissell et al., 1986; Rowentree, Wadeson, 1998; Wadeson, Rowentree, 1998; Maddock, 1999; Thomson et al., 2001; Brierley, Fryirs, 2002; Pool, 2002). These works were used as conceptual guidelines for the development of a model of River Landscape Hierarchical Classification (RLHC) according to Lehotský, Grešková (2003), Lehotský (2004), and Kidová, Lehotský (2012). It is structured into seven taxonomies: 1. river/drainage basin; 2. zone; 3. segment; 4. riverine landscape unit; 5. channel reach; 6. morpho-hydroecological unit; and 7. facies. Every taxon is different from the others with the specific characteristics of landform, its kinds, processes and structures, as well as the structure of other components of the landscape. They are interrelated based on the river continuum in horizontal, as well as in lateral, vertical and time dimensions (Fig. 1).

From the perspective of sustainable water management, its sources and river systems, the term *river basin* is applied in the natural sciences and technical disciplines as a spatial unit. In the listed hierarchical classification, it represents the highest taxonomic level. From the hydrological point of view, it represents a depression on the Earth's surface, delimitated by the watershed divide and the mouth with the river system, from which water flows into the given profile of one main stream. In geomorphological

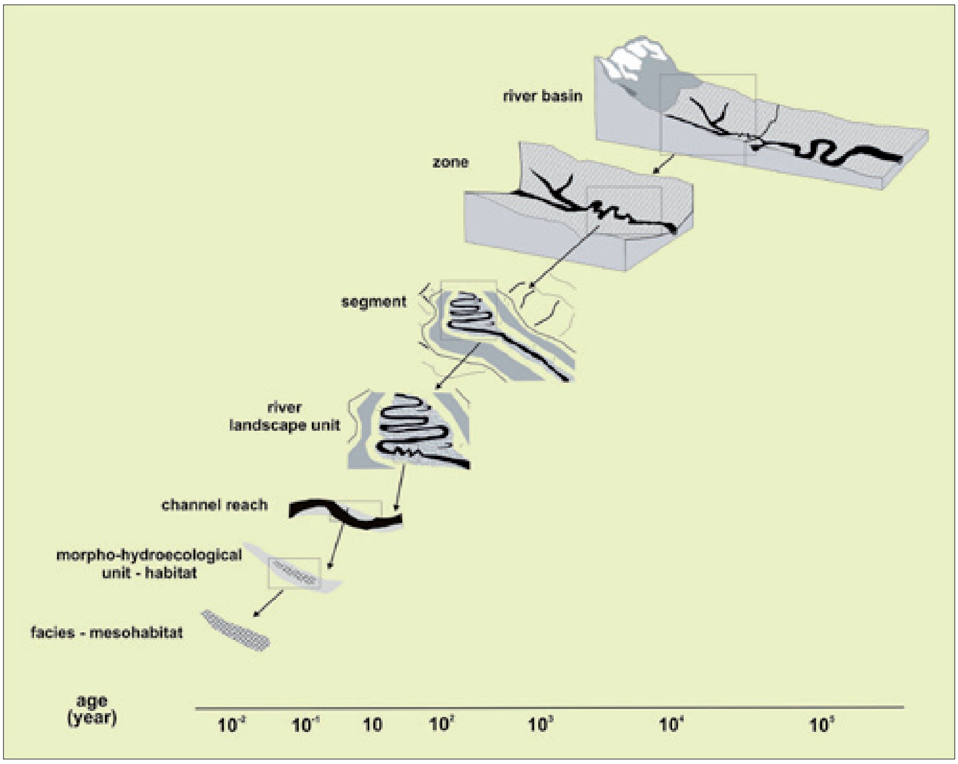


Fig. 1: Riverine Landscape Hierarchical Classification (after Lehotský, 2004, modified)

terms, it is a depression, a horizontally tilted formation on the Earth's surface, the characteristics of which determine the river system properties.

Higher taxa – *zones* and *segments* – within the RLHC generate by their morphotectonic qualities the river's energy character, while by their morphoclimatic and substrate-soil conditions and by the landscape cover, they determine the processes within the drainage basin, i.e. they form the character of lower taxonomic units. The zone and the segment are delimited by the water divide, and by the line running through the lateral valley profile up to reaching the water divide. Morphographic types of ridges and platforms are delimited by the line connecting inflexed points and slope cuts, with the line running through the lateral profile of the valley up to reaching the defined line (Lehotský, Lacika, 2007).

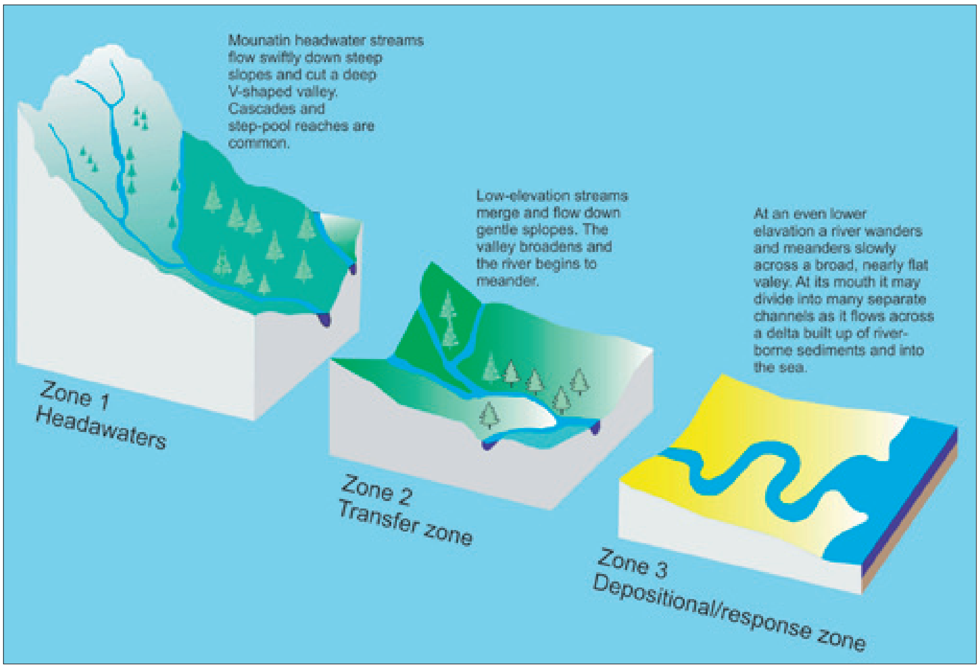
A zone: this represents an area inside the drainage basin, which is homogenous in terms of relief energy, runoff, production of sediments and geology. Fundaments of the zone typology of streams in Slovakia were compiled by Lehotský and Novotný (2004). In their classification, the hierarchically primary criterion was the principle of longitudinal connectivity (Fig. 2). They stem from the concept of three fundamental regimes (activities) of the stream – erosion, transport and accumulation, as according to Schumm (1977), who distinguishes three zones of the river geomorphological continuum:

- Zone 1 – *Source (headwaters) Zone* (erosion): i.e. spring parts of the drainage basin with rivers up to the 4th order (Strahler, 1957) with the straight simple channel, high flow velocity and beds made of gravel, low temperature and high concentration (repletion) of oxygen. In most cases, these are valleys with the dominating colluvial types of river reaches;
- Zone 2 – *Transfer Zone* (erosion/deposition): represents relatively broad and shallow segments (brooks, small rivers) with well-oxygenated water, relatively fast currents and higher channel sinuosity; and
- Zone 3 – *Depositional/response Zone* (deposition): represents downstream sinus reaches of larger rivers with slow currents and with the lower concentration of oxygen, with a high amount of coarse particulate organic material (CPOM).

In the rivers of lower orders or running through mountain landscapes, the deposition zone is confined only to an alluvial fun or confluence environment.

A segment: this is a part of the zone with a quasi-homogenous relief type (valley) and a substrate, river network, with an identical amount of water and sediment discharge. It is classified based on the index of sediment/flow discharge, presence of knickpoints along the longitudinal profile, and on the specific river network or tributaries with the drainage area up to ½ of the trunk stream drainage basin.

A riverine landscape unit: this is an integrated simple corridor consisting of riverbed, bank, riparian zone, floodplain, upland fringe and aquifer, which is distinguished from the rest of the drainage basin; however, it is well integrated with it. Its boundaries are determined by the river type (channel planform and floodplain width), morphology and ecosystem parameters of the floodplain and its land cover.



Mounatin headwater streams flow swiftly down steep slopes and cut a deep V-shaped valley. Cascades and step-pool reaches are common.

Low-elevation streams merge and flow down gentle splopes. The valley broadens and the river begins to meander.

At an even lower elevation a river wanders and meanders slowly across a broad, nearly flat valey. At its mouth it may divide into many separate channels as it flows across a delta built up of river-borne sediments and into the sea.

Fig. 2: Three zones within RLHC (Miller, 1990)

A channel reach: this is a longitudinal part of the channel with the uniform structure of its morphological units, which lead to a typical grouping of geosystems and ecosystems. Their typology is presented in the study by Grešková, Lehotský (2004).

Morpho-hydroecological unit – habitat: this is a fundamental structure of the channel formed by either vertical or lateral channel erosion, or by channel accumulation (sand and gravel bar, etc.), with plants or animals. Boundaries of this taxon are determined by fine geomorphological features.

Habitat unit – mesohabitat: this is the spatially clearly internal riverbed environment. It is determined by temporally variable hydraulic and substrate characteristics, associated with hyporheic flow, different kinds of currents and in-channel and stream plant communities, as well as with the communities of fish and invertebrates.

Every taxon is differentiated from the others by specific relief characteristics, processes and the structure of other riverine landscape components. They are mutually interrelated on the principles of connectivity and the river continuum in longitudinal, lateral, vertical and time dimensions. As opposed to geosystems located in other landscape types (terrestrial), there are more intense taxa relations, greatly influencing characteristics and formation of hierarchically higher or lower taxa. Processes between particular hierarchical levels of a riverine landscape take place both ways (Pool, 2002).

3. Research Results

3.1 Drainage Basin

The Smrečianka brook is a right-bank tributary of the Váh River. It springs in the Liptov Tatra Mts., the western part of the Tatra Mts., at an altitude of 1,680 m a.s.l., in a small glacial cirque (kar) on the southern slopes of Plačlivé, between the Žiarske sedlo Saddle and Smrek, in the northern fork of Baranec, on the north-eastern slopes of the Žiarska dolina Valley. It flows into the Liptov basin, in the part called the Smrečianska Upland and flows into the Váh River in the part called the Liptovská floodplain at 588.2 m a.s.l. The stream is 18.5 km long. The studied drainage basin has an elongated, feathery shape. Its main tributary is the Vrbička, which is 3.65 km long and flows into the Smrečianka in the village of Smrečany (Fig. 3).

3.2 Zones

In accordance with Lehotský and Novotný (2004), we distinguish three zones in the drainage basin of the Smrečianka brook: 1. source zone, composed of the Žiarska Valley; 2. transfer zone, covered by the Liptov basin hilly land up to the Podbreziny housing estate area; and 3. response zone, which is spreading from the Podbreziny area up to the confluence of the Smrečianka brook with the Váh River.

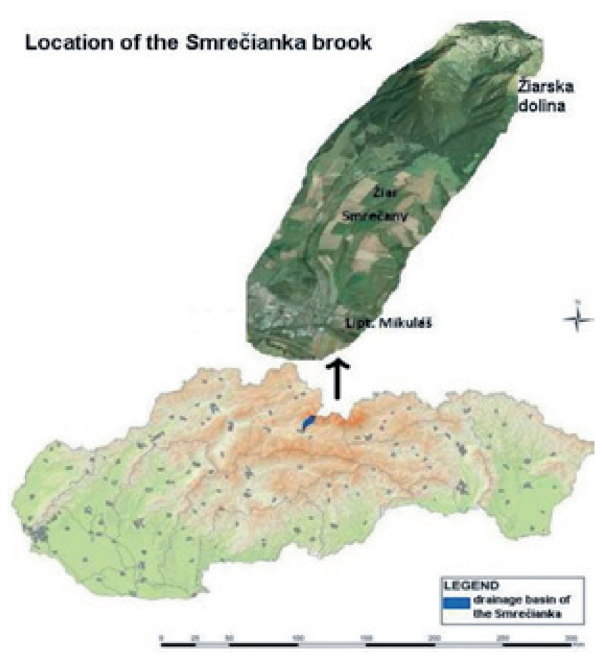


Fig. 3: Location of the Smrečianka brook in Slovakia

<table>
<tr><th colspan="2">Number and name of water meter station</th><th>Stream</th><th>Period</th><th colspan="5"></th></tr>
<tr><td rowspan="4">5530</td><td rowspan="4">Žiarska dolina</td><td rowspan="4">Smrečianka</td><td rowspan="4">1963–80</td><td>Drainage basin surface (km^2)</td><td>H_{as} (mm)</td><td>Outlet (mm)</td><td>Losses (mm)</td><td>Outlet coefficient</td></tr>
<tr><td>17.99</td><td>1,658</td><td>1,260</td><td>398</td><td>0.76</td></tr>
<tr><td>$q_š$ (l . s^{-1} . km^2)</td><td>Q_a (m3 . s–1)</td><td>Q_{rmin} (m^3 . s^{-1})</td><td>Q_{rmax} (m^3 . s^{-1})</td><td rowspan="2"></td></tr>
<tr><td>39.91</td><td>0.718</td><td>0.571</td><td>1.178</td></tr>
</table>

Tab. 1: Some hydrographic and hydrological characteristics of the Smrečianka brook. Source: Adámyová,1989

The source (headwaters) zone (A) has a valley character. It is a zone with a high degree of gradient and stream energy. The Smrečianka brook channel has a steep slope (ca. 10%). In the source part, speaking in morphological terms, the riverine landscape consists only of the channel and adjacent slopes, the character of which is mainly determined by the morphometric character of slopes and substrate, vertical stream erosion and material delivery, with the domination of the colluvial type of river reaches. In the central part of the zone, the channel material is composed of boulders, which are structured in step-pool channel morphology. At a number of spots, especially with the moraine deposition, we can find channel reaches of boulder/block morphology type, which is typical for streams with boulder-formed riverbeds and boulders emerging from the riverbed. The down-stream material is differentiated and the particle-size of bed material is diminishing and poorly sorted. The valley is "V" shaped. At the valley mouth, the morphological basis of the riverine landscape in the valley is the cross-section, in spite of its low width composed of three main morphologically distinct levels (floodplain, 2–3 low Holocene terraces and narrow colluvial upland fringe). The floodplain is characterized by high energy, mostly built of non-cohesive coarse-grained material. The channel has a gentler slope and increased index of sinuosity. Some river reaches exhibit stream braiding, which gives rise to a system of multiple, seasonally active, meandering channels separated from one another by islands. These are covered by shrubs and trees, namely by spruce, pine, birch and willow.

The transfer zone (B) is localized in the Liptov Basin hilly-land. Its valley shape represents a broad "U". The channel planform downstream is changing from a single thread channel to a relatively narrow braided one. Dominant channel morphological features are bar structures alternated by plane bed channel morphology. However, almost one half of the length of the stream is channelized. The floodplain is wide, with two-three generation of Holocene terraces, only scarcely directly connected with the channel during large floods. According to the floodplain classification by Nanson, Croke (1992), it is a medium-energy non-cohesive floodplain with moderate resistance against erosion

Zone		Altitude (m a.s.l.)		Stream length (m)
		beginning	ending	
A. Source (headwater) zone				
AS1	High mountainous amphitheatric, cirque-spur type	1,680	1,285	2,100
AS2	High mountainous through type with debris flow and stepped valley bottom	1,285	1,125	2,120
AS3	High mountainous breached moraine and debris-flow cones type	1,125	1,003	1,960
AS4	High mountainous "V"-shaped valley type	1,003	875	1,690
B. Transfer zone				
BS1	Foothill alluvial fan type	875	700	4,870
BS2	Hilly basin terraced valley type	700	602	5,500
C. Response (depositional) zone				
CS1	Basin confluence fan type	602	585	994

Tab. 2: Selected zones and segments in the studied basin of the Smrečianka brook

Segment	Altitude (m a.s.l.)	Riverbed average angle (%)	Actual length of riverbed (m)	Valley line length (m)	Degree of sinuosity	Valley average width (m)	Riverbed average width (m)	Degree of valley enclosure
AS1	1,680–1,285	18.81	27,100	1,955	1.07	–	1	–
AS2	1,285–1,125	10.19	1,570	1,416	1.11	8	3	2.7
AS3	1,125–1,003	7.22	1,690	1,450	1.17	35	5	7.0
AS4	1,003–875	6.27	2,040	1,830	1.11	60	8	7.5
BS1	875–700	3.59	4,870	4,380	1.11	160	8	20.0
BS2	700–602	1.78	5,500	5,167	1.06	300	10	30.0
CS1	602–585	1.71	994	947	1.05	1,200	30	40.0

Tab. 3: Basic data on individual segments in the study area

processes. Floodplain land cover is represented mostly by agricultural categories and urbanized areas. Only a narrow (up to 30 m) riparian zone with willow trees is typical of the middle and upper part of this zone.

The response zone (C) – in this zone, the medium energy non-cohesive floodplain becomes broader, forming an alluvial fan. The braided channel is completely channelized in this zone. The riparian zone consists of dykes covered by grass and dispersed willow shrubs.

3.3 Segments

When studying the segments in the study area, the main criterion was the presence of knickpoints along the stream longitudinal profile. Morphologically, their boundaries are defined by a quasi-homogenous slope of the riverbed, degree of channel confinement in the valley and channel sinuosity. The confinement of the channel in the valley was expressed by the ratio of the floodplain width to the watercourse channel width. The degree of sinuosity was expressed by the ratio of stream length to the length of the talweg.

Taking into account all the above-mentioned criteria and the shape of the valley cross-section, we distinguish the following segment types in the study area (Fig. 5). In the source zone (A), we distinguish 4 segments (AS1 to AS4), in the transfer zone (B) two segments (BS1 to BS2), and in the response zone (C) one segment (CS1). Their terminology and basic characteristics are summarised in Tabs. 2 and 3 (Tomčíková, 2008, Tomčíková, 2011).

High mountainous amphitheatric, cirque-spur type (AS1) is the highest segment of the study area. It is located in the source, glacially modelled part of the valley. The riverine landscape is limited to a narrow strip of the valley bottom without floodplain and without marked human activity. Slopes of the segment are almost continuously covered with coarse-grained material, consisting of crystalline complex, in which metamorphic rocks dominate over granitic rocks. Sediments from the Würm period consist of gravel and blocks of boulders. Water is practically motionless, stuck in ice and snow for most of the year. The frozen water absorbs more relief processes, and on the other hand it causes the mechanical destruction of sediments, leading to the enlargement of mantle rock, which is put into motion in the summer period through water or gravity (Figs. 6 and 7).

High mountainous through type with debris flow and stepped valley bottom (AS2) is composed of an asymmetric valley with slopes modelled by debris flows. This segment is typical of considerable relief steepness. In the slope direction, it has a convex shape. The bed is filled with boulder moraine sediments of the Würm. The sediments, namely boulders and cobbles, are not sorted. Rib structures are typical features of the channel. Dwarf pine is replaced by spruce here, whence the stream flows in a continuous spruce forest (Fig. 8 – see cover p. 2).

High mountainous breached moraine and debris-flow cones type (AS3) is typically broader with a developed riverbed and symmetrical valley slopes. The segment is situated on the border of an area, which had multiple glaciers in the Würm period. The rock outcrop in the channel is less frequent than in other

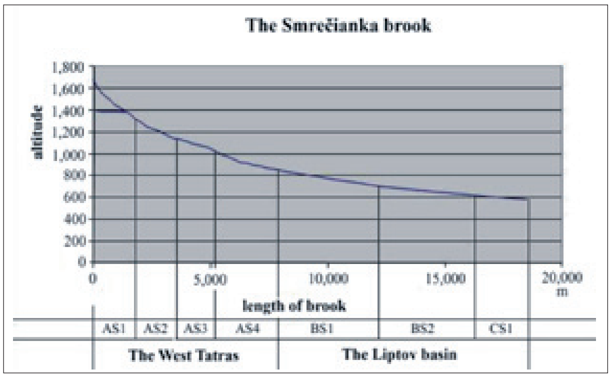


Fig. 4: The longitudinal stream profile of the Smrečianka brook (after Tomčíková, 2008, 2011 modified)

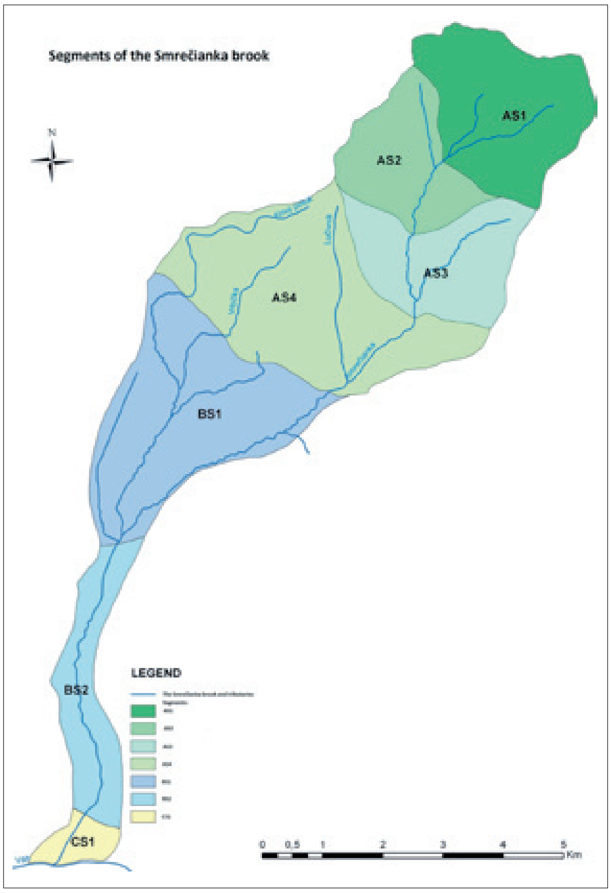


Fig. 5: Segments of the Smrečianka brook (after Tomčíková, 2011)

Figs. 6 (left) and 7 (right): AS1 type segment of Smrečianka brook / AS1 type segment (close-up)
(Photo I. Tomčíková, 2011)

parts of the valley; it is covered by glacial and glaciofluvial material and deluvial deposits. The riverbed is filled with the moraine sediments of the Würm period, with a greater content of fragments, which formed the frontal moraine. The Würm sediments are significantly washed up and also joined with the side valley. The mass-movement of weathering products on the slope dominated, and the water falls through steep rock walls in the form of a cascade. It is identified on the lateral profile by a gentle curve in the upper part and by a steep curve in the lower part (Fig. 9).

High mountainous "V" shaped valley type (AS4) is situated in the area stretching from the altitude of 1,003 m a.s.l. (wooden bridge) up to the end of the valley and its transition into the Liptov basin. The dominant geomorphological process is fluvial modelling present in the channel pattern; the processes of slope modelling on the valley side slopes are less prominent. The segment is situated outside the area modelled by Würm glaciers. The relative altitude of the slopes is lower as compared with the previous segment, and the floodplain is clearly developed. The single cascade and step-pool reaches alternate with the bifurcated rapids. Channel islands are mostly covered by trees. Longitudinally, avulsions typically occur at reaches marked by the lower degree of inclination. The floodplain is characterized by great energy, mostly built by sediments composed of cobbles, pebbles and sand. There is an asphalt road leading to the Žiarska Chalet built on the top of it. The landscape is covered by spruce forest (Fig. 10).

Foothill alluvial fan type (BS1) follows on the AS4 segment as early as in the Liptovská hollow basin. From the longitudinal profile curve, it is difficult to identify the start of this segment, since in the upper part it is similar to the previous segment. Its identification is however clearly determined by the morphogenetically distinctly developed fan at the foot of the mountain range. The slope is gradual; therefore, the boundary with the BS2 segment is not evident, either. The front of the fan is situated on the transfer of the mountain into the basin, with the villages of Žiar and Smrečany being situated at its tail. On the border with the hills, the stream used to be bifurcated in the past; today it is a single channel with a rapids character. In many locations, a sharp contact of the channel with the terrace (abut) is evident. Material in the channel consists of larger cobbles and boulders, upper layers of the floodplain are composed of fine-grained pebbles (Tomčíková, 2011).

The river landscape of the Smrečianka brook in the segment is markedly influenced by human activities. At the head of the alluvial fan, there are hotels, company chalets and resorts with individual houses and objects. Human activity is especially evident in the villages of Žiar and Smrečany, but also in their surroundings. There are meadows and pastures in the floodplain. Meadows are predominant, which are alternatively used for pasture and for agriculture. Wet meadows are covered by high grass that is valuable as fodder. Pastures are used for cattle and sheep alike. In Smrečany, a small dam in the form of a polder was built for retaining the flood waters. The dam disrupts the river continuum and impacts the free passage of fish. Following the dam, the riverbed has been regulated up to its confluence with the tributaries of Vrbička, Trstie and a small affluent on the left side. The village of Žiar borders the village of Smrečany on the south. These two villages are joined, giving the impression of being just one village. The village used to have a water mill with the mill canal, but it was destroyed by flood in 1948. The only thing that remained was the canal, as a tributary of the Smrečianka (Fig. 11).

Hilly basin, terraced valley type (BS2) stretches from Smrečany up to the housing estate named Podbreziny. The channel of Smrečianka is asymmetrically (to the right side) localised in its floodplain and fully regulated throughout the segment. Small check-dams built in the channel mediate and slow down the downslope transit of sediments. The banks are reinforced by willow trees, which form a continuous riparian zone. The sinuosity index is low.

Downstream of the segment, on the young Holocene terrace, Vitálišovce, a municipality of Liptovský Mikuláš is situated, followed by the largest housing estate of Liptovský Mikuláš – Podbreziny. Vitálišovce is situated in the floodplain on the left at an altitude of 620 m a.s.l. It used to be an integral part of the

Fig. 9: AS3 type segment of the Smrečianka brook (Photo: I. Tomčíková)

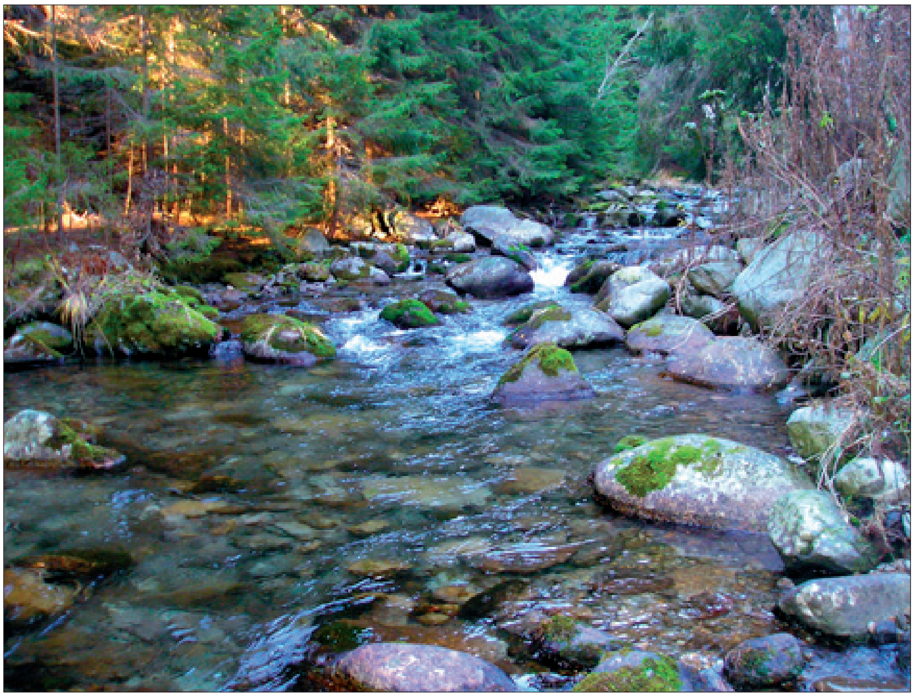


Fig. 10: AS4 type segment of the Smrečianka brook (Photo: I. Tomčíková, 2011)

village Okoličné. In the 1970s, it became an integral part of Liptovský Mikuláš. In 2006, the village population was 106 persons. In the 1980s, the housing estate Podbreziny was built along the channel downstream Vitálišovce in lengths of approximately 1 km, which became the largest housing estate of Liptovský Mikuláš. The present population is around 10,000 people, who live in 54 blocks of flats. The Smrečianka River divides this housing estate into two parts (eastern and western). The left part is situated on the left bank of the stream; it is densely built-up with old blocks of flats, a stadium, supermarket and shops. A road is built at the contact of the floodplain with the terrace, leading toward Smrečany, Žiar and the Žiarska Valley. The newly-built blocks of flats - an old people's home and the centre for social services, are on the right bank. The western part of the river landscape is abutted with the segmented slope of Háj-Nicovô hill, which is partly forested and partly covered by bushes (Fig. 12).

Fig. 11: BS1 type segment of the Smrečianka brook (Tomčíková, 2011)

Fig. 12: BS2 type segment of the Smrečianka brook (Photo: I. Tomčíková)

Basin confluence fan type (CS1) is the only segment of the response zone in the Smrečianka riverine landscape. In morphological and genetic terms, it is linked to the development of the Váh River floodplain, into which it gradually enters. The alluvial fan of the Smrečianka brook transforms into a low terrace of the Váh R. (T-Ib) at a relative elevation of 2–3 m above the channel water level; the surface is inundated only during catastrophic floods (Droppa, 1964). The thickness of sediments in the floodplain varies from 4 to 9 m. According to the channel planform classification system (Nanson, Knighton, 1996), Smrečianka represents in this segment a laterally inactive slightly braided channel, rarely diverging by islands. Central bars, reinforced by the tree vegetation (especially young willow trees), are frequent here. The riverbed material is composed of fine up to rough gravel and cobbles of various sizes. The riverbed is channelized by duplex dams for the flow volume of $Q_{100} = 93.0\ m^3.s^{-1}$.

The built-up area of Okoličné village as a municipal district of Liptovský Mikuláš, with some 1,196 inhabitants as of 1 April 2006, is situated in the floodplain. The village was affected by a disastrous flood in 1812. The flood wave carried away a number of houses and severely damaged the church and the monastery. Okoličné merged with Liptovský Mikuláš in 1971 (Fig. 13 – see cover p. 2).

4. Conclusion

Rivers are natural hierarchical systems that can be resolved into different levels of organization. A level, taxon, or holon, is a discrete unit of the level above and an agglomeration of discrete units from the level below, in the conceptual model of River Landscape Hierarchical Classification. At higher hierarchical levels, the process is slower or of lower frequency, and the reactions are therefore slower than at lower levels.

Studying the riverine landscape as a holistic and hierarchical spatial structure contributes to the knowledge and understanding of mutual relations among the parts of this complex system, and at the same time creates a basis for its sustainable development.

Since this kind of research has been launched only very recently in Slovak geography and in landscape ecology, this paper represents a case of river research oriented towards the presentation of holistic perceptions and knowledge of riverine landscapes, exemplified by the riverine landscape of the Smrečianka brook.

From the top to the bottom, we identified three taxa in the riverine landscape of the Smrečianka brook. These zones are singled out in accordance with seven taxa of the hierarchical model of riverine landscape morphology, together with the classification of zones based on Lehotský, Novotný (2004). Regarding the basic criteria of river system longitudinal connectivity, we distinguish these three main zones – the source (headwater) zone in the Žiarska dolina Valley, the transfer zone in the Liptovská Basin, in the part called the Smrečianska Upland, and the response (depositional) zone – in the part called the Liptovská Floodplain, where it flows into the Váh River.

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References:

ADÁMYOVÁ, S. (1989): Dlhodobé ročné prietoky, ich územná a časová premenlivosť. Zborník prác SHMÚ, 29/II, p. 30.

DROPPA, A. (1964): Výskum terás Váhu v strednej časti Liptovskej kotliny. Geografický časopis, Vol. 16, No. 4, p. 313–325.

GREŠKOVÁ, A., LEHOTSKÝ, M. (2004): Priestorové štruktúry riečnej krajiny. Zborník z konferencie Říční krajina, Palackého univerzita, Olomouc, p. 44–51.

LEHOTSKÝ, M. (2004): River Morphology hierarchical Classification (RMHC). Praha, Acta Univeristatis Carolinae, Geographica, XXXIX, No. 1, p. 33–45.

LEHOTSKÝ, M. (2005): Riečna krajina – základné koncepty. ALFA SPECTRA STÚ, Urbanistické listy FA STÚ, p. 38–46.

LEHOTSKÝ, M. (2006): Riečna krajina a jej udržateľný rozvoj – nová oblasť aplikácie integrovaného prístupu, In: Izakovičová, Z.: Smolenická výzva III, Smolenice 18.–19. apríl 2006, Bratislava: Ústav krajinnej ekológie, p. 155– 159.

LEHOTSKÝ, M., GREŠKOVÁ, A. (2003): Geomorphology, fluvial geosystems and riverine landscape (methodological aspects). Geomorphologia Slovaca, No. 2, p. 46–59.

LEHOTSKÝ, M., LACIKA, J. (2007): Typy segmentov dolinovo-riečnych systémov s veľvysočinovou zdrojovou zónou: príklad Tatier. Geomorphologia Slovaca et Bohemica Vol. 7, No. 1, p. 27–35.

LEHOTSKÝ, M., NOVOTNÝ, J. (2004): Morfologické zóny vodných tokov Slovenska. Geomorphologia Slovaca, No. 2, p. 48–53.

MILLER, G. T. (1990): Living in the Environment: An Introduction to Environmental Science. Wadsworth Publishing, Belmont, 60 pp.

NANSON, G. C.,CROKE, J. C. (1992): A genetic cassification of floodplains. Geomorphology, Vol. 4, p. 459–486.

NANSON, G. C., KNIGHTON, A. D. (1996): Anabranching rivers: their cause, character and classification. Earth Surface Processes and Landforms, Vol. 21, p. 217–239.

POOL, G. C. (2002): Fluvial landscape ecology: addressing uniqueness within the river discontinuum. Freshwater Biology, Vol. 47, p. 641–660.

SCHUMM, S. A. (1977): The fluvial system. Wiley-Interscience, Chichester. 338 pp.

TOMČÍKOVÁ, I. (2008): Priestorová variabilita morfológie bystrinného vodného toku. Geomorphologia Slovaca at Bohemica Vol. 8, No. 2, p. 58–68.

TOMČÍKOVÁ, I. (2011): Štruktúra riečnej krajiny Smrečianky. VERBUM Ružomberok, 160 p.

WADESON, R. A., ROWNTREE K. E. (1998): Application of the hydraulic biotope concept to the classification of instream habitats. Aquatic Ecosystem Health and Management, Vol. 1, No. 2, p. 143–157.

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THE NORTH ATLANTIC OSCILLATION AND WINTER PRECIPITATION TOTALS IN SLOVAKIA

Lívia LABUDOVÁ, Pavel ŠŤASTNÝ, Milan TRIZNA

Abstract

The North Atlantic Oscillation (NAO) is the most important circulation phenomenon in the Northern Atlantic which impacts climate in Europe in various ways. Precipitation is a basic climatic element which affects the landscape significantly. Therefore in this paper, the relationship between the NAO and winter precipitation in Slovakia is analysed. A Spearman's correlation analysis was used, which detected the impacts of NAO on the above-mentioned seasonal precipitation in different regions of Slovakia. The correlation coefficients obtained positive values in the region of Orava and Kysuce and changed to negative ones in a southward direction. The detected zonal configuration can be explained by the topographic barrier effect of the Carpathians.

Shrnutí

Vztah Severoatlantické oscilace a zimních úhrnů srážek na Slovensku

Severoatlantická oscilace (NAO) je nejvýznamnějším cirkulačním jevem na severní polokouli, která ovlivňuje klima Evropy v různých směrech. Srážky jsou základním klimatickým prvkem, který významně ovlivňuje krajinu. Proto je v tomto příspěvku analyzován vztah mezi NAO a zimními úhrny srážek na Slovensku. Byla použita Spearmanova korelační metoda, která zjistila protikladné vlivy NAO na již zmiňované sezonní srážkové úhrny. Zatímco kladné korelační koeficienty byly dosažené v oblasti Oravy a Kysuc, směrem k jihu se korelace měnila na negativní. Zjištěná zonální stratifikace může být vysvětlena bariérovým efektem Karpat.

Key words: *North Atlantic Oscillation, winter precipitation totals, precipitation regions, Spearman's correlation analysis, Slovakia*

1. Introduction

The North Atlantic Oscillation (NAO) is one of the most important modes of atmospheric circulation, which affects significantly climate variability not only in Europe, but in the whole area from the eastern coast of USA to Siberia in a latitudinal direction, and from the Arctic to subtropical Atlantic in a meridional direction (Hurrell, 1996; Hurrell et al., 2003). In Europe, the strongest impacts of oscillation on the air temperature and precipitation regimes are detected in Scandinavia, in the British Isles and in the Mediterranean region, where impacts have different effects (Doležalová, 2007). The assessment of the relation between NAO and climatic elements is of interest in Slovakia, because of its location between the above-mentioned regions. Precipitation is one of the basic climatological elements, which affects the landscape significantly. Pekárová et al. (2010) published an analysis of the relationship between the NAO and the long-term discharge of Slovak rivers. It was recorded that the influence of the NAO on the discharge of lowland rivers is stronger than on the discharge of the rivers in northern mountainous part of Slovakia. Considering that precipitation is the main input element into the river catchments and forms a discharge, it is interesting to identify the relationship between the NAO and precipitation. The impact of the oscillation is much smaller in summer than in winter. Therefore, the main focus here is on the assessment of the impact of the North Atlantic Oscillation on the winter precipitation totals in Slovakia.

2. The Concept of the North Atlantic Oscillation

The phenomenon of the North Atlantic Oscillation is based on the existence of a pressure gradient between the Azores high and Icelandic low, which are stable semi-permanent pressure systems (as the Azores high moves northwards during summer). They are located almost in one line in a meridional direction in the northern Atlantic. The earlier-mentioned pressure gradient is caused by such a pattern of pressure fields and determines the strength of westerlies in this region. Westerlies are controlled by the direction of rotation in pressure systems which is caused by the Coriolis force, i.e. in the Azores high clockwise and in the Icelandic low counterclockwise (Fig. 1). The periodic variability of the strength and the position of these semi-permanent pressure systems (Ahrens, 2007; Oliver, 2008) is a natural source of climate variability in the affected area (Barnston, Livezey, 1987; Hurrell et al., 2003; Lamb, Peppler, 1987).

The direction of the westerlies coincides with the direction of storm tracks. If the air pressure is above-normal over the Azores and below-normal across the Iceland area, the gradient between the Azores high and Icelandic low is higher than normal, the westerlies are enhanced and the meridional flow is weakened. In this case, there is a positive phase of oscillation. During the opposite situation, the gradient between them is lower and conditions for enhanced meridional flow are more favourable (Hurrell, 2003). This situation is demonstrated in wintertime by an influx of very cold arctic air into middle latitudes, which is caused by 'leaking' Rossby waves during weakened Arctic Oscillation.

The North Atlantic Oscillation is one of the most prominent teleconnection patterns, because parallel climate variability with different effects over large geographical regions is caused by its activity. This means that some regions appear colder and dryer, while other regions hundreds of kilometres away appear warmer and wetter than during normal conditions (Oliver, 2008).

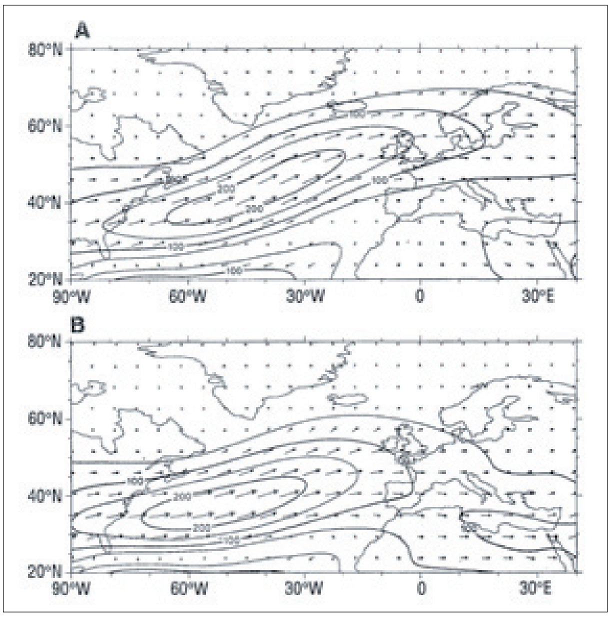

Fig. 1: Vectors of the vertically integrated moisture transports for high NAO index winters (A) and normal or low NAO index winters (B)
Source: Hurrell, 1995

The positive oscillation phase also causes the storm tracks to prevail in a northward direction to Scandinavia. Over Scandinavia, there is the strongest positive oscillation influence, as well as in the British Isles. During this phase, westerlies bring more relatively warmer and wetter air from the ocean into the European continent. It causes milder and wetter winters, especially in the western and northern parts of Europe, but also a plunging of very cold air over the northwestern Atlantic. This phase is demonstrated by lower sea level temperatures and a larger extent of the sea ice cover near the Labrador Peninsula (Fig. 2). The different effects of cooling and drying are marked in the Mediterranean, Northern Africa and Middle East. During the negative phase, the stormtracks move towards the Mediterranean region, where higher air temperature and precipitation totals are recorded during this phase. On the other hand, the precipitation totals are below-normal in Scandinavia and in the British Isles (Hurrell, 1995; Hurrell, 2001; Barry, Chorley, 2003; Doležalová, 2007; Beranová, Huth, 2008). The temperatures in Central Europe correlate positively with the NAO phases, but there is a more complicated relation between the NAO and precipitation totals (see below). Within this relation, a theoretical borderline between positive and negative correlation coefficients could be placed in the Alpine and Carpathian regions.

The phases of the North Atlantic Oscillation are characterized by the NAO Indices. There are several indices, which use different data sources. Some of them are based on the difference of normalized sea level pressure between two stations near the Azores and Iceland (e.g Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland). The sea level pressure values at each station are normalized by removing the long-term mean and consequently by dividing by the long-term standard deviation (Hurrell, 1996; Hurrell, 2011; Hurrell, 2013). The long-term means and long-term standard deviations were extracted from data in the period 1864–1983.

$$p_N = p / \overline{\sigma_{\overline{p}}} \qquad [A]$$

p_N – normalized sea level pressure,

p – seasonal mean sea level pressure,

$\overline{\sigma_{\overline{p}}}$ – long-term mean standard deviation.

3. Previous analyses of relationships between the NAO and precipitation in Europe

Correlation and spectral analyses are often used for the assessment of NAO effects. Several studies have been carried out to analyse the impact of the North

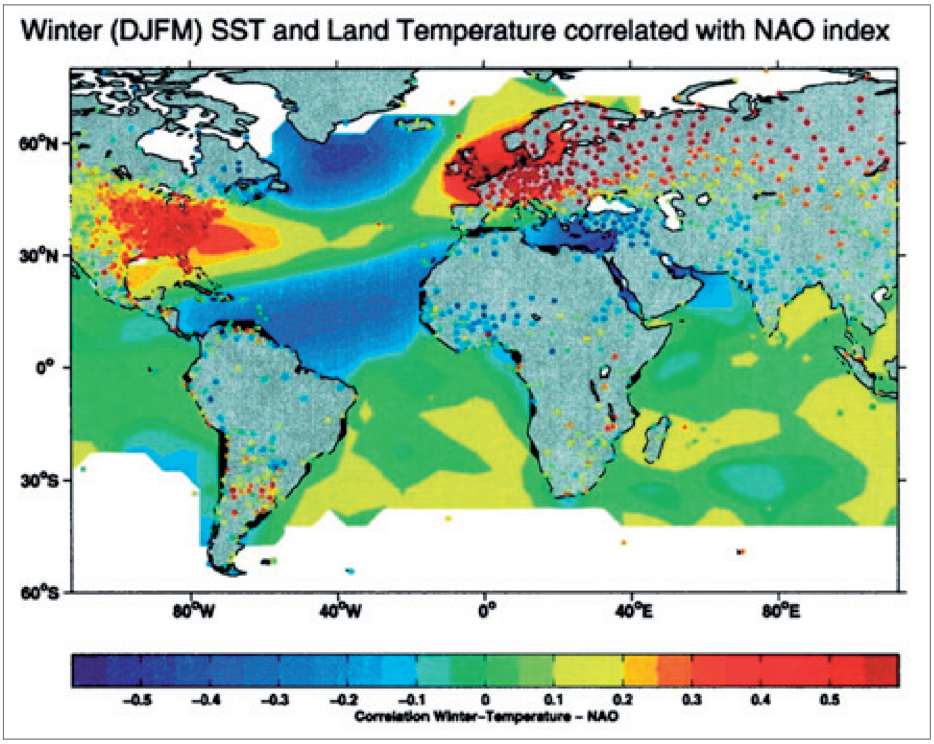

Fig. 2: Correlation coefficients between the average winter temperature and the Hurrell Oscillation Index during the positive NAO phase (Source: Visbeck et al., 2001)

Atlantic Oscillation on precipitation totals in Europe. Europe as a whole was assessed by Hurrell (1995), Osborn et al. (1999), Beranová, Huth (2008), inter alia. The last-mentioned authors employed Pearson correlation coefficients to evaluate the relation between the oscillation, the mean air temperature and the precipitation totals in winter in the period from 1958 to 1998. Using a 15-year moving window, they eliminated the low-frequency variability, and focused on the fact that the relationship between the NAO and precipitation is not stable over time. The results for the whole period indicate that the correlation between the NAO index and the maximum air temperature in Europe is positive (maximum + 0.73 in Copenhagen), except for the most northwestern (– 0.28, Iceland) and southeastern (Greece) European stations. The spatial distribution of the NAO impact on precipitation totals was different. The correlation coefficients varied from – 0.62 in Lisbon (Portuguese) and Badajoz (Spain), to + 0.69 in Eskdalemuir (Scotland). No significant correlations were found in Eastern and Central Europe, Greece and Valencia (Spain). A cluster analysis of the 15-year moving correlation window identified three clusters, which were basically oriented in a zonal direction. The first cluster with decreasing correlation during the whole period, consists of stations located in the southern parts of Europe. In the second cluster, the stations in the UK, Western, Central and Eastern Europe are included. The correlation trend in this cluster was decreasing until 1975. In the period from 1975 to the end of the study period, however, an increasing trend was observed. The third cluster consists of stations with an increasing trend during the whole period, which are located in Northern Europe. Statistically significant results were identified only for the second cluster.

Osborn et al. (1999) tested the output data of the integrated coupled model HadCM2. Precipitation totals and also deviations from normal values were taken into consideration. The strongest drying effect was found over the Iberian Peninsula, but the analysis of deviations from normal identified more drying in Algeria. The results showed that the data from the integrated coupled model could reproduce quite good conditions obtained from measured station data. Therefore, it is required to use the output data from the model in further model-based experiments to identify the driving mechanism of low-frequency variability of the oscillation.

Many studies have been carried out on a regional scale, especially in the regions which have the highest correlation between the NAO indexes and climatic elements in previous studies. The first such region is Portugal, Spain and northwestern Africa. Relations between the North Atlantic Oscillation and precipitation, but also between the NAO and the discharge of three international rivers (Douro, Tajo and Guardiana) in the Iberian Peninsula were analysed by Trigo et al. (2004). The strongest influence of the oscillation on discharge in Europe was recorded in this area, and the relation is strongest with a one-month shift (the correlation of the discharge in the January–March period with the NAO index in the December–February period, is higher than the correlation of the discharge and the NAO index in the months December–February). This finding can be used for early extreme discharge prediction in these river basins.

This study led to further research in which the relation between the NAO and landslides near Lisbon was examined (Trigo et al., 2005). The results showed that the winter precipitation during the negative NAO phase (619 mm) is almost two times higher than the precipitation during the positive phase (339 mm). The negative phase is responsible for long-lasting precipitation episodes, which caused the largest landslides in the studied area in the past. In Spain, regional analysis of the relationship between the NAO and winter precipitation was made by Queralt et al. (2009). The analysis found the highest negative correlation in January along the northwestern Spanish coast (Galicia; correlation coefficient = – 0.83). The correlation decreases eastward and the lowest values are reached on the east coast near Valencia. These results coincide with the study by Gimeno et al. (2005), which pointed out the value of the main precipitation period in Galicia (8.4 years), which is very close to value of the main NAO period (8.3 years).

Morocco also belongs to the region with negative correlation of the NAO and precipitation, especially the most northern coastal area of this country with a correlation coefficient equal to – 0.64 (Lamb, Peppler, 1987). The seasonal correlation coefficients were also evaluated for northwestern Italy in the period 1952–2002 (Ciccarelli et al., 2008). A negative correlation (– 0.31) between the NAO and precipitation was identified in winter and no significant correlation was found in other seasons.

Different impacts of the oscillation on the precipitation totals were detected in the United Kingdom and Ireland (Murphy, Washington, 2001). The impact is significant from September to April, when the correlation coefficients increase from southeast to northwest with a maximum in the Hebrides and Shetland Islands. A similar study was also carried out for southwestern Norway and southern Spain/northern Morocco, as the most influenced regions by the North Atlantic Oscillation (Matti et al., 2009). These authors used reconstructed data of precipitation for the period 1500–2000 to evaluate a 30-year moving Spearman's correlation. The correlation in southwestern Norway is most of the time positive and from 1780 also mostly significant. A different situation can be found in southern Spain/northern Morocco, where the correlation is mainly negative and significant from 1720 (the exception is a small interruption around 1770). During the last decades of the 20th century, a positive NAO phase prevailed, which can be partly explained by the negative trend of the Mediterranean winter precipitation as well as the positive trend of winter precipitation in southwestern Norway.

A strong dependence of precipitation on the NAO is presented by Cherry et al. (2000), using the example of the relation between the NAO and electricity production by hydropower stations in Norway. On the other hand, the location of Iceland close to the northern action centre of the NAO, causes the correlation of the NAO Index and precipitation in Iceland and its significance to vary in space. A significant positive correlation (+ 0.51) was recorded only in the northeastern part of the territory. Higher and significant correlations were recorded with Arctic Oscillation (AO) for all parts of the country (Jónsdóttir, Uvo, 2009).

Several studies have been reported for Central Europe. Precipitation data from the seven oldest climatological stations in Central Europe from 1851 to 2007 were analysed by Niedzwiedz et al. (2009). Relevant correlations could only be found for the data from Budapest. The oldest Slovak station – Hurbanovo – was not considered in this research. Studies carried out in the Czech Republic indicate much less influence of the North Atlantic Oscillation on precipitation than on air temperature. This influence also varies in space, with no significant impact in the region of Bohemia, but with the negative correlation in the region of Moravia and Silesia (Doležalová, 2007). A relatively low influence of the NAO on the precipitation in Bohemia was confirmed by Bodri et al. (2005). The results of Brázdil et al. (2009) and Brázdil et al. (2012) are in accordance with these previous studies. The authors identified a low correlation (+ 0.32) between precipitation in the Czech Republic and the NAO Index. Although it is statistically significant, this relationship can only explain 10% of the precipitation variability in this area (Brázdil et al., 2009), such that any reflection of the NAO in precipitation variability is very limited. The same conclusions were made on the basis of correlation analyses of long-term precipitation data of 12 meteorological stations in the Czech Republic: statistically significant results were identified for only a few stations, while insignificant correlations prevailed (Brázdil et al., 2012). On the other hand, the correlation between the NAO Index and the number of days with snow is strongly negative (January: – 0.70, winter: – 0.64) (Brázdil et al., 2009).

Similar results were published by Bednorz (2004) for Eastern Europe. He assessed the correlation between the Hurrell NAO Index and days with snow cover. In early autumn, a negative correlation was detected only in northwest Russia. In November, the correlation line of – 0.5 (p ≥ 0.99) moved westward. The strongest correlation coefficient (– 0.7) was observed in January and February in the west of the study area. Similar results were published by Twardosz et al. (2011). They evaluated the correlation coefficients between the amount of liquid and solid (snow) precipitation and the NAO, as well as between the NAO and the number of days with liquid and solid precipitation. The NAO has a significant impact on both the number of days and the total amount of rain- and snow-fall in winter. The increasing NAO was reflected in the increase of the number of days with rainfall (January: + 0.52) and the total amount of rainfall (January: + 0.39), while the number of days with snowfall (January: – 0.50) and the total amount of snowfall (January: – 0.45) decreased.

Casty et al. (2005) used a reconstructed data series of temperature and precipitation in the Alpine region (since 1500) to assess the relationship between these climatic elements and the NAO. A 31-year moving correlation was used in their research. The correlation coefficients indicate that the Alpine winter precipitation correlates negatively with the North Atlantic Oscillation. However, this relationship was not stable in time and was not always statistically significant during this period. According to the authors, the instability of this relation can be caused by the location of the Alps on the band of varying influence of the NAO and other atmospheric circulation modes, which controlled Alpine precipitation variability during the recent past. Negative correlations between the NAO Index and precipitation were identified in Hungary. The relationship is stronger in autumn and winter than in other seasons (Domonkos, Tar, 2003). According to these researchers, this relation can be caused by the fact that a large portion of winter precipitation in Hungary falls from Mediterranean or quasi-Mediterranean cyclones. Weather fronts of northern-tracked cyclones contribute only a small part of the precipitation in Hungary because of the special orographical conditions. This effect was reflected in the significant decrease of winter precipitation in Hungary during the last decades of the 20th century, when the NAO Index had an increasing tendency and the frequency of Genoa cyclones, which have an important effect on weather in Hungary, substantially declined.

4. Data and methods

The monthly precipitation totals from 202 rain gauge stations in Slovakia from 1901 to 2010 were used as the main data base (Fig. 3). The dataset of the precipitation sums was obtained from Šamaj, Valovič (1982) till 1980, and then continued from the DB system of the Slovak Hydrometeorological Institute (SHMI). In the case of missing values, the dataset was completed according to a spatial analysis of the monthly precipitation field in a given month, taking into account neighbouring stations (completion of the data set by SHMI).

The data were analysed at two resolution levels: at the level of the individual rain gauge stations, but also at the generalised level of the precipitation regions. More exactly, the generalised level consists of nine precipitation regions distinguished on the base of precipitation regime, which is characteristic for every individual region (Fig. 3, Tab. 1).

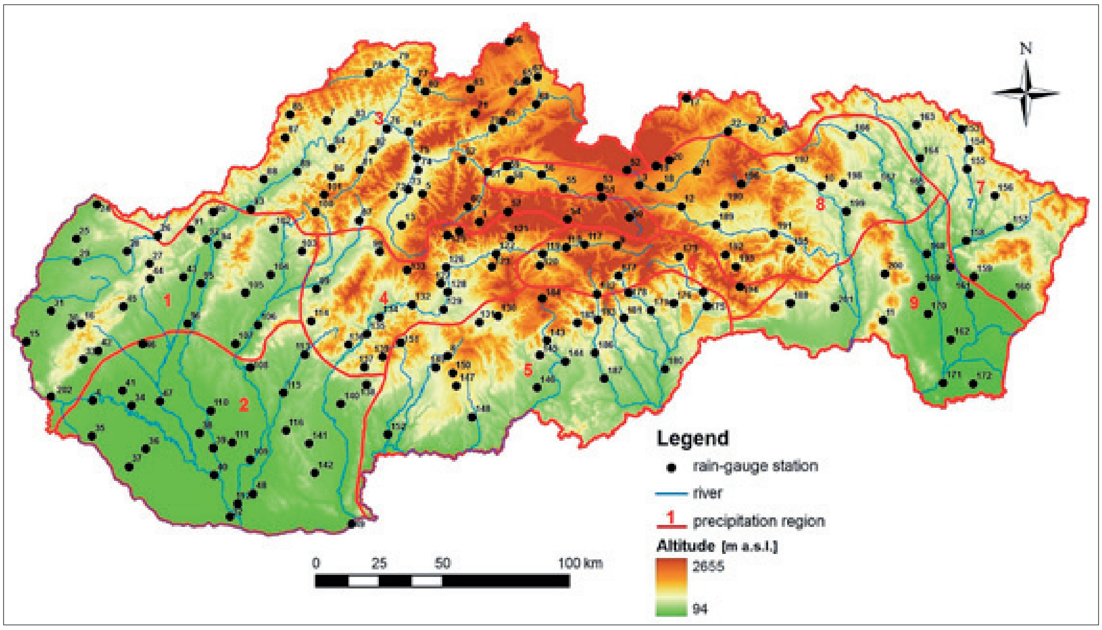

Fig. 3: The location of the rain-gauge stations within the precipitation regions

Region	Description of region
region 1	transition region between two-peak and one-peak annual precipitation regime with regular occurrence of rainstorms in summer
region 2	region with one main and one secondary maximum in annual precipitation regime and with precipitation deficit in a part of summer
region 3	region with simple annual precipitation regime with maximum in summer
region 4	region with one main and one secondary maximum in annual precipitation regime and with occurrence of rainstorms in summer
region 5	region with sharp two-peak annual precipitation regime and with occurrence of rainstorms in summer
region 6	transition region between two-peak and one-peak annual precipitation regime with a precipitation decrease in winter under the influence of continentality
region 7	region with simple annual precipitation regime with sharp peak in summer
region 8	region with high contrast between summer and winter precipitation
region 9	region with simple annual precipitation regime with sharp peak in summer and possible precipitation deficit in winter under the influence of continentality

Tab. 1: Precipitation regions in Slovakia

From oscillation indexes, the Hurrell winter oscillation index (NAOI-H), defined by Hurrell in 1995, was selected. It is the station-based index, based on the difference of normalised sea-level pressure at two reference stations: Lisbon (Portugual, 39 °N, 9 °W), and Stykkisholmur (Iceland, 65 °N, 23 °W). The time series of NAOI-H is available for every winter period (December–March) since 1864. Data are available at the website of the National Center for Atmospheric Research, Boulder, USA (Hurrell, 2012), and they are regularly updated.

The seasonal (winter: December–March according to the Hurrell winter NAO Index) precipitation totals for individual stations in Slovakia were calculated from monthly sums. These data were the basis for the first, more exact resolution level of the assessment. The normality of the data series was tested using the Lilliefors (Kolmogorov-Smirnov) normality test. Not all stations had a normal distribution of the seasonal precipitation; therefore Spearman's rank correlation method was used for further analysis. Then, the statistical significance of correlation with a significance level $\alpha = 0.05$ at both spatial resolution levels was tested with a T-test (Sachs, Hedderich, 1972). The critical value for the correlation is ± 0.187 for the p-value 0.05 (two-tailed), with sample size = 110.

For the visualisation of the results on this resolution level, it was necessary to select an appropriate interpolation method considering the use of 3-D interpolation. This method would be correct in the case of dependence between correlation coefficients and altitude. Such dependence was not confirmed (Fig. 4), however, as the resulting coefficient of determination (R^2) was only 0.161. In the next step, a 2-D interpolation method was selected and the module v.surf.rst of the program GRASS was used. Considering the density of the station network that was used, it was confirmed that the interpolation results correspond well to our conception of the geographical impacts on the precipitation distribution in Slovakia.

For the generalized level, the seasonal precipitation totals for every precipitation region were calculated. In the next step, rain gauge stations were divided into nine groups in accordance with nine precipitation regions. Then average regional winter precipitation totals were calculated and used as basis for the estimation of the long-term Spearman's rank correlation coefficients between the Hurrell winter oscillation index and the winter precipitation totals. All regression analyses were carried out in the statistical environment R (v. 2.13.1).

5. Results

Analyses of the relation between the North Atlantic Oscillation and the precipitation totals in winter showed the impact of the NAO on a seasonal sum of this climatological variable. A zonal configuration of the correlation coefficient with lower values in the northern part and higher values in the southern part of Slovakia, was identified at a generalized resolution level (Fig. 5).

Figure 5 shows that more precipitation is brought into the region of Orava and Kysuce (region 3) during the positive oscillation phase, even though

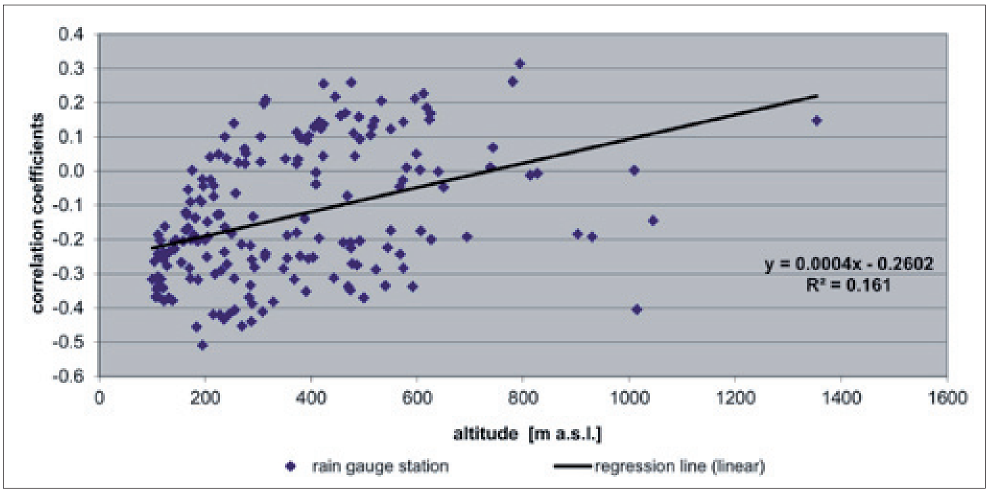

Fig. 4: Dependence of correlation coefficients between Hurrell winter oscillation index and winter precipitation on altitude

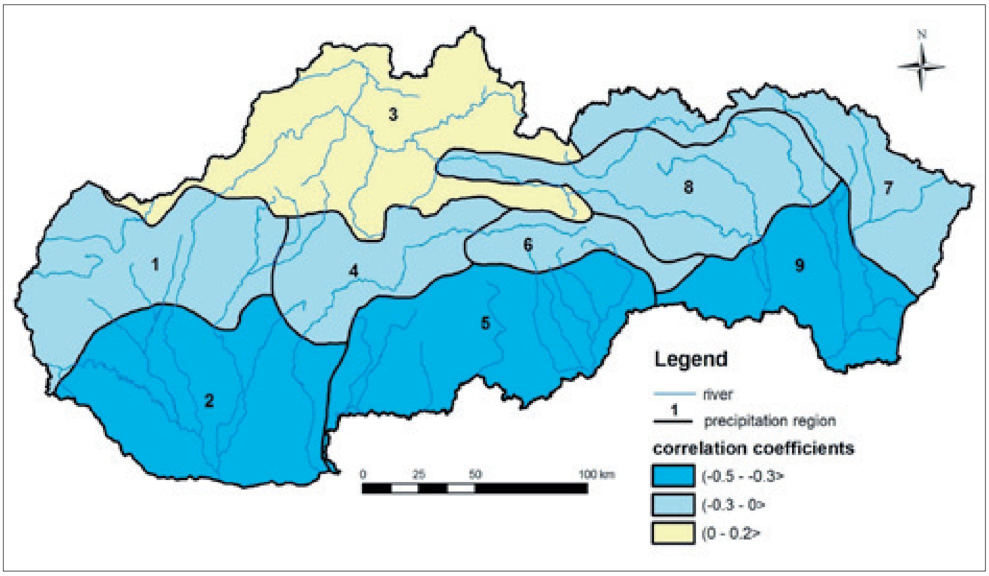

Fig. 5: Correlation coefficients between winter precipitation totals and Hurrell winter oscillation index for individual precipitation regions in Slovakia in period 1901–2010

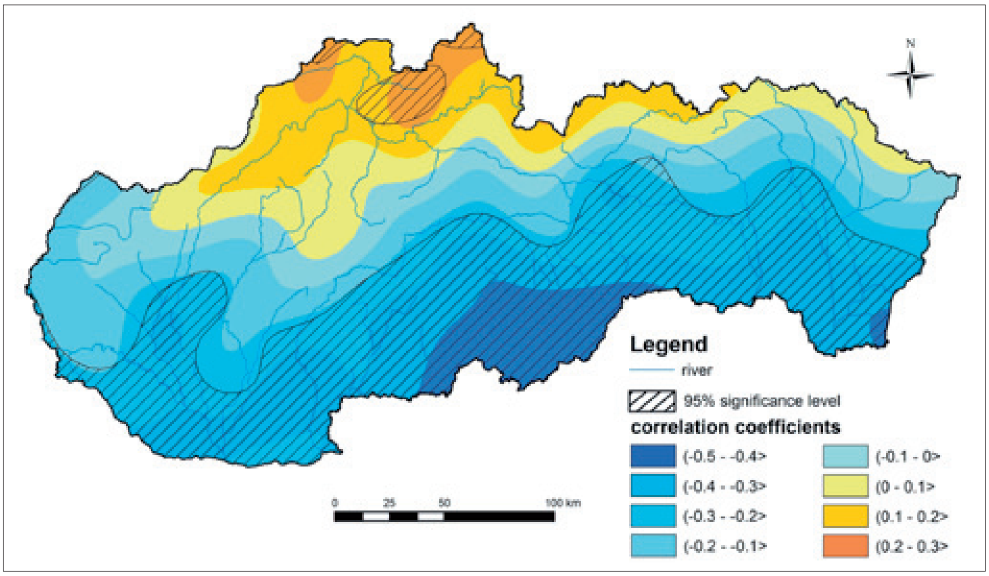

Fig. 6: Spatial distribution of the correlation coefficients between the Hurrell winter oscillation index and the winter precipitation totals in Slovakia in period 1901–2010

the correlations do not reach high values and only less than 2% of the winter precipitation variance in region 3 can be explained by the influence of the NAO. This zone with low positive correlation values is neighbour to a transition zone, characterised by low negative correlation coefficients. This zone consists of the region of Záhorie and a part of middle Považie (region 1), upper Nitra, upper and middle Hron river basin (region 4 and 6) and the northern part of eastern Slovakia (region 7 and 8). The closest relation between the NAO and the winter precipitation totals was detected in the most southern regions of Slovakia, more exactly at Podunajská and Východoslovenská nížina (region 2 and 9) and in the southern part of central Slovakia (region 5). In southern regions, some 17% of the winter precipitation variance can be explained by the NAO impact. The significant results were only obtained in these last-mentioned regions with the strongest correlation of winter precipitation and the NAO. The exception is region 6, which is located in the transition zone (correlation coefficient is equal to − 0.26) and the correlation in this area is also significant.

The spatial distribution generated from this generalised method was replicated by the analysis of the relations at the higher resolution level. The zonal configuration of the NAO impact on the winter precipitation totals is displayed in the final map, with higher spatial resolution (Fig. 6). Similar to the generalised level, the Orava and Kysuce region is the only one which records positive correlation coefficients, but this zone continues as a narrow belt through the High Tatra's ridge and along northern country border, almost to the Slovakia-Ukraine border. To the south, a transition zone with lower values of correlation coefficients is located in a latitudinal direction. The highest, but negative correlation is recorded in the region of Juhoslovenská kotlina, where correlations up to − 0.5 were identified (Tab. 2). A relatively higher negative correlation was also recorded in the Spiš region. This region has a special orographical position, because it is completely surrounded by mountains. The annual precipitation total is relatively low here, because of a multiplied shadow effect. A similar phenomenon of a higher negative correlation appears in the surroundings of Galanta. This region is located in the rain shadow of the mountains neighbouring this area from the west and north, which influences the prevailing flow from the west and northwest and brings less precipitation into this region.

Not all correlations are statistically significant at the significance level $\alpha = 0.05$. The statistically significant results were identified mostly in the southern half of Slovakia, with negative values of the correlation coefficient. In the small areas in the most northern region (Orava and Kysuce region), the highest positive (and statistically significant) correlation was recorded. The relationship between the NAO and the winter precipitation totals in the area with statistically significant correlation of the winter precipitation variance can explain at most 25% in the region of highest negative correlation, and 7.3% in the region of the most positive correlation. Without doubt, this distribution of statistical relationships between the NAO Index and winter precipitation refers better to the real conditions in landscape situations than the results obtained from the generalised way, because the precipitation regions cover quite large areas and therefore local differences within smaller regions are smoothed.

Rain gauge station	Latitude	Longitude	Correlation coefficient
Cinobaňa	48°26'45"	19°39'20"	– 0.42
Dolné Plachtince	48°12'24"	19°19'12"	– 0.41
Hnúšťa	48°35'3"	19°56'43"	– 0.40
Hrachovo	48°27'46"	19°57'6"	– 0.40
Jelšava	48°37'50"	20°14'20"	– 0.42
Kráľovský Chlmec	48°25'15"	21°58'46"	– 0.40
Lučenec	48°19'46"	19°39'16"	– 0.50
Poltár	48°26'4"	19°47'59"	– 0.42
Ratková	48°35'32"	20°6'0"	– 0.42
Rimavská Sobota	48°22'26"	20°0'38"	– 0.40
Slanec	48°38'	21°29'	– 0.44
Tornaľa	48°25'15"	20°19'46"	– 0.45

Tab. 2: The most negative correlation coefficients (at significance level $\alpha = 0.05$) between the Hurrel winter NAO Index and the winter precipitation totals in Slovakia

A relatively high gradient of correlation coefficients in a north-south direction was found, considering such a ‘narrow’ territory as that of Slovakia. This zonal configuration can be explained mostly by the orography of the area, where the barrier effect of mountains (rain shadow effects) influences the precipitation distribution. The prevailing air-flow over the study area is from a northwestern and western direction. The prevailing air flow and the orography of the Carpathian belt cause multiple rain shadows, especially in the Juhoslovenská kotlina, but also in the lowland regions (Východoslovenská and Podunajská nížina) and in the region of Spiš. In these regions, in particular, the highest negative correlations are detected. This indicates that during the positive oscillation phase, when most storms move into Scandinavia, then the western, northwestern and northern cyclonic situations have a dominant role in the spatial distribution of precipitation in Slovakia. The precipitation connected with these situations falls mainly on the windward northwestern and northern parts of the Carpathians and the precipitation totals decrease southward and southeastward.

In other words, the more often that precipitation comes from the northwest and the north, lower precipitation totals occur in the south of Slovakia. Vice versa, during the negative oscillation phase, when storms from the Atlantic move towards the Mediterranean region, then southwestern, southern and southeastern synoptic situations bring more precipitation to the regions of Slovakia, which are situated in the rain shadow during the positive phase of oscillation. The distribution of precipitation during these situations was described in Ballon et al. (1964), Brádka (1972) and Šamaj et al. (1985).

This hypothesis of the influence of the Carpathian belt barrier effect on the final impact of the NAO on the precipitation totals is supported by the fact that no dependence of the correlation coefficients on altitude was detected. The positive NAO – precipitation correlation is not reached even in the high mountains located in central part of Slovakia, but in lower mountains situated in northern part of the Carpathians as well.

The precipitation conditions in the southern part of Slovakia are more dependent on southern air flows, and an explanation could be the impact of other circulation modes. Its influence on the precipitation totals is supposed especially in the lowland regions (Podunajská nížina, Východoslovenská nížina) and in the region of Juhoslovenská kotlina. These regions are very important from an agricultural viewpoint, where precipitation has a major importance. Therefore, further research should be oriented to understanding these relations.

6. Discussion and conclusions

The impact of the North Atlantic Oscillation on climatic elements is very complicated. It results from the complexity of the phenomenon itself, which is caused by internal atmospheric processes within oscillation, which influence each other, and unpredictable (random) changes in the NAO phases which are a product of this co-influence (Hurrell, 2011). The assessment of the NAO impact on the amount, time and spatial distribution of precipitation in Slovakia is interesting due to the location of the country within Europe, especially since Slovakia is situated in the region where two different oscillation influences (the North Atlantic and the Mediterranean Oscillation) probably collide.

Our results agree with those of Casty et al. (2005), who also inferred the possible influence of other circulation modes on precipitation in Alpine regions. However, our study area is not in the Alpine region, but it is very close to it and the Carpathians produce similar barrier effect to the Alps. Therefore similar phenomena of the influence of circulation modes can occur in the Carpathians region. Domonkos and Tar (2003) depicted the fact that a large portion of precipitation in Hungary falls from Mediterranean or quasi-Mediterranean cyclones. This fact is most important for the southern parts of Slovakia close to the borders with Hungary, where similar negative correlations are identified. This finding indicates the needs for further research regarding the influence of other circulation modes (especially of the Mediterranean Oscillation) and the relationships between them.

The results presented here are not in accordance with the results published by Beranová, Huth (2008). One of their conclusions was that the impact of the NAO on precipitation in Central Europe was insignificant. The difference in these results is probably caused by the fact that those authors selected only the climatological station Hurbanovo as representative for the whole of Slovakia. More detailed spatial analysis was not done, despite the fact that the country is very heterogeneous from an orographic viewpoint. In addition, the results of our analyses confirm the conclusions of Pishvaei (2003), who used relatively detailed spatial generalisation with five precipitation regions and two representative stations in each region, although the time period used was shorter than that in our study.

In addition, our results can be interpreted as the impact of orography on precipitation conditions. The regions of Slovakia with the highest negative correlations are situated in the multiple rain shadows of the Carpathians. The orographic effects prevent the occurrence of higher precipitation caused by western, northwestern and northern cyclonic situations, which prevail during the positive NAO phase. The southwestern, southern and southeastern cyclonic situations are more important during the negative oscillation phase, when higher precipitation totals are recorded in the southern parts of Slovakia. Our hypothesis corresponds to Cherry et al. (2000). They present the same explanation of the NAO impact in Scandinavia. This hypothesis is also confirmed by Doležalová (2007): in her analyses, a significant oscillation impact was only shown in the region of Moravia and Silesia, and it was probably caused by the orographic effect of the neighbouring Carpathians. The hypothesis is also in accordance with the results by Domonkos and Tar (2003), who demonstrated that the negative correlation between the NAO and winter precipitation in Hungary is caused by the specific orographic conditions of the country. The final oscillation impact on the precipitation in the south of Slovakia is probably caused by the barrier effect of the Carpathian Mountains.

Our results detected the impact of the North Atlantic Oscillation on the winter precipitation totals in Slovakia. The zonal distribution of the final correlation coefficients between the Hurrell winter oscillation index NAOI-H and the winter precipitation totals was demonstrated for the territory of Slovakia, for both of the spatial resolution levels that were used. A positive correlation was obtained only in the region of Orava and Kysuce, with low, but significant values. Southward, the correlation coefficients change into negative values, which are the lowest and most significant in the region of Juhoslovenská kotlina and the lowland regions (Podunajská nížina, Východoslovenská nížina). This distribution can be explained by the barrier effect of the Carpathian Mountains. It can also be expected that the impact of other circulation modes is important for these last-mentioned regions.

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References:

AHRENS, C. D. (2007): Essentials of Meteorology: An Invitation to the Atmosphere (5th Edition) Brooks Cole, 504 pp.

BALLON, L., FORGÁČ, P., MOLNÁR, F. (1964): Počasie na území Slovenska za typických poveternostných situácií. HMÚ, Praha, 30 pp.

BARNSTON, A. G., LIVEZEY, R. E. (1987): Classification, Seasonality and Persistence of Low-Frequency Atmospheric Circulation Patterns. Monthly Weather Review, Vol. 115, No. 6, p. 1083–1126.

BARRY, R. G., CHORLEY, R. J. (2003): Atmosphere, weather and climate. London, Butler and Tanler Ltd., 368 pp.

BERANOVÁ, R., HUTH, R. (2008): Time variations of the effects of circulation variability modes on European temperature and precipitation in winter. International Journal of Climatology, Vol. 28, No. 2, p. 139–158.

BEDNORZ, E. (2004): Snow cover in Eastern Europe in relation to temperature, precipitation and circulation. International Journal of Climatology, Vol. 24, No. 5, p. 591–601.

BODRI, L., CERMAK, V., KRESL, M. (2005): Trends in precipitation variability: Prague (the Czech Republic). Climatic Change, Vol. 72, No. 1–2, p. 151–170.

BRÁDKA, J. (1972): Srážky na území ČSSR při jednotlivých typech povětrnostní situace. Sborník prací HMÚ 18. Praha, p. 8–62.

BRÁZDIL, R., CHROMÁ, K., DOBROVOLNÝ, P., TOLASZ, R. (2009): Climate fluctuations in the Czech Republic during the period 1961–2005. International Journal of Climatology, Vol. 29, No. 2, p. 223–242.

BRÁZDIL, R., ZAHRADNÍČEK, P., PIŠOFT, P., ŠTĚPÁNEK, P., BĚLÍNOVÁ, M., DOBROVOLNÝ, P. (2012): Temperature and precipitation fluctuations in the Czech Republic during the period of instrumental measurements. Theoretical and Applied Climatology, Vol. 110, No. 1–2, p. 17–34.

CASTY, C., WANNER, H., LUTERBACHER, J., ESPER, J., BÖHM, R. (2005): Temperature and precipitation variability in the European Alps since 1500. International Journal of Climatology, Vol. 25, No. 14, p. 1855–1880.

CHERRY, J., CULLEN, H., VISBECK, M. (2000): Impacts of the NAO on the Energy Sector: the Norwegian example. Paper presented at the AGU Chapman Conference „The North Atlantic Oscillation“, Galicia 28.11.–1.12.2000. [online]. [cit. 20.10.2012]. Available at URL: http://xtide.ldeo.columbia.edu/~visbeck/nao/poster/Cherry.pdf

CICCARELLI, N., VON HARDENBERG, J., PROVENZALE, A., RONCHI, C., VARGIU, A., PELOSINI, R. (2008): Climate variability in north-western Italy during the second half of the 20th century. Global and Planetary Change, Vol. 63, No. 2–3, p. 185–195.

DOLEŽALOVÁ, M. (2007): Projevy Severoatlantské oscilace v časové variabilitě teploty vzduchu a srážek na území České republiky. Meteorologický Časopis, Vol. 10, No. 2, p. 91–99.

DOMONKOS, P., TAR, K. (2003): Long-term changes in observed temperature and precipitation series 1901–1998 from Hungary and their relations to larger scale changes. Theoretical and Applied Climatology, Vol. 75, No. 3–4, p. 131–147.

GIMENO, I., DE LA TORRE, L., NIETO, R., ANEL, J. A. (2005): North Atlantic Oscillation (NAO) and precipitation in Galicia (Spain). Atmósfera, Vol. 18, No. 1, p. 25–32.

HURRELL, J. W. (1995): Decadal Trends in the North Atlantic Oscillation: Regional Temperatures and Precipitation. Science, Vol. 269, No. 5224, p. 676–679.

HURRELL, J. W. (1996): Influence of variations in extratropical wintertime teleconnections on Northern Hemisphere temperature. Geophysical Research Letters, Vol. 23, No. 6, p. 655–668.

HURRELL, J. (2001): North Atlantic Oscillation. Encyclopaedia of Ocean Sciences, Vol. 4, p. 1904–1911.

HURRELL, J. W., KUSHNIR, Y., OTTERSEN, G., VISBECK, M. [eds.] (2003): The North Atlantic Oscillation: Climatic Significance and Environmental Impact, Geophysical Monograph Series, No. 134, 279 pp.

HURRELL, J. W. (2011): Introduction to NAO Indices. [online] [cit. 05.10.2011]. Available at URL: http://www.cgd.ucar.edu/cas/jhurrell/naointro.html

HURRELL, J. W. (2012). NAO Index Data provided by the Climate Analysis Section, NCAR. [online] [cit. 02.12.2011]. Available at URL: http://climatedataguide.ucar.edu/guidance/hurrell-north-atlantic-oscillation-nao-index-station-based

HURRELL, J. W. (2013): The Climate Data Guide: Hurrell North Atlantic Oscillation (NAO) Index (station-based). [online] [cit. 11.11.2013]. Available at URL: https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-station-based

JÓNDÓTTIR, J. F., UVO, C. B. (2009): Long-term variability in precipitation and streamflow in Iceland and relations to atmospheric circulation. International Journal of Climatology, Vol. 29, No. 10, p. 1369–1380.

LAMB, P. J., PEPPLER, R. A. (1987): North Atlantic Oscillation: Concept and an Application. Bulletin American Meteorological Society, Vol. 68, No. 10, p. 1218–1225.

MATTI, C., PAULING, A., KÜTTEL, M., WANNER, H. (2009): Winter precipitation trends for two selected European regions over the last 500 years and their possible dynamic background. Theoretical and Applied Climatology, Vol. 95, No. 1–2, p. 9–26.

MITCHELL, T. (2002): North Atlantic Oscillation (NAO) Index. [online] [cit. 29.10.2012]. Available at URL: http://jisao.washington.edu/data_sets/nao/

MURPHY, S. J., WASHINGTON, R. (2001): United Kingdom and Ireland precipitation variability and the North Atlantic sea-level pressure field. International Journal of Climatology, Vol. 21, No. 8, p. 939–959.

NIEDZWIEDZ, T., TWARDOSZ, R., WALANUS, A. (2009): Long-term variability of precipitation series in east central Europe in relation to circulation patterns. Theoretical and Applied Climatology, Vol. 98, No. 3–4, p. 337–350.

OLIVER, J. E. [ed.] (2008): Encyclopedia of world climatology. Cornwall, Springer, 854 pp.

OSBORN, T. J., BRIFFA, K. R., TETT, S. F. B., JONES, P. D., TRIGO, R. M. (1999): Evaluation of the North Atlantic Oscillation as simulated by a coupled climate model. Climate Dynamics [online], Vol. 15, No. 9, p. 685–702. [cit. 20.01.2012]. Available at URL: http://www.springerlink.com/content/h1lj48bd98w6tln5/fulltext.pdf

PEKÁROVÁ, P., MIKLÁNEK, P., PEKÁR, J. (2010): Možnosti dlhodobej predikcie prietokov slovenských tokov na základe indexu Severoatlantickej oscilácie NAOI. Acta Hydrologica Slovaca, Vol. 11, No. 2, p. 282–290.

PISHVAEI, M. R. (2003): Study of precipitation time series in Slovakia and Iran. Bratislava, Univerzita Komenského, 256 pp.

QUERALT, S., HERNÁNDEZ, E., BARRIOPEDRO, D., GALLEGO, D., RIBERA, P., CASANOVA, C. (2009): North Atlantic Oscillation influence and weather types associated with winter total and extreme precipitation events in Spain. Atmospheric Research, Vol. 94, No. 4, p. 675–683.

SACHS, L., HEDDERICH, J. (1972): Angewandte Statistik. Heidelberg, Springer, 902 pp.

TRIGO, R. M., POZO-VÁZQUEZ, D., OSBORN, T. J., CASTRO-DIÉZ, Y., GÁMIZ-FORTIS, S., ESTEBAN-PARRA, M. J. (2004): North Atlantic Oscillation influence on precipitation, river flow and water resources in the Iberian peninsula. International Journal of Climatology, Vol. 24, No. 8, p. 925–944.

ŠAMAJ, F., VALOVIČ, Š., BRÁZDIL, R. (1985): Denné úhrny zrážok s mimoriadnou výdatnosťou v ČSSR v období 1901–1980. Zborník prác SHMÚ, 24. Alfa, Bratislava. p. 9–113.

ŠAMAJ, F., VALOVIČ, Š. (1982): Priestorové úhrny zrážok na Slovensku (1881–1980). Meteorologické zprávy, 35, p. 108–112.

TRIGO, R. M., ZEZERE, J. L., RODRIGUES, M. L., TRIGO, I. F. (2005): The Influence of the North Atlantic Oscillation on Rainfall Triggering of Landslides near Lisbon. Natural Hazards, Vol. 36, No. 3, p. 331–354.

TWARDOSZ, R., LUPIKASZA, E., NIEDWIEDZ, T., WALANUS, A. (2011): Long-term variability of occurrence of precipitation forms in winter in Krakow, Poland. Climatic Change, Vol. 113, No. 3–4, p. 623–638.

VISBECK, M. H., HURRELL, J. W., POLVANI, L., CULLEN, H. M. (2001): The North Atlantic Oscillation: Past, present and future. PNAS [online], Vol. 98, No. 23, p. 12876–12877. [cit. 20.10.2012]. Available at URL: http://www.pnas.org/content/98/23/12876.full.pdf+html

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SHORT WAVES OF SUPERMARKET DIFFUSION IN TURKEY

Martin FRANZ, Alexandra APPEL, Markus HASSLER

Abstract

In order to categorize the global diffusion of supermarkets, the metaphor of waves is often used. This is a simplification, however, which obscures the fact that developments in the countries experiencing these waves of innovation are much more nuanced. This case study on the development of the Turkish grocery retail sector since the 1950s, shows how this development can be divided into different phases. Furthermore, it demonstrates that state retail chains paved the way for private actors, while most studies about the modernization of the retail sector have a focus on private companies or – even more specifically – on transnational corporations.

Shrnutí

Krátké vlny difuze supermarketů v Turecku

Ke kategorizaci globálního rozšiřování supermarketů je často používán obraz vln. Nicméně tato zjednodušená metafora zastírá skutečnost, že vývoj v zemích zasažených těmito vlnami má mnoho odlišností. Tato studie zaměřená na rozvoj tureckého potravinářského sektoru od roku 1950 ukazuje, jak může být tento vývoj rozdělen do několika fází. Práce navíc ukazuje, že státní maloobchodní řetězce vydláždily cestu soukromým subjektům, zatímco většina obdobných studií věnovaných modernizaci maloobchodního sektoru je zaměřena na soukromé společnosti – nebo ještě konkrétněji – na nadnárodní korporace.

Keywords: *food, globalization, retail, transnational, wholesale, Turkey*

1. Introduction

The metaphor "*waves of diffusion rolling along*" (Reardon et al., 2003, 1142), is often used to describe different phases of the so-called "supermarket revolution" (Reardon, Hopkins, 2006, 522). The waves refer to the quantitative and spatial diffusion of supermarkets and other modern retail formats such as discounters and hypermarkets. The diffusion of such retail formats into more and more countries and regions can be understood not only as the success of a specific business model but also as the success of a series of accumulating innovations.

The first wave identified by Reardon and Minten (2011) took place in the early to mid-1990s, and included much of South America and East Asia (not including China and Japan), South Africa, the northern parts of Central Europe (including the Czech Republic: see Szczyrba et al., 2007), and the Baltic countries. The second wave rolled over much of Southeast Asia, the southern parts of Central Europe, Mexico and Central America. The third wave included Eastern and Southern Africa, other parts of Central and South America, China, India, Russia and Vietnam. In those countries, the spread of supermarkets had its take-off in the late 1990s or early 2000s. Reardon et al. (2003) and Reardon et al. (2004) cite a fourth wave beginning in the early 2000s that includes South Asia and Western Africa. These different wave categorizations are used in much of the recent literature about the processes of globalization in the retail sector (e.g. Coe and Wrigley, 2007; Humphrey, 2007; Tacconelli and Wrigley, 2009). Waves, however, are a simplifying metaphor and, as Sengupta (2008), as well as Reardon and Minten (2011), determined for India, the spread of supermarkets inside one country can occur in different phases as well.

This article tries to demonstrate, for the case of Turkey, that the 'supermarketization' of the country happened in different phases, which include waves of innovations with different reach. Furthermore, it aims to answer the following research questions: What factors start off the different waves of innovations that accompany the diffusion of modern retail formats? How do the developments in Turkey correlate or differ from those developments that are regarded as typical for the so-called supermarket revolution? The latter question includes an attention to the often neglected role of state institutions and cooperatives for the diffusion of modern retail formats. This article adds to knowledge about the retail sector in Turkey, and furthers a more differentiated understanding of the processes behind ‘supermarketization’.

The next section presents the methodological approach of the paper. After incorporating the study in the relevant literature, the different phases of supermarket diffusion in Turkey are identified and analyzed, leading to some final conclusions.

2. Methods

This article presents an historical analysis of macro-level change and innovation diffusion in Turkey, based on evidence from the literature and the analysis of primary qualitative data and secondary quantitative data. The qualitative primary data were collected during a fieldwork period from 2011 to 2012. The authors conducted 26 expert interviews with representatives of retail and wholesale companies (including Metro Cash & Carry, Migros Ticaret, Real and Tesco, to name only the biggest), food suppliers (e.g. Günesler and Kiliclar Gida) and retail associations (the Turkish Retail Federation PERDER and the Trade Council of shopping centres and retailers: AMPD). The interviews have been analyzed with a qualitative content analysis. The interview languages were English, German and Turkish. German and Turkish quotes have been translated into English for this article. For quantitative data, we used the Country Report Turkey 2011 of Planet Retail. Planet Retail is a retail data service (see: www.planetretail.net). Furthermore, we counted the stores on the company websites of the retail companies to gain data about the spatial diffusion of the biggest store chains (Figs. 4 and 5). After incorporating the study into the relevant literature, the different phases of supermarket diffusion are identified and analyzed. In the final section, conclusions are drawn.

3. Waves of supermarket diffusion – reasons and impacts

As mentioned above, the metaphor of three or four waves of supermarket diffusion is often used to describe the different phases of modernization in the food retail sector in countries of the Global South and transition countries in Central and Eastern Europe. This diffusion of modern food retail[1] not only includes supermarkets, but also other format innovations such as hypermarkets, discounters and wholesale cash and carry stores. Furthermore, these formats usually come along with other innovations, e.g. in the supply chain management. An analysis of knowledge transfers in the retail sector has to differentiate between product-based (e.g. assortment, retail format, price) and process-based (e.g. expansion strategy, IT systems, logistics, supplier relationships) knowledge (Currah, Wrigley, 2004). In essence, “*Retailers by the nature of competition provide a relatively high level of transparency in respect of their front of store operations with commercial success encouraging less innovative retailers to copy the formula*“ (Dawson, 2007, 391). Thus, process-based knowledge is of strategic importance for retailers to gain a competitive edge (Currah, Wrigley, 2004).

In many countries, the diffusion of modern retail formats was strongly connected to the emergence of foreign direct investment (FDI) in the retail sector, as transnational corporations (TNCs) such as Carrefour, Metro Group and Tesco, entered the markets and introduced innovations in formats and processes (Coe, Hess, 2005; Kulke, Pätzold, 2009). The importance of TNCs for the diffusion of modern retail formats has resulted in many studies on the geographical spread of supermarkets that focus on the transnational expansion of TNCs: “*The geographical dimension of retail internationalization is a common theme in the academic literature, typified by studies measuring who went where, when, and how*” (Burt et al., 2008, 79). In a series of papers, the transnational expansion of individual TNCs has been charted (e.g. Currah, Wrigley, 2003; Coe, Wrigley, 2007) or the patterns of spatial spread have been analyzed beyond company borders (e.g. Muniz-Martinez, 1998; Burt et al., 2008). However, domestic retail chains have played an important role for the diffusion of retail innovations, too (Coe and Wrigley, 2007).

The transfer of knowledge and the diffusion of supermarkets had often already started before TNCs entered the respective markets. In some countries, large domestic companies were the first movers into the supermarket business (Reardon et al., 2004): “*… there are considerable transfers of management expertise between different domestic retail systems, through international searches for new ideas and technologies*” (Coe, 2004, 1581).

De Rocha, Dib (2002) use the case of Brazil to show how competitive pressure due to the market entry of TNCs resulted in various attempts to implement innovations by domestic retail companies.

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[1] We follow the definition of Romo et al. (2009, 56) which identifies “a minimum scale either of an independent store or a chain of stores of any scale per outlet, plus self-service” as the basic criteria for modern retail.

This includes the implementation of IT systems, optimization of logistics, the introduction of bigger retail formats, as well as training courses for its own management. Managers of Brazilian retail chains visited countries in the Global North to learn more about modern retailing (learning-by-observation). Furthermore, the new formats that were introduced by TNCs in Brazil were copied by domestic companies: e.g. Sendas Group opened Send's Club, an obvious imitation of Wal-Mart's Sam's Club. After a court case, the name had to be changed into Sendas Clube.

Imitation is the one-way transfer of existing solutions from one company to another (Hammer et al., 2012). Hammer et al., (2012) differentiate between friendly and unfriendly imitation. Friendly imitation is the transfer of solutions based on cooperation between two companies. An unfriendly imitation is the transfer of a solution that is unintended by the company that is the source of the solution. The company tries to avoid such transfers or condemns the already-happened transfer of the solution (Hammer et al., 2012). Unfriendly imitation includes the imitation of transparent parts of knowledge (learning-by-observing, e.g. Malmberg and Maskell, 2002), the mobility of employees who transfer knowledge into their new companies (learning-by-hiring, e.g. Song et al., 2003) or the extreme of industrial espionage (learning-by-espionage, e.g. Wright and Roy, 1999). While the last mentioned is illegal, learning-by-observing and learning-by-hiring are not. As this paper will show, the diffusion of innovations in the retail sector is often based on unfriendly imitation.

A recent example for a country where indigenous companies are dominating the modern retail business is India. Retailers like Reliance Fresh or Pantaloon Retail imitated foreign role models, while the TNCs are largely restricted in their activities due to government regulations (Franz, 2010). Based on the Indian example, Reardon and Minten (2011) show the importance of state and coop chains for the diffusion of modern retail. They point out that both have been widely neglected in the debate about the diffusion of supermarkets: "*Partly the neglect seems because it was not recognized that state and coop chains had and have the basic characteristics that meet the definition of 'modern retail.' The neglect seems to be due in part to retail and development researchers have been fascinated by and focused on how globalization and market liberalization and reform have touched off an explosion of private (per se) retail investment, even multinationalization*"… (Reardon, Minten, 2011, 135).

Furthermore, the state chains in many countries were privatized. In Central and Eastern Europe, this happened mostly in the first half of the 1990s. An example is the Lithuanian retail company Vilniaus Prekyba, which started to buy shops from the Lithuanian state in 1992 and runs supermarkets in Estonia, Latvia, Lithuania and Bulgaria today. Reardon and Minten (2011, 135) see another reason for the neglect of the topic by recent literature in this "*'withering away' of the state and coop food retail (and processing) segments in various countries where modern private retail has been studied*". However, to paint a complete picture of the history of supermarket diffusion, these initial developments have to be integrated into the analysis.

While the motives of TNCs to invest in new markets have been widely researched and discussed (e.g. Wrigley, 2000; Reardon et al., 2003; Kulke, 2011), there are fewer analyses of the investment motives of domestic companies in the Global South or transition countries. The growing investments of retailers from North America or Europe in emerging markets beginning in the early 1990s was caused by a number of push and pull factors. Push factors include the access to low cost capital, the strong competition and consolidation, as well as tight regulations in the home markets. Pull factors are the liberalization of FDI in the retail sector and the growth opportunities in the host countries (Wrigley, 2000; Coe, Wrigley 2007). For domestic investments in the retail sector, Reardon and Minten (2011, 147) hypothesize that in the case of India, the expectation of liberalization of the retail sector "*pervaded the retail industry and was an inducement for domestic chains to invest vigorously. That could be to establish scale and thus competitive defences … or appear to be a good partner for an MNC* [Multinational Corporation]."

Beside the reasons from the investment side, Reardon et al. (2003, 1141) also identify reasons from the consumer demand side that determined the diffusion of supermarkets in the Global South. These include:

- More women work outside of the home and have less time for cooking, which results in an increased demand for processed food and short shopping times;
- Sinking prices for processed food due to economies of scale and growing competition between different supermarkets and food manufacturers;
- Growing per capita income and the emergence of a middle class;
- Diffusion of refrigerators and the resulting less frequent need to go shopping; and
- The growing number of private cars and improved public transportation.

Of course, the diffusion of supermarkets is not only a consequence of these demand side developments, but also spurs or accelerates some of the mentioned developments.

The named push and pull factors do not always appear simultaneously. Their intensities can rise and diminish over time as they are constrained by political, economic, social and cultural developments. This may result in short waves of supermarket diffusion: i.e., a gradual modernization of the retail sector that can sometimes accelerate and sometimes decelerate, based on the changing circumstances in which it is embedded.

4. The phases of supermarket diffusion in Turkey

The Turkish retail sector is traditionally dominated by family-run retail outlets (Bakkallar), street vendors, markets and bazaars (Fig. 1). Planet Retail (2011, 23) estimated that there are about 550,000 Bakkals in Turkey today. However, in the 1950s, the first wave of change in the food retail sector started a process which is still ongoing. Waves are those phases in which the retail sector is changing strongly (strong diffusion of innovations). However, there can also be phases with low dynamics. The development of food retailing in Turkey, in relation to processes of globalization, can be divided into four phases, which will be presented and analyzed subsequently. The rationale for this differentiation is based on changes in the composition of the main actors in the retail sector, the introduction of innovations and their spatial diffusion, especially the modern retail formats.

1954–1975 – The first wave: Migros changes the retail landscape

The first wave was not characterized by a broad spatial spread of retail innovations, but important innovations were introduced to Turkey that were catalysts for changes in the retail sector, and new actors entered the sector, including a foreign company and different state institutions. Thus, it can be said that the first wave was more qualitative than quantitative in importance.

From the foundation of the Turkish Republic in 1923 through to the late 1970s, Turkey had an import-substitution economic policy. In 1954, the Turkish government adopted a liberal FDI Law, but still the FDI inflows were very limited (Yavan, 2010). The initial phase of retail change started in the same year with the involvement of the Swiss Migros Genossenschaft, a retail cooperative. This happened clearly ahead of the first wave of supermarket diffusion, defined by Reardon et al. (2004). In October 1953, the municipality of Istanbul, supported by the government, invited Gottlieb Duttweiler, the founder of the Swiss Migros, to bring his expertise to Istanbul. Altogether 19 private and public partners invested in the new joint venture. The main part of the investment capital, however, was provided by credits from the state-owned Ziraat Bank (Agriculture Bank) and the Yapı Kredi Bank (the first private bank in Turkey) (Özcan, 2008, 189). In this case, then, actors were involved in the founding of the Turkish Migros that are normally active on different scales and in different sectors: local actors (municipality of Istanbul), national actors (e.g. banks), and the Swiss Migros.

The aims of the Turkish institutions were to organize an effective and affordable food supply for the urban population and to control the black market. The municipality of Istanbul and the Turkish government believed that foreign knowledge was needed to improve

Fig. 1: The Egyptian Bazaar (Mısır Çarşısı) in Istanbul is one example of traditional retail in Turkey. Today it is a tourist attraction (Photo: A. Appel)

the food supply situation. This can be seen as a state-induced knowledge transfer. The reasons for the Swiss Migros to enter the Turkish market can be attributed more to corporate social responsibility than to real business interests: "*… when in 1956 the Turkish government invited him [Gottlieb Duttweiler] to come to Istanbul in order to help in developing the economy, he accepted because he saw the opportunity to serve a country which needed economic development very badly*" (Hochstrasser, 1968, 42–43). The pull factors for FDI in the retail sector, which have been identified by Wrigley (2000) and Reardon et al. (2004), did not play any role in this phase, but the active courting of a foreign retailer by state institutions from a different spatial scale, did.

In the beginning, Migros Türk operated twenty mobile sales trucks. The first stationary self-service store was installed in 1957. Although the company appeared successful from the outside (by 1959 it already had sixty sales trucks, and eleven roadside stands in Istanbul), it faced many problems (Özcan, 2008, 189–190). These included (1) financial losses, (2) state-controlled prices for food products, (3) difficulties to get new trucks and spare parts for the trucks due to import and foreign exchange controls, (4) lack of skilled staff and staff fluctuations, (5) poor infrastructure, (6) cold winters and hot summers, which affected food delivery (Özcan, 2008).

As its efforts to give the undertaking a new structure were not shared by their Turkish partners, the Swiss thought that it was "*expected to play a purely technical, advisory and marginal role. The venture reached the point of collapse by the end of the 1950s … Negotiations continued and repeated assurances were given to the Swiss partners to persuade them to stay*" (Özcan, 2008, 191). Migros Türk was recapitalized and Swiss Migros received a share of 51 per cent (Özcan, 2008, 191). In the 1960s, Migros Türk started to vertically integrate parts of the supply chain: a buying office was opened in the south of Turkey (Mersin), and the company became involved in food processing (Özcan, 2008).

Knowledge transfer was an important part of the Swiss Migros' engagement in Turkey. As Charles Hochstrasser (1968, 43), at that time Chairman of the Board of the Swiss Migros cooperatives, pointed out: "*Turkish employees and workers have been trained in Switzerland and are acquainted with our ideas and our methods of working. The experiences may not have been proved 100 percent successful, but several of these people are now working in Migros Turk [sic] and doing a good job training their countrymen.*" Besides the training of its employees, the market entry of Migros Türk also had an indirect effect of learning-by-observing: "*Individuals and companies tried to imitate Migros Turk [sic] by renewing their shops so that today you can find modern stores and supermarkets even in Anatolia. On the other hand, the efforts on the agricultural side to get standardized fruits and vegetables induced many farmers to look at this problem from a different point of view than before*" (Hochstrasser, 1968, 42).

The innovations introduced to the Turkish market were not only imitated by private actors. In Ankara, a partnership of the state-owned Agricultural Bank, the Turkish Grain Board and the Günes Insurance Company, followed the Migros Türk example by founding the supermarket chain Gima A.Ş. in 1956. The Turkish Army started its own supermarket chain Ordu-Pazarları in 1963 (Oyak Corporate, 2011). At this time, private investors in Turkey did not show any interest in investing in the retail sector. Thus, local governments and consumer cooperatives were the driving forces for the second generation of supermarkets in Turkey (Özcan, 2008). While most of these chains failed, some of them were successful. The most important examples are the Tansaş supermarkets, set up by the municipality of Izmir in 1973, and the already-mentioned Gima and Ordu Pazarları (Koç et al., 2008).

The development of modern retail enterprises in Turkey in the phase from 1954 to 1975 is an example of supermarket chains that were founded by state institutions. While comparable developments in other countries were often based on the engagement of central or federal states, the initiative in Turkey was taken mainly by local institutions (although it was supported by the central government) in agglomerations. Furthermore, the early cooperation between the Turkish actors and the Swiss Migros seems to be a unique case. Nevertheless, these state chains paved the way for the private actors. First, they were important contributors to a development in which the consumers in Turkeys' biggest agglomerations got slowly used to modern retail, and thus got amenable to private supermarket chains that entered the Turkish retail stage later. Second, most of them were required by their private (and often transnational) competitors to expand the store networks and to profit from their long-lasting experience in the Turkish market. There are some similarities with the developments in Central and Eastern Europe, where state institutions and state-induced cooperatives were organizing the retail sector.

The developments in the retail sector were accompanied by state efforts to make food wholesale more effective. In 1960, the law for the administration of wholesale markets (law No. 80) came into effect. It gave municipalities the right to open wholesale market halls[2] (Yilmaz, Yilmaz, 2008).

1975–1989 – The low dynamic phase

The second phase has to be characterized as a less dynamic phase in the retail sector. While private capital was still widely reluctant to invest in the retail sector on a large scale, state institutions did not intensify their efforts in the field. Thus – to stick to the wave metaphor – it can be said that this phase was more like a sea without waves, but with a slowly rising water level.

In 1975, the Swiss Migros sold its shares in Migros Türk to Koç Holding, one of the large Turkish industrial corporations. The reasons were political and economic instability, high inflation combined with controlled food prices. Migros in Turkey became Migros-Türk Limited, after an agreement with the Swiss Migros to keep the name Migros (Koç et al., 2008):

"*We pay some royalties because we are using their name… But that is the only relation with them. …From time to time, they want to come to Turkey and we take them and show them our locations. But we do not have to and they do not have to. But we do it since we used to have a link some years ago*" (interview: Supply-chain-solutions Manager of Migros Türk, 2011).

Due to the investment of Koç, Migros became an entirely Turkish company. Koç was the first large Turkish corporation that got involved in the retail business: *"At that date the company was still only an Istanbul-based retailer, with sixteen stores, thirty-two trucks and 707 employees. Most of the equipment and merchandise was old and the facilities were in a dire condition"* (Özcan, 2008, 193). The Koç Holding responded to these challenges with huge investments and the recruitment of new managers. Growth was slow, however, and in the course of the 1980s, Migros Türk lost its role as a model of modernity for the Turkish market, as the owners of the company stuck to the existing formats and strategies. It took until 1988 before the first Migros supermarket was opened outside of Istanbul (in Izmir), and even to 1990 before the first new technological upgrade was implemented (Özcan, 2008).

The slow development of Migros is representative of general developments in the Turkish retail sector. The phase between 1975 and 1989, when no transnational retailers operated in Turkey, had relatively low dynamics in the food retail sector as its main characteristic. The developments were limited to the founding of municipal supermarket chains following the example of Migros, and the slow adoption of the supermarket format by more and more local retailers (learning-by-observation). Examples include Pehlivanoğlu (founded 1980), Kiler (1981) and Beğendik (1986). These developments were already indications of the dynamics that would arise in the 1990s. Processes of liberalization, deregulation and privatization that started after the military coup in 1980 laid a basis for these dynamics. Under the pressure of the International Monetary Fund (IMF), the government started to transform the economy from an import-substituting economy towards a liberal export-orientated one. Furthermore, in 1985, the Turkish government started to stimulate modern retail with the aim to boost tax revenues (Koç et al., 2008).

1990–2003 – The second wave: The rise of transnational corporations

While the first wave brought new actors and innovations to the country, but had little spatial range, the second wave brought not only new actors (TNCs and Turkish corporations) and innovations (e.g. new formats and organizational innovations), but also a growing spatial range. The gradual liberalization that started in the 1980s became an important pull factor for FDI in the Turkish retail sector in the 1990s. Several TNCs got active in Turkey and created new market dynamics. This happened parallel to the first wave of supermarket diffusion identified by Reardon et al. (2003).

In 1990, the German-based Metro Group opened its first Cash & Carry markets (Fig. 2), operating on a wholesale concept and addressing preferably professional customers (hotels, restaurants, catering – HORECA). It took until 1998 before Metro Group opened the first store of its hypermarket division Real: "*We had a very steeply learning curve; we had to do a lot to optimize it. … Understanding the customer's needs and demands, which always differ from country to country, often also from region to region, is crucial for our business' success. So despite all our market research, we continually had to optimize and improve our product range and offer in order to adapt to the Turkish customer*" (interview representative of Metro Group, 2012).

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[2] The law did not include any rules concerning product quality, standardization or prices, but gave the municipalities the right to fill this gap with its own regulations. It took until 1995 before the Government Decree (No. 552) for "Regulation of Trading of Fresh Fruits and Vegetables and Wholesale Markets" regulated product quality, standardization and prices for wholesale markets Turkey-wide (Yilmaz, Yilmaz, 2008).

Carrefour entered the Turkish market in 1991. Since 1996, Carrefour formed a joint venture with the Turkish conglomerate Sabanci Holding under the name Carrefour SA in Turkey. Following the launch of Metro Cash & Carry and Carrefour, numerous transnational, regional and local retail chains became active in Turkey. The Spanish discounter Dia[3] opened its Turkish subsidiaries in 1999. The British Tesco took over the supermarket chain Kipa in Izmir in 2003, and expanded along the west and south coast (Fig. 3).

Although a number of TNCs entered Turkey during this phase, it is noteworthy that a lot of TNCs that were part of the "supermarket revolution" (Reardon, Hopkins, 2006, 522) in Central and Eastern Europe did not enter Turkey (e.g. Aldi, Auchan, Rewe Group, Schwarz Group). They partly (e.g. Aldi, Rewe Group and Schwarz Group) focused their investment and management on expansion in Central and Eastern Europe (e.g. Dries et al., 2004). Others (e.g. Ahold and Delhaize) were also attracted by the opportunities for

Fig. 2: Metro Cash&Carry store in Istanbul (Photo: M. Franz)

Fig. 3: Kipa store in Fethiye. The hypermarkets belong to the UK-chain Tesco (Photo: M. Franz)

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[3] A year later Dia was taken over by Carrefour. Dia in Turkey became a joint venture between Carrefour and Sabanci Holding and operates since then in Turkey under the name DiaSA. In 2011 Carrefour in Spain brought Dia in the stock market (see Table 2). Thus, Dia became once again an independent company based in Spain (Carrefour, 2011).

cheap investments in existing assets in South East Asia in the aftermath of the Asian crisis in 1997 and invested there (e.g. Mutebi, 2007). Furthermore, those who entered Turkey did not advance with the expansion in the market as fast as they did elsewhere (e.g. Carrefour and Metro Group) or entered relatively late (Tesco). This unassertive behaviour of the companies seems to be partly related to political developments: "*Our investment in the Turkish business was done step by step – mainly due to the turbulent political circumstances over the past years*" (interview representative of Metro Group, 2012).

However, in this period, foreign role models were increasingly imitated by Turkish companies in terms of formats, services, product range and marketing techniques (learning-by-observing). In some cases, foreign managers or Turkish managers that had gained experience in TNCs were hired by Turkish companies (learning-by-hiring). The increasing market dynamics, as well as the knowledge transfers after the market entry of TNCs, reflect developments that have been observed for other markets. One characteristic for the developments of the 1990s in Turkey is the increasing diversification of formats, including the introduction of discount stores and hypermarkets. Turkey's first discount chain, BIM, was established in 1995: "*They brought know- how. … Especially BIM changed the way of doing things a lot*" (interview Macromarket format manager of Migros Türk, 2011). BIM is an imitation of the German discount retailer ALDI. The know-how was transferred by consulting a former ALDI manager (learning-by-hiring) and the training of some members of management in Germany. Shortly after, Migros Türk established its own discount brand, named Şok. Besides BIM and Şok, today the major discount chains are Dia SA and A101. In comparison to super- and hypermarkets, discounters have a higher number of branches and wider geographical distribution all over Turkey (Franz and Hassler, 2011). This may be linked to the lower need for capital per store, less infrastructure requirements and the lower potential exit cost. While the success of discounters was bigger than expected, "*the hypermarket concept grew slower than anticipated*" (Planet Retail, 2011, 18). The high investment requirements and the potential exit costs discouraged investors from a stronger engagement in the hypermarket sector.

Besides the format diversification, organizational innovations were also undertaken. For example, credit card payment and customer loyalty cards were introduced. Also noteworthy is the early introduction of on-line grocery retail by Migros Türk in 1999. Starting in 1997, Turkish companies also invested abroad (Migros Türk started in Azerbaijan, later on it invested in Kazakhstan, Russia, Bulgaria, Macedonia and Kirgizia; Gima in Bulgaria and Russia; Koç et al., 2008). They are part of the strong transnational expansion of second-tier retail TNCs identified by Dawson (2007).

2003 – Today – Third wave: diffusion and consolidation

While the main drivers of the second wave were the impacts of policy changes that started in the decade before, the year 2003 brought a change in the politico-economic developments in Turkey that proved to have a great influence on the retail sector. As it also marked a change in the speed and spatial range of the developments, it can be seen as the start of a new wave.

In 2003, the Justice and Development Party (Turkish: Adalet ve Kalkınma Partisi – AKP) won the election as a moderate Islamic and neoliberal party. Under the new leadership, liberalization was taken forward and investors became more confident due to the growing political stability in the country. These political developments, together with the growing purchasing power of consumers in Turkey, had impacts on the retail sector: TNCs intensified their investments (Fig. 4): "*Turkey is one the focus countries for Metro Group in terms of investment and expansion now. We see a huge potential in the Turkish market with its economic growth, demographic structure and the general business-friendly environment*" (interview, representative of Metro Group, 2012).

The growing FDI in the sector was one of the reasons for far-reaching horizontal consolidation processes. Other reasons included the falling margins in the sector, increasing competition at attractive locations and between different formats (supermarket, hypermarket, discounter), and the strategy to buy regionally well-known chains to accelerate expansion, and to avoid problems of embeddedness that potentially would have occurred in organic growth. The consolidation processes took place in a similar manner, but faster than the developments in many parts of North America and Western Europe in the second half of the 20th century. Migros Türk took over the local or regional chains Tansaş (2005), Maxi (2008) and Yonca (2009). CarrefourSA acquired the chains Gima (2005, including Endi discount stores which became part of DiaSA) and Pınar Marketçilik (2009). The Kiler Group bought Canerler Marketler (2005), Güler Market (2006), Karıncalar (2007), and a number of stores from the struggling competitor Yimpaş. Makromarket bought Nazar (2007), Afra (2008), Kaya and Eras (2009) and merged with Uyum (2007) (Koç et al., 2008; company websites).

However, there is still a confusing amount of local and regional chains and the top five players only hold a market share of less than 10 percent (Planet

Retail, 2011, 23). As the head of the association of Turkish food retailers, Perder, stated in an interview, over 450 locally and regionally operating grocery retail chains are present: "*You can see local brands you have never heard of dominating the market against certain international huge success stories*" (interview, representative of a food wholesale company, 2011). Many of the locally and regionally operating chains copy the strategies of discounters. On the other hand, they introduce high-end formats. In general, a trend of

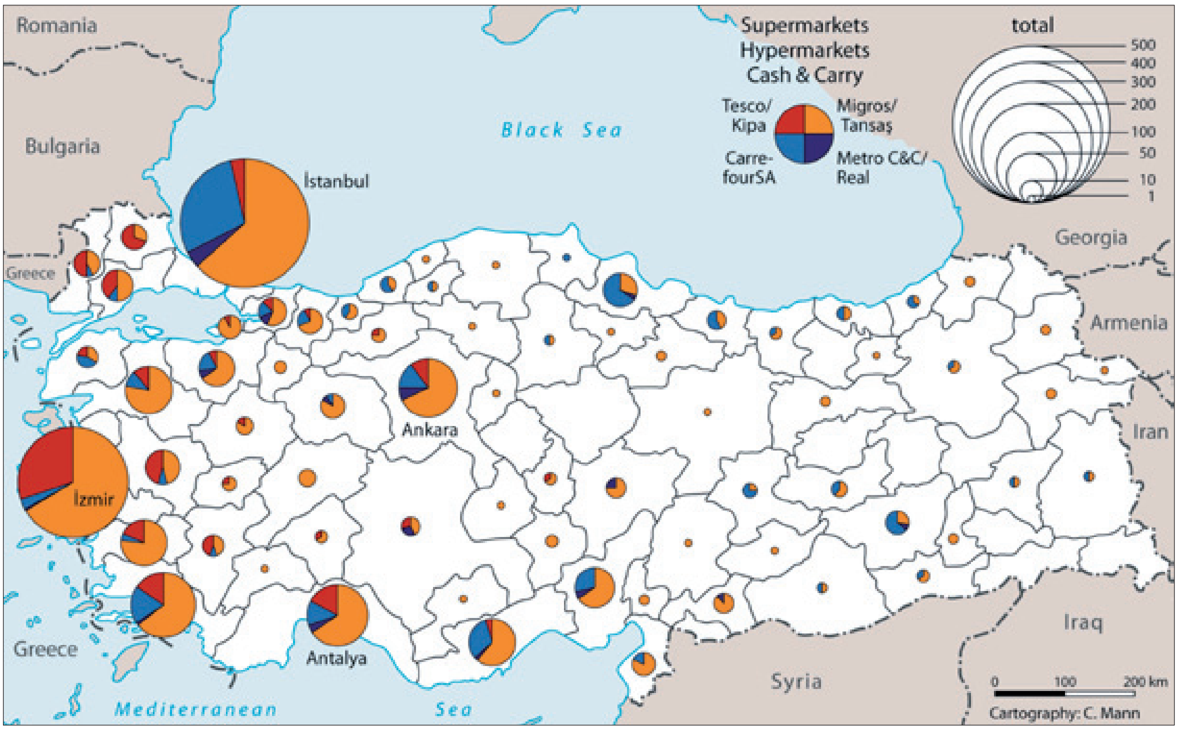

Fig. 4: The spatial diffusion of supermarkets, hypermarkets and cash & carry markets of selected companies in Turkey in December 2012
Sources: company websites, elaboration: C. Mann

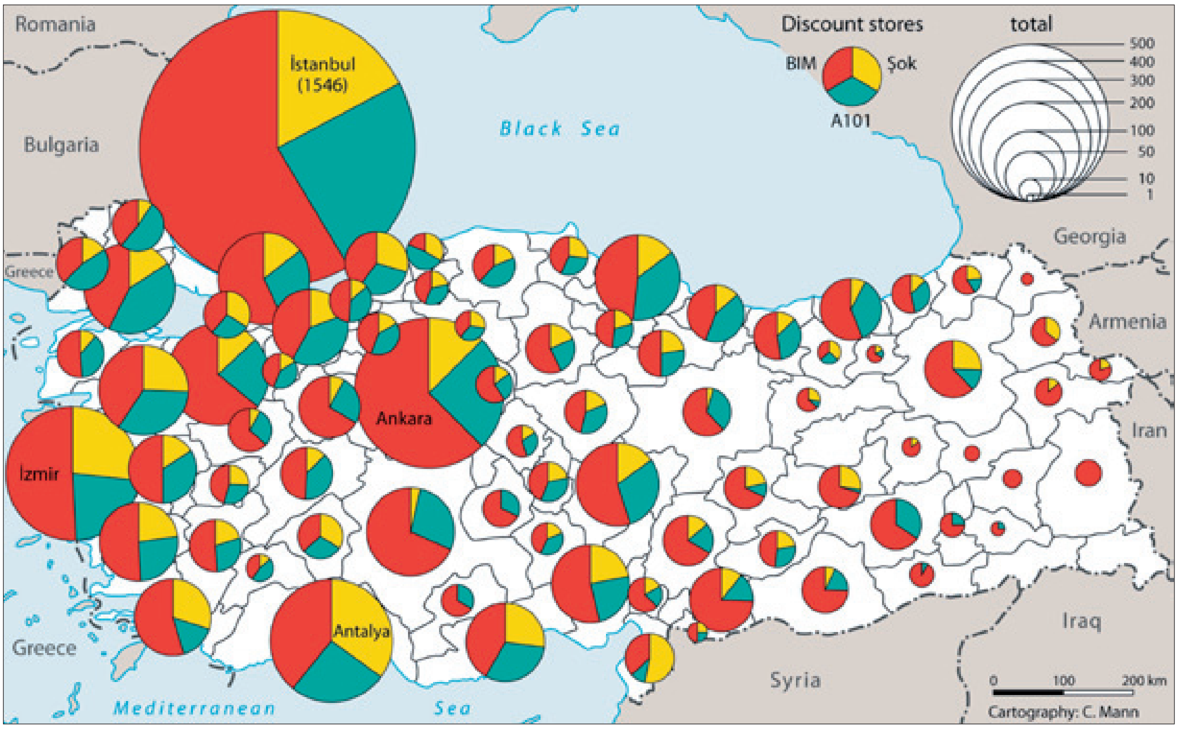

Fig. 5: The spatial diffusion of the three largest discount store chains in Turkey in December 2012
Sources: company websites, elaboration: C. Mann

chaining-up of smaller actors can be identified: "*Local traditional one-spot retail markets … have a tendency to organize up … either by themselves by branching up or joining forces with others in that manner*" (interview, representative of a food wholesale company, 2011). These developments include a harmonization of the product as well as the process knowledge between TNCs, Turkish corporations and regional players by observation and strong employee mobility between the different companies. One new development of this phase is the development of retail cooperatives in which small retailers unite to keep a competitive basis. The first one was founded in 2006 in Inegöl (Bursa region).

While new actors are entering the retail scene, others are leaving it. Huge business conglomerates reorganize themselves and sell their shares to retail companies because of the falling margins (Karadağ, 2010). Thus, Koç sold the majority of its shares in Migros Türk in 2008 to the British private equity fund BC Partners. Migros became the new name Migros Ticaret. Three years later BC Partners sold the Migros Ticaret discount chain Şok to Ülker: "*It's a strategic decision. They want to focus on the supermarket and hypermarket issue. The discount issue is very different from the supermarket issue … (It's) not a sales operation but a logistics operation*" (interview with manager of Şok, 2011).

During the 2000s, modern formats diffused into smaller agglomerations, similar to the third wave described by Reardon et al. (2003). Among those were cities highly frequented by tourists, as well as areas with increasing economic activity and thus a rising amount of people in the middle-class income group. Table 1 gives an overview of the top five grocery retailers, Figure 4 and 5 give an overview of the diffusion of the most important retail companies. It can be seen that there is still a stronger distribution of the stores in the west of the country.

Due to economic development, reforms and changes in consumer demand (Reardon et al., 2003, 1141), hypermarkets grew quickly after 1999 in large cities (there are no general size restrictions for retail stores in Turkey which would limit the expansion of hypermarkets): "*Here consumers are more aware of international trends, have higher disposable incomes and have automobiles to travel to and from the stores. However, it is not easy for the sector to expand at a high speed: in many cases the search for large sites cause [sic] substantial difficulties owing to administrative hurdles*" (Planet Retail, 2011, 18). The diffusion of super- and hypermarkets was and is sometimes accompanied by the development of shopping malls: "*… many large supermarkets encourage purpose-built shopping centre developments (such as Migros in Istanbul's Atrium shopping centre or Begendik in Istanbul's Carrousel shopping centre), or play a more direct role in the development of their own shopping centres (such as Carrefour in Istanbul's Carrefour shopping centre and Migros in Migros shopping centre in Beylikdüzü, Istanbul)*" (Tokatli and Boyaci, 1998, 354). In 2009, there were 236 Shopping Centres in Turkey (PWC Turkey, 2011, 112).

Discount stores in Turkey, already established in the previous phase, were also successful (Fig. 5 and Tab. 2). They increasingly put pressure on the other formats with cheap prices, a close-meshed net of markets, and an aggressive and early expansion into new locations. Thus, many companies seem to put more efforts on the expansion of their discount formats than on hypermarkets (Planet Retail, 2011). This shows that there is great potential in emerging markets for a format that is not confined to the middle- and upper-income groups. This is affirmed by the successful expansion of the Turkish discount chain BIM in Morocco with 110 stores at the end of 2012 (BIM 2013, 3). Both formats, hypermarkets and discounters, are important product-based innovations that have spread with different intensity. Due to the differences in catchment areas (huge catchment areas for hypermarkets), investment needs (lower investment

Company	Country of origin	Number of Outlets	Total Sales Area SQM	Average Sales Area SQM	Grocery Retail Banner Sales (EUR)
BIM	Turkey (investors from USA and Saudi Arabia)	2,951	1,215,812	412	3,013,659,522
Migros Ticaret	Turkey (owned by British investment fond)	1,902	939,845	494	2,729,859,601
CarrefourSA (incl. DiaSA)	France and Turkey (joint venture)	1,138	579,360	509	1,276,416,890
Metro Group	Germany	31	275,200	8,877	944,156,429
Tesco	UK	121	286,332	2,366	598,200,600

Tab. 1: Top five grocery retailers 2010
Source: Planet Retail, 2011, 25

Year	Supermarkets, hypermarkets, cash & carry markets				Discount store chains			
	CarrefourSA	Metro Cash & Carry and Real	Migros and Tansas	Tesco/Kipa	A101	BIM	DiaSA	Şok
2010	248	31	1,902*	121	No data	2,951	890	No data
2012	242	40	852	188	1,784	3,556	1,093	1,217

Tab. 2: The number of outlets of selected companies in Turkey in 2010 and 2012
*Sources: Planet Retail, 2011, 25 and company websites. Note: *including Şok*

per store for discounters), risks (higher potential exit costs for hypermarkets) and target groups (higher income groups for hypermarkets), discounters have reached higher quantities and are already successful in smaller and less developed cities of Turkey (Fig. 5).

As the chains of large retail companies reach more parts of Anatolia, new challenges await their distribution networks. While, for a long time, the distribution networks were focused on the western part of Turkey, the companies now have to bridge long distances in Central and Eastern Anatolia. This is a challenge for the food processing companies, too. Until now, they were mostly concentrated in the Istanbul region and not adjusted for country-wide distribution. Thus, a further diffusion of process-based knowledge can be expected. The situation concerning the large suppliers of fruits and vegetables is not improved: "*At Metro Cash and Carry in general we source over 90% of our products from local suppliers … However, this has been quite a challenge in Turkey because in the past most of the Turkish suppliers, especially the ones offering good quality, focused much more on export than on building a national distribution network. It is only a recent trend that Turkish companies are trying to really focus on establishing a proper country-wide distribution network in order to meet growing demand and quality requirements*" (interview, Supply Chain Manager of Metro Cash & Carry, 2012).

Further changes could happen in the aftermath of an expected further liberalization of food wholesale, which is desired by many modern retailers. It has often been argued that the existing marketing system, which dictates the trade in wholesale markets, is protecting the role of intermediaries and disadvantages producers and consumers (Yilmaz, Yilmaz, 2008).

Although the growth of modern retail companies is partly happening very fast (Tab. 2), the traditional retail formats still have a dominant role in the Turkish food retail sector. This is especially true in rural areas and small towns, as the presence of supermarkets, hypermarkets and discounters is limited there (Planet Retail, 2011). The east still dwells on agriculture and largely suffers from its remoteness. However, those are the areas which are increasingly targeted by retail companies: "*New, fast-growing economic centres have developed [in the central and eastern parts of Turkey], some of which show even better economic growth rates than the rest of the country. Among these, new industrial and economic centres are for example Kayseri, Adana, Diyarbakır, Gaziantep and many others. So … if you want to do further expansion in Turkey, you have to move further to the east*" (interview, Board Member of Metro Cash & Carry Turkey, 2012).

While there are still some untapped potentials in the east, the competition is generally getting stronger and margins are narrowing due to high competition and consumers' strong price-sensitivity (Euromonitor International, 2011).

Promoting on-line shopping, which is a product as well as a process-based innovation in the food retail sector, turns out to be one strategy to face the falling margins and can contribute to further growth and outreach. Especially, the increasing spread of mobile internet devices such as smart phones or tablet PCs, can mobilize customers to adopt new channels. Already, posters of store shelves have been set up by Migros to make customers aware of on-line shopping possibilities. The customers can directly scan products QR codes from the posters and place their order online. It seems that for parts of the Turkish society, material supermarkets may only be a short interlude between traditional retail and on-line shopping.

5. Conclusions

To categorize the global diffusion of supermarkets, the picture of waves rolling along is often used. However, this simplifying metaphor clouds the developments in different countries hit by these supermarket waves, which are much more differentiated. In general, the case of Turkey shows that the development of different phases or waves of the diffusion of retail innovation inside one country can be driven by a variety of interwoven factors, including institutional, economic and cultural aspects. At the level of state institutions, the development includes direct investments of state institutions in the retail sector, direct incentives for retail companies like subsidies and courting for FDI, as well as indirect incentives (liberalization, deregulation). Furthermore, the political stability in a country can spur developments in the retail sector. From the economic perspective, economic growth, grades of competition, transfer of knowledge from other markets and capital availability seem to be the main factors. Growing demand is not only a consequence of higher incomes, but also of cultural changes, for example in family structures.

This case study of the development of the Turkish retail sector from the 1950s shows how the so-called supermarket revolution was based on short waves of innovations, changing actor constellations, and a growing spatial range of the diffusion of modern retail formats.

Major development trends are listed as follows:

- 1954–1975: State institutions which are normally active on different scales (municipalities, state-owned banks, state agencies, army, etc.) played a major role in the introduction of modern retail, as they established new retail companies and attracted the Swiss Migros to transfer knowledge to Turkey;
- 1975–1989: The phase in which no TNCs operated in Turkey, and thus had low dynamics in the Turkish grocery retail sector. Developments were limited to the founding of state and cooperative supermarket chains in urban agglomerations, and the slow adoption of the supermarket format by local retailers (learning-by-observing). The retail knowledge that was imported in the previous phase diffused in Turkey, but the transfer of new retail knowledge into the country was very limited;
- 1990–2003: The advent of retail TNCs in Turkey sparked new dynamics in the sector. However, the TNCs were still not assertive in their investments mainly due to the absence of political stability in the country. Nevertheless, foreign role models were increasingly copied by Turkish companies and a strong differentiation of retail formats (supermarkets, hypermarkets, discounters) changed the Turkish retail landscape (learning-by-observing and learning-by-hiring); and
- Since 2003: The stronger political stability, combined with neo-liberal policies, acted as a pull factor for FDI. FDI, falling margins, increasing competition at attractive locations and between different formats, resulted in market consolidation. However, Turkey is still characterized by a highly fragmented retail landscape.

The first, third and fourth phase can be considered as different short waves not only of investments and supermarket diffusion, but also of knowledge transfer. Current developments can be a sign that a new wave is on its way: the wave of grocery e-commerce.

The different phases also had different impacts on the supply systems. While the impact was still low during the first two phases (first short wave, phase of low dynamics), it was growing fast during the second short wave. However, it was still limited to the development of food processing and logistics, mainly in Istanbul and partly in other large agglomerations.

Nevertheless, most large fresh food suppliers were strongly focused on export. In the course of the third wave, the pattern changed. The Turkish retail sector was an increasingly attractive buyer for big suppliers and the demand spreads from Istanbul and the western part of Turkey to most of the country. Suppliers react with the development of new distribution networks, which are adequate to supply their goods to retailers all over the county.

This case study shows that state and cooperative retail chains paved the way for private actors, while most studies about the modernization of the retail sector have a strong focus on private companies or – even more specifically – on transnational corporations. Until 1990, state institutions and cooperative actors were the key drivers of retail innovations in Turkey. Later, the entry of transnational corporations in the market – headed by Metro Group and Carrefour – strongly influenced the Turkish retail scene, not only because of their own economic activities but also because they functioned as role models for other retailers.

Generally, the institutional changes that spurred developments in the retail sector during the last centuries can be seen as an example of changes in times of a neo-liberal policy agenda (Karadağ, 2010). As Karadağ (2010, 29) emphasizes: "*Similar regime dynamics and patterns of legitimization exist in other countries and regions that have experienced the transformation and retrenchment of the state, for example, in Latin America and Southeast Asia. Elites in oligarchic settings face the challenge of political contestation in highly fragmented configurations*".

However, there are not only similarities with other countries at an institutional level, but also concerning the developments in the retail sector itself. In Central and Eastern Europe, state institutions and state-induced cooperatives were organizing the retail sector before 1990, although in a much more extensive way too. These retail chains also paved the way for private actors, who took over their businesses in many cases after 'liberalization'. However, in most countries of Central and Eastern Europe, the spatial diffusion of supermarkets, hypermarkets and discounters happened much faster after 1990 than in Turkey (see e.g. Dries et al., 2004).

References:

BIM (2013): Annual Report 2012 [online]. [cit. 07.10.2013]. Available at: URL: www.bim.com.tr/english/Uploads/dosyalar/1_12591379_bim_eng_2012.pdf

BROWN, S. (1987): Institutional Change in Retailing: A Review and Synthesis. European Journal of Marketing, Vol. 21, No. 6, p. 5–36.

BURT, S., DAVIES, K., DAWSON, J., SPARKS, L. (2008): Categorizing patterns and processes in retail grocery internationalisation. Journal of Retailing and Consumer Services, Vol. 15, No. 2, p. 78–92.

CARREFOUR (2011): Carrefour acquires 100% of Dia from its subsidiary Norfin Holder S. L. prior to the distribution of the Dia shares by Carrefour [online]. [cit. 05.10.2011]. Available at: URL: www.carrefour.com/docroot/groupe/C4com/Pieces_jointes/Communiques_financiers/2011/DIACOMMUNIQUE01072011UK.pdf

COE, N. M. (2004): The internationalization/ globalisation of retailing: towards an economic geographical research agenda. Environment and Planning A, Vol. 36, p. 1571–1594.

COE, N. M., HESS, M. (2005): The internationalization of retailing: implications for supply network restructuring in East Asia and Eastern Europe. Journal of Economic Geography, Vol. 5, No. 4, p. 449–473.

COE, N. M., WRIGLEY, N. (2007): Host economy impacts of retail TNCs: the research agenda. Journal of Economic Geography, Vol. 7, No. 4, p. 341–371.

CURRAH, A., WRIGLEY, N. (2004): Networks of organizational learning and adaptation in retail TNCs. Global Networks, Vol. 4, No. 1, p. 1–23.

DAWSON, J. A. (2007): Scoping and conceptualising retailer internationalisation. Journal of Economic Geography, Vol. 7, No. 4, p. 373–397.

DE ROCHA, A., DIB, L. A. (2002): The entry of Wal-Mart in Brazil and the competitive responses of multinational and domestic firms. International Journal of Retail and Distribution Management, Vol. 30, No. 1, p. 61–73.

DRIES, L., REARDON, T.; SWINNEN, J. F. M. (2004): The Rapid Rise of Supermarkets in Central and Eastern Europe: Implications for the Agrifood Sector and Rural Development. Development Policy Review, Vol. 22, No. 5, p. 525–556.

EUROMONITOR INTERNATIONAL (2011): Retailing – Turkey. London.

FRANZ, M. (2010): The role of resistance in a retail production network: protests against supermarkets in India. Singapore Journal of Tropical Geography, Vol. 31, No. 3, p. 317–329.

FRANZ, M., HASSLER, M. (2011): Globalisierung durch Supermärkte – Transnationale Einzelhändler in der Türkei. Geographische Rundschau, Vol. 63, No. 5, p. 28–34.

HAMMER, I., BECK, S., GLÜCKLER, J. (2012): Lernen im lokalen Unternehmensnetzwerk: Imitation zwischen Konvention und Tabu. In: Glückler, J., Dehning, W., Janneck, M., Armbrüster, T. [eds.]: Unternehmensnetzwerke. Architekturen, Strukturen und Strategien. Heidelberg: Unternehmensnetzwerke – Architekturen, Strukturen und Strategien. Heidelberg, Springer, p. 163–182.

HOCHSTRASSER, C. H. (1968): Opportunities and responsibilities of retailers around the World. Journal of Retailing, Vol. 44, No. 1, p. 38–44.

HUMPHREY, J. (2007): The supermarket revolution in developing countries: tidal wave or tough competitive struggle? Journal of Economic Geography, Vol. 7, p. 433–450.

KARADAĞ, R. (2010): Neoliberal Restructuring in Turkey – From State to Oligarchic Capitalism. MPIfG [Max Planck Institut für Gesellschaftsforschung] Discussion Paper 10/7. [online]. [cit. 23.04.2012]. Available at: URL: www.mpifg.de/pu/mpifg_dp/dp10-7.pdf, 23.4.2012.

KOÇ, A. A., CODRON, J.-M., TEKELIOĞLU, Y., LEMEILLEUR, S., TOZANLI, S., AKSOY, Ş., BIGNEBAT, C., DEMIRER, R., MENCET, N. (2008): Agrifood Sector Studies – Restructuring of Agrifood chains in Turkey: The produce Sector (A). In: Regoverning Markets – Small Scale Producers in modern Agrifood Markets. [online]. [cit. 05.10.2011]. Available at: URL: www.regoverningmarkets.org/en/filemanager/active?fid=743

KULKE, E. (2011): Internationalisierung des Einzelhandels – das Beispiel IKEA. Geographische Rundschau, Vol. 63, No. 5, p. 12–19.

KULKE, E., PÄTZOLD, K. [eds.] (2009): Internationalisierung des Einzelhandels – Untersuchungsstrategien und Anpassungsmechanismen. Geographische Handelsforschung 15, Passau.

MALMBERG, A., MASKELL, P. (2002): The elusive concept of localization economies: Towards a knowledge-based theory of spatial clustering. Environment and Planning A, Vol. 34, p. 429–449.

MUNIZ-MARTINEZ, N. (1998): The internationalisation of European retailers in America: the US experience. International Journal of Retail and Distribution Management, Vol. 26, No. 1, p. 29–37.

MUTEBI, A. (2007): Regulatory Responses to Large-format Transnational Retail in South-East Asian Cities. Urban Studies, Vol. 44, No. 2, p. 357–379.

OYAK CORPORATE (2011): Corporate History 1961–1970 [online]. [cit. 29.08.2011]. Available at: URL: www.oyak.com.tr/EN/corporate/corporate-history/1961-1970.html

ÖZCAN, G. B. (2008): Surviving through transplantation and cloning: The Swiss Migros hybrid, Migros-Türk. In: Smith, C. [ed.] Remaking Management. Cambridge: Cambridge University Press, p. 181–205.

PLANET RETAIL (2011): Country Report Turkey. London.

PWC TURKEY (2011): Shining Star – The Effects of the Retail Industry on the Turkish Economy. Istanbul: PWC Turkey.

REARDON, T., HOPKINS, R. (2006): The supermarket revolution in developing countries: policies to address emerging tensions among supermarkets, suppliers, and traditional retailers. European Journal of Development Research, Vol. 18, No. 4, p. 522–545.

REARDON, T., MINTEN, B. (2011): Surprised by supermarkets: diffusion of modern food retail in India. Journal of Agribusiness in Developing and Emerging Economies, Vol. 1, No. 2, p. 134–161.

REARDON, T., TIMMER, P., BARRRET, C. B., BERDEGUE, J. (2003): The rise of supermarkets in Africa, Asia, and Latin America. American Journal of Agricultural Economics, Vol. 85, No. 5, p. 1140–1146.

REARDON, T., TIMMER, P., BERDEGUE, J. (2004): The Rapid Rise of Supermarkets in Developing Countries: Induced Organizational, Institutional, and Technological Change in Agrifood Systems. Electronic Journal of Agricultural and Development Economics, Vol. 1, No. 2, p. 168–183.

ROMO, G. D., DIGAL, L., REARDON, T. (2009): The Transformation of Food Retail in the Philippines. Asian Journal of Agriculture and Development, Vol. 6, No. 2, p. 51–84.

SENGUPTA, A. (2008): Emergence of modern Indian retail: an historical perspective. International Journal of Retail & Distribution Management, Vol. 36, p. 689–700.

SONG, J., ALMEIDA, P., WU, G. (2003): Learning–by–Hiring: When Is Mobility More Likely to Facilitate Interfirm Knowledge Transfer? Management Science, Vol. 49, No. 4, p. 351–365.

SZCZYRBA, Z., KUNC, J., KLAPKA, P., TONEV, P. (2007): Difúzní procesy v prostředí českého maloobchodu. Regionální studia, Vol. 1, No. 1, p. 8–12.

TACCONELLI, W., WRIGLEY, N. (2009): Organizational challenges and strategic responses of retail TNCs in post-WTO-entry China. Economic Geography, Vol. 85, p. 149–173.

TOKATLI, N., BOYACI, Y. (1998): The changing retail industry and retail landscapes – The case of post-1980 Turkey. Cities, Vol. 15, No. 5, p. 345–359.

WRIGHT, P. C., ROY, G. (1999): Industrial espionage and competitive intelligence: one you do; one you do not. Journal of Workplace Learning, Vol. 11, No. 2, p. 53–59.

WRIGLEY, N. (2000): The globalization of retail capital: themes for economic geography. In: Clark, G. L., Feldman, M. P., Gertler, M. S. [eds.]: The Oxford Handbook of Economic Geography. Oxford, Oxford University Press, p. 292–313.

YAVAN, N. (2010): The Location Choice of Foreign Direct Investment Within Turkey: An Empirical Analysis. European Planning Studies, Vol. 18, No. 10, p. 1675–1705.

YILMAZ, S., YILMAZ, I. (2008): Evaluation of the wholesale market system for fresh fruits and vegetables in Turkey: A case study from Antalya Metropolitan Municipality. New Zealand Journal of Crop and Horticultural Science, Vol. 36, No. 2, p. 85–95.

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THE COMPETITIVENESS OF THE LONG-DISTANCE PUBLIC TRANSPORTATION SYSTEM IN SLOVAKIA

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Abstract

The long-distance public transport services among the eight regional centres of Slovakia, representing the key urban locations with concentrations of most of the country's services, including business, educational and financial institutions, as well as political power, are examined in this article. It is assumed that the mutual transport interconnections within this group of cities will be a focus for public transport operators in their attempt to gain the largest possible share of potential customers, passengers who would otherwise be users of individual transport means. Hence, one of main aims of this study is to compare public and individual transport modes, and the possibilities offered by them in the mutual interconnections of major regional centres in the country.

Shrnutí

Konkurenceschopnost systému dálkové veřejné dopravy na Slovensku

Předkládaná studie věnuje pozornost dálkovým spojům veřejné dopravy, které spojují osm regionálních metropolí Slovenska. Ty představují rozhodující městská centra a koncentrují ekonomické, vzdělanostní a finanční aktivity i politickou moc v zemi. Práce vychází z předpokladu, že vzájemné propojení těchto metropolí bude středem pozornosti provozovatelů veřejné dopravy ve snaze získat co největší počet potenciálních zákazníků – cestujících, kteří by jinak využili osobní automobil. Proto je jedním z hlavních cílů studie srovnání veřejné a individuální osobní dopravy a možností, které nabízejí ve vzájemném propojení klíčových regionálních center země.

Key words: *long-distance transport, public transport, individual transport, regional centres, Slovakia*

1. Introduction

From the spatial perspective, the public transport system represents an extremely complicated network of links. Although partly subsidized by central, regional or local authorities, the routing and frequency of links and particular services should be optimized to gain a maximum number of passengers and to guarantee the sustainability of public transport as an alternative to individual passenger car transportation. Bussieck (1998), Borndörfer et al. (2007) and others suggest that planning public transport lines should guarantee services, the quality of which is given not only by reasonable cost of travel, safety and convenient means of transport, but also by the quality of lines and schedules.

Mobility trends in Slovakia appear to resemble those in Western Europe where individual transport has a strong position, especially in rural areas with poor public transport networks. In European long-distance transportation, however, the position of public transport is much stronger and still growing (as demonstrated by Paulley et al., 2006), strengthened by intensive political and financial support for high-speed train systems. This is shown explicitly by numerous studies, for example, Couto and Graham (2008) or Lopéz-Pita and Robusté (2005). Deregulation processes in the sector of bus transport services play a role, too. These trends are apparent even in the Slovak Republic, where the process of railway network modernization lags and deregulation has to some degree led to a gradual relative improvement of the services of public transport operators, especially if long-distance and international transport services are considered (see Pšenka, 2011; Michniak, 2007).

With the improvement of Slovakia´s road networks and vehicle stock, providers of public transport services will soon have to cope with new challenges. Except for the competitiveness between particular modes of transport, as well as public transport companies, the position of passenger cars is apparently strengthening (see Fig. 1).

Taking into consideration long-distance transportation, the growing network of motorways in Slovakia shortens the travel time between particular regional centres,

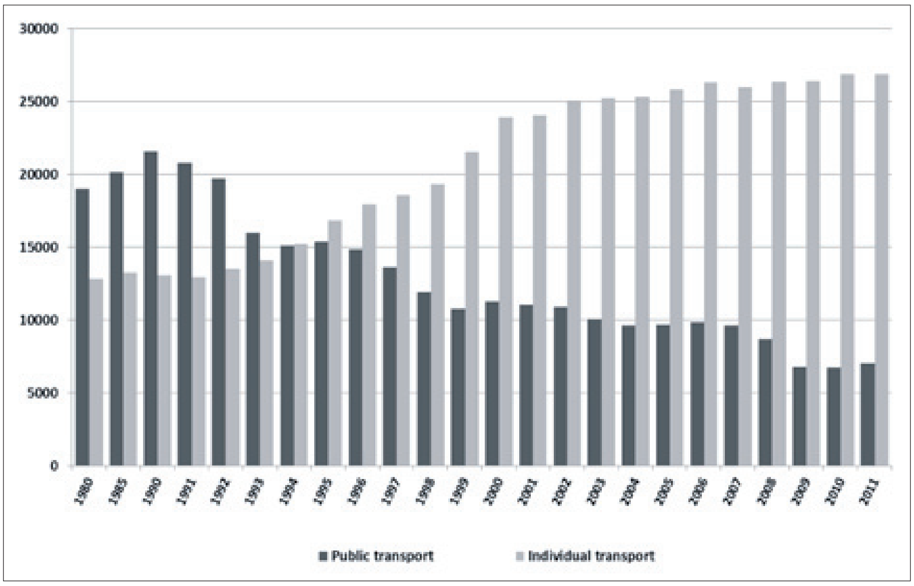

Fig. 1: Public transport and individual transport performance (in million passenger-km) in Slovakia
Source: Statistical Office of the Slovak Republic (Slovstat database)

which affords advantages for bus companies and users of passenger vehicles. This is supported by the fact that the modernization of key railway corridors in the country (up to the standard of 160 km.h^{-1}) has been belated so far, and at this moment there is only a short part of the railway network in Slovakia where express trains can travel at standard European speed.

In this research project we analyse the time quality of mutual connections between eight major regional centres of Slovakia in the public transport network (both trains and buses), based on travel times (expressed as a simple measure of accessibility), and on the frequency of connections (for locations of the cities – see Fig. 4). The selected eight regional centres (Bratislava, Trnava, Nitra, Trenčín, Žilina, Banská Bystrica, Prešov and Košice) play a crucial role in the regional and settlement structure of Slovakia as administrative, political, financial and economic cores of eight self-governing regions. From a geographical point of view, however, they do not represent transport cores of the respective self-governing regions and their intra-regional transport accessibility is not always perfect (see Michniak, 2006). As shown by numerous studies by Czech transport geographers, there is a strong relationship between the hierarchy of settlements, position in the administrative system of the country and their transport hierarchy (e. g. Marada et al., 2010; Kraft and Vančura, 2009; Kraft, 2012). Also, some Polish studies underline the importance of location and transport accessibility in the development of large cities (Cudny, 2011; Cudny, 2012; Jakóbczyk-Gryszkiewicz, 2011; Stepniak and Rosik, 2013).

Favourable location and the growing road network attract developers and are among important factors of economic development. To evaluate the change in public transport network competitiveness over time, we analyse travel times estimated for travel by passenger cars for the same interconnections. Because the infrastructure of railways and roads, as well as the public transport network serving long-distance travel, are subject to permanent change, our intention is also to show how the parameter of travel times by public and individual transport has changed in Slovakia since the collapse of the socialist regime in 1989.

The principal aim of this paper then is to evaluate selected attributes of mutual transport interconnections among eight regional centres in Slovakia (Bratislava, Trnava, Nitra, Trenčín, Žilina, Banská Bystrica, Prešov and Košice), with respect to the spatial (Slovak territory) and temporal (for the years 1989, 1999 and 2011) aspects of transportation. The investigation is focused on a comparative analysis of public (both bus and railway) and individual transportation, with respect to the networks connecting the selected centres.

2. The changing roles of public and individual transport in Central Europe

Although 'glorified' for the high shares of public transport compared to passenger cars in the passenger transport modal split at the beginning of the 1990s, Central and Eastern European countries have failed to maintain this "positive" trend due to several factors. These include the growing unemployment rate, changing living standards, and somewhat dubious governmental transport policies (Pucher and Buehler, 2005). New EU member countries (accessed in 2004 and later) have witnessed a considerable decrease in the role of public transport in the total performance of passenger transport, which is contrasted to the trends visible in most of the EU-15 member states. From 2000 to 2008, the percentage of passenger cars (of total inland passenger-km) in the EU-27 recorded only a slight change – from 83.1% to 83.3%. In Slovakia, this proportion grew from 67.9% to almost 75%; in the Czech Republic from 73.2% to 76%; in Poland from 72.8% up to 85.5%; and in Slovenia from nearly 83% to over 86% (Europe in Figures, 2011). Due to the turbulent development of transportation systems in the transition societies of Central and Eastern Europe, and the strong impacts that these changes have brought in the modal split of passenger transport, the struggle between individual and public transportation systems in these countries has become a subject of numerous scientific studies.

The volatile modal split and problems stemming from the increasing dominance of individual transport appear to be considered as the crucial issues of passenger transport sector development trends in the transition societies of Central Europe. Dolinayová's (2011) research on the determinants of passengers´ decisions on transport mode in the Slovak Republic claims that increasing car-ownership and utilisation of passenger cars result from "new" consumer preferences, but on the other hand they induce road congestions, insufficient parking capacities, air and noise pollution, accidents and fatalities (Pucher and Buehler, 2005). These negative impacts are very much a consequence of underdeveloped road networks in post-socialist countries, as presented by Komornicki (2005) or Horňák (2004).

The economic background of public transport and the system of subsidies for regional transportation became unstable in the 1990s (for details see Van de Velde, 2009), which led to reduced frequency and impaired performance of train and bus services. As far as regional transportation (covering daily commuting) is concerned, the transformation of local labour market structures subverted the regular commuting flows set long before the collapse of the socialist regimes. The growing motorisation of the population and rising prices of regional public transport services led to a decreasing use of regional public transport services, which negatively affected the frequency of the services. This, in turn, leads to a higher dependence on cars, which appears as a serious problem in the less populated areas of Central Europe, where car ownership gradually becomes a necessary condition for life - the so-called "vicious circle" of rural transport, as defined by Nutley, 1998. Similar studies are reported for central-European cases: see Džupinová et al., 2008; Horňák and Džupinová, 2009; Komornicki, 2008; Marada and Květoň, 2010; Marada et al., 2010; and Boruta and Ivan, 2010. Considering the above-mentioned factors, Ivan (2010a, 2010b) applied commuting distance and commuting price to develop a comparison between individual and public transport modes in some Czech regions, suggesting that carpooling might be a solution for commuting and could compensate for decreasing performances and the rising prices of public transport services. This approach to daily commuting may well apply to long-distance travel, too.

Long-distance public transport, however, might offer more opportunities for public transport providers than regional passenger transport. Comfort, travelling speed and additional services make the long-distance (sometimes called "inter-urban" or "inter-regional" transport) public transport still quite attractive, as claimed by Steg (2003). For this segment, high-speed railways in particular may offer a convincing alternative, as a rival predominantly to air transportation (Lopéz-Pita and Robusté, 2005). Nowadays, the post-industrial society induces "more frequent and longer distance inter-urban and regional transport", as stated by Charlton and Vowles (2008). In Slovakia, long-distance trips in the public transport networks are not defined strictly: the law only delimits a minimum of 100 km from the initial to terminal station for long-distance bus links, to distinguish between subsidized regional transport (up to 100 km) and the commercial long-distance public-transport links (Act No. 56/2012 Coll. on Road Transportation). For the purposes of our analyses, all relevant services (see Methods, below) explicitly defined as long-distance services in bus and train travel schedules, were taken into account.

Slovakia belongs to the group of European countries with the lowest share of passenger-car transport, yet it heads towards the EU-27 average values and the trend towards an increasing predominance of passenger cars seems to be irreversible (Fig. 1). Faith (2008) observed that the increasing economic performance of the Slovak economy and thus the rising standard of living of Slovak residents, positively influence the utility rate of passenger cars. This results in the fact that the passenger car gradually becomes dominant in long-distance transfers, as well as in intra-regional and urban transport.

Fig. 1 shows that in terms of transport performance, the passenger car has no more serious rival in the country's passenger-transport market. On the other hand, the public transport system still plays a crucial role in the mobility of people who search (daily or occasionally) for an alternative to a passenger car, or who (for various reasons) cannot afford using a passenger car. However, a matter for discussion might be what is behind the human decision leading to the use of a certain means of transport and what factors affect the rate of passenger car use. Numerous scientific studies (including Van Vugt et al., 1995; Marada et al., 2010; Dolinayová, 2011) show that it is almost impossible to predict a human's decision for a certain transport mode. Van Vugt et al. (1995) apply a set of preferences such as social value orientation, day of travel, expectations on others' commuting choices, and congestion to judge an individual's decision. Dolinayová (2011) applies an approach specific for Central European transition societies and differentiates between economic characteristics of residents (unemployment rate, average salary, motorisation rate) and qualitative attributes of transport modes (fees, accessibility of public transport, travelling comfort, timetable co-ordination, etc.). As shown by Limtanakool et al. (2006) who analysed attributes of long-distance travel (trips of 50 km and over) in the Netherlands, there might be a difference in the weights of individual factors depending on the territorial scale and purpose of travel. According to this study, the passenger car is absolutely dominant in medium- and long-distance business trips, while the propensity of using public transport is higher for leisure trips. In the case of both leisure and business travel, a higher share of travelling by car was detected in households with better passenger car availability. The fact that women tend to use public transport while men travel by passenger car, is not very surprising.

No study has been carried out in Slovakia specifically focused on factors affecting long-distance travellers' preferences. Similarly, there are no statistics revealing the modal split of long-distance trips made in Slovakia. We can only assume that trains are more attractive for longer distances and longer inland trips than buses. Data on passenger-transport volumes and performances in Slovakia (according to the database of the Statistical Office of the Slovak Republic) clearly show two crucial facts related to passenger-transport modal split. First, bus transport has a stronger position in both volume (number of passengers) and performance (number of passenger-kilometres). In 2011, for example, the share of railways in the total number of passengers reached 2%, while as many as 11% of passengers travelled by bus. Secondly, the position of railways is relatively stronger in passenger-transport outputs. As of the same year, bus transport still took a larger share (over 13%) of the total amount of passenger-kilometres, but the share of railways was relatively greater (up to 7% of the total passenger-transport output in the country) than in the passenger volumes. In other words, passengers make longer trips by trains rather than by buses (on average it was 51 km by trains, but only 15 km by buses in 2011). However, no specific data are available on long-distance bus and train links.

3. Methods

Assuming that the principal interregional public transport outputs take place among the group of the largest urban cores of a country, in this research we focused on a group of eight cities of the Slovak Republic (in terms of their population size in 2011). These eight cities represent the regional centres of eight self-governing regions (centres of NUTS III) of the Slovak Republic (Bratislava, Košice, Prešov, Žilina, Nitra, Banská Bystrica, Trnava and Trenčín). Institutionally, bus and train public transport services are ordered and subsidized by different public authorities. While the train travel schedules (for both regional and long-distance connections) are created and approved by central institutions under the direction of the Ministry of Transport, Construction and Regional Development of the Slovak Republic, the schedules of public bus networks are supervised by regional self-governments (both regional and long-distance networks). Due to a lack of communication between the central (Ministry) and regional authorities in the process of creating travel schedules, the coordination of bus and train schedules and links is very poor (for details, see Gašparík et al., 2012). Although both bus and train systems of long-distance transport are partly subsidized in order to compensate the public transport providers' economic loss caused by offering reduced fares to students, retired persons, etc. (Kejíková, 2008), they are organized as commercial systems.

The measurement of public transport competitiveness is subject to various discussions. From the geographical point of view, numerous approaches can be used. Partly inspired by Paulley et al. (2006) and Chmelík et al. (2010), we decided to use an available database of public transport services travel timetables to gain data on mutual time accessibility for the selected eight regional centres of the Slovak Republic. In comparison, individual transport travel times were applied to survey the values of accessibility using individual transport by a passenger car. Due to transport infrastructure modernization and extension, the time accessibility values of both public transport and individual transport have changed considerably. Respecting this, we decided to assess indirect effects of investments in transport infrastructure on the mutual competitiveness of buses, trains and passenger cars in terms of time accessibility rates among the selected Slovak cities in three different periods.

As an additional parameter, the frequency of public-transport services among the eight cities was used to measure the quality of bus and train transport.

3.1 Database of public transport links

For our purposes, we analyzed direct train and bus links connecting each of the eight urban centres with the rest of the group. In our opinion, only the direct links can be competitive to individual transport in interregional communication, as one or more changes during a single trip from one region to another may act as a time barrier and bring discomfort for passengers. The survey covers three different periods (1989, 1999 and 2011), which allows us to make judgements on how the time competitiveness of public transport has changed after the collapse of the socialist regime. Printed versions of archived train and bus timetables were used to gain data for the years 1989 and 1999. The 2011 database was accessed via www.busy.sk and www.zssk.sk web pages (in November 2011), internet timetables freely available on the internet. The public transport links and services included in the survey were selected according to the following limitations:

- Train transport: all direct trains including categories of Zr (fast regional trains), R (fast trains), Ex (express trains), IC (InterCity trains), EC (EuroCity trains) and EN (EuroNight trains) operated on a routine workday (i.e. at least 5 days per week) were included; and
- Bus transport: all direct international and interregional bus links operated on a routine workday (at least 4 days per week).

In the survey, we searched for the shortest possible train or bus connection for each combination of cities within the group of eight. Travel times necessary to reach either a bus/train station in the town of departure or a target point in the place of arrival, were not considered. The shortest times of interconnections were used for the direct comparison with travel times by individual transport. Where both train and bus links were under operation, the shorter mode was taken into consideration. Intra-regional bus links and regional trains (Os trains) were not considered in our analyses: in terms of travel time, they cannot compete with individual transport. Although the regional train connections can be considered as serving well over short distances (e.g. Košice–Prešov or Trnava–Bratislava), they are hardly competitive at longer distances.

Only direct public transport links were included in our database. According to numerous studies (such as Hine and Scott, 2000; Beirão and Sarsfield Cabral, 2007, inter alia), interchanges act as serious barriers and they are mostly perceived as negative factors, especially in long-distance travel chains where cumulative delays may occur.

For detailed analysis, two measures of accessibility were applied for each of the regional centres. The first one was a metric accessibility rate, expressed as a cumulative sum of time or distance or cost spent by a traveller to reach each node in the surveyed network. It is defined as a positive measure of accessibility (higher value indicating better accessibility of the node). The metric weight accessibility rate Acc_i of the top i in a set M in a graph G is equal to the sum of minimum distances from node i to all other nodes j (each separately) within the set M (Tolmáči, 1999):

$$Acc_i = \sum_{i=1}^{m} c_{ij} \qquad i \in M, |M| = m$$

$$a = 1, 2, 3, ..., 8; i = 1, 2, 3, ..., 8$$

The rate was used in three transport networks (car, bus and train). In the study of urban regions (Baxter and Lenzi, 1975), the metric accessibility rate is considered as essential.

A topological weight measure was used as the second accessibility rate. The measure is defined as a total number of lines L (direct connection) between nodes i (origin) and j (destination) due to some variable (time, population, etc.). In our study, a time variable t (number of connections per 24 hours) was used. This measure is directly proportional to the quantity of transportation systems (Tolmáči, 2002):

$$Acc_i = \sum_{i} \frac{L}{t} \qquad L = \sum_{i} L_{s1} + L_{s2} + \ldots, L_{sn}$$

where L_{zx} is the number of connections based on station x located in the town and s is the total number of these stations (in our research, Bratislava was represented by several bus and train stations).

The topological weight measure was used as an additional parameter applied to calculate the rate of public transport competitiveness within the group of eight cities (see below). As claimed by Paulley et al. (2006), the service intervals of public transport may influence the individual's preference. We assume that the more direct public transport connections from one city to another exist per 24 hours, the higher is the probability that a passenger will select one of the public transport means. A passenger car is generally independent and can be used for travelling virtually at any moment, although in some cases this might not be completely true (traffic jams, carpooling).

3.2 Individual transport database

To survey the individual transportation attributes, we used the internet version of Google Maps. However, we had to respect Slovakia's status of road infrastructure in the respective years. For the years of 1989 and 1999, new sections of motorways and new road bypasses were excluded to calculate a proper travelling time necessary to drive from each of the eight cities to the others. In some cases, archived printed road atlases were used (Atlas ČSSR, 1989; Podrobný autoatlas – Slovenská republika, 1999). The centres of these urban settlements were used as starting and target points, respectively.

3.3 Synthetic view

In an attempt to provide a synthetic view, we created a series of simple schematic maps illustrating how the competitiveness of public transport links interconnecting the eight regional centres has changed since 1989. Methodologically, the maps are based on two elementary indicators: travel times by public transport and individual transport, respectively, and frequency of public transport services per 24 hours as an additional indicator reflecting the quality of the public transport network. We applied these parameters to compare the situation in three different years (1989, 1999 and 2011). A combination of the parameters led to the construction of the following categories of public transport competitiveness of particular city-to-city interconnections:

a) competitive public transport connection (travel time longer by a maximum 20.0% as compared with individual transport travel time for the same city-to-city connection, and 20 or more public transport services/24 hours);
b) partially competitive public transport connection (only one of the above-mentioned conditions for competitiveness is fulfilled); and
c) uncompetitive public transport connection (travel time longer by 20.1% or more as compared with individual transport travel time for the same connection and 19 or less public transport services/24 hours).

The above-mentioned categories are derived from the simple assumption that commercial speed is a principal factor in a passenger's decision. The factor of service frequency is often used as an indicator of public transport operation, too, and many times as a qualitative counterbalance to the advantages of individual transportation. Although the application of merely two indicators may be seen as a simplification, both parameters are frequently (conjointly or separately) used to measure the quality of public transportation (see e.g. Fellesson and Friman, 2008; Rietveld et al., 2001; Too and Earl, 2010; Beirão and Sarsfield Cabral, 2007; Paulley et al., 2006; and in the Czech and Slovak literature, see Dolinayová, 2011; Chmelík et al., 2010; Seidenglanz, 2005, etc.).

4. Results

Their position within the network of principal railways gives the citizens of the regional centres good opportunities to use train transport, which is (in most cases) faster than bus services. On the other hand, for some interconnections (such as Košice–Banská Bystrica, Bratislava–Nitra, Bratislava–Prešov, Nitra–Trnava and Košice–Prešov), the poor railway network positions of Nitra, Banská Bystrica and Prešov usually act in a negative way. Table 1 shows that out of 28 possible interconnections within the group, eleven are with no direct train services, usually due again to the location of Nitra, Banská Bystrica and Prešov lacking efficient train coverage with the rest of Slovakia's territory. Bratislava is the only metropolis within the group connected with the other regional centres by both trains and buses; however, direct train connections are not necessarily faster than buses.

The evaluation of public transport accessibility within the group of eight centres of Slovakia shows a slight improvement in the metric accessibility rate for all of the cities after 1989 (see Fig. 2A). Generally, Žilina and Banská Bystrica show the most favourable accessibility, located in central regions of the country. On the other

		Public transport modes							
	From/To	Bratislava	B. Bystrica	Košice	Nitra	Prešov	Trenčín	Trnava	Žilina
Time accessibility (min)	Bratislava	x	▒	▒	▒	▒	▒	▒	▒
	B. Bystrica	🟨 180	x	▒	■	■	■	■	▒
	Košice	🟩 282	🟥 223	x	■	▒	▒	▒	▒
	Nitra	🟥 63	108	318	x	■	■	▒	■
	Prešov	🟥 432	230	🟥 25	350	x	■	■	■
	Trenčín	🟩 67	160	🟩 220	112	272	x	▒	▒
	Trnava	🟩 28	145	🟩 263	🟥 38	420	40	x	▒
	Žilina	🟩 114	🟩 85	🟩 164	219	210	🟩 54	🟩 95	x
🟩	train faster than bus	🟨	bus faster than train		🟥	equal travel times			
▒	bus and train services	■	bus services only						

Tab. 1: Metric accessibility rates (in minutes) among the regional centres of Slovakia (2011)
Source: Authors´ calculations based on bus and train time-schedules (www.cp.sk: accessed in November 2011)

hand, the peripheral location and lower population of Prešov (as compared with Košice), disadvantage the city in the public transport networks. In the period from 1989–2011, however, the accessibility of Prešov improved most within the group – by more than 70 minutes on average.

The rates for the individual transport metric accessibility (Fig. 2B) are generally better than the public transport means. The effect of the large population size of Košice is balanced by the relatively better location of Prešov within the motorway and highway networks, yet both eastern Slovakia centres show a somewhat peripheral position compared to the others. Considering individual transport accessibility, the concentration of most regional centres in western and central regions of the country shows very clearly in the unfavourable accessibility of Košice and Prešov in the eastern part of the country. Improvement of time-accessibility by passenger car in 1989–2011 was not as significant as in the case of public transportation; however, Prešov recorded a relatively greater positive change than the rest of the group (improvement by 50 minutes on average).

Public transport links are subject to permanent changes that come annually with the regular public-transport schedule modification. Relevant authorities (such as regional self-governments responsible for bus time-schedules, and the State Railroad Authority for trains) are supposed to grant public-transport links and services that can compete with

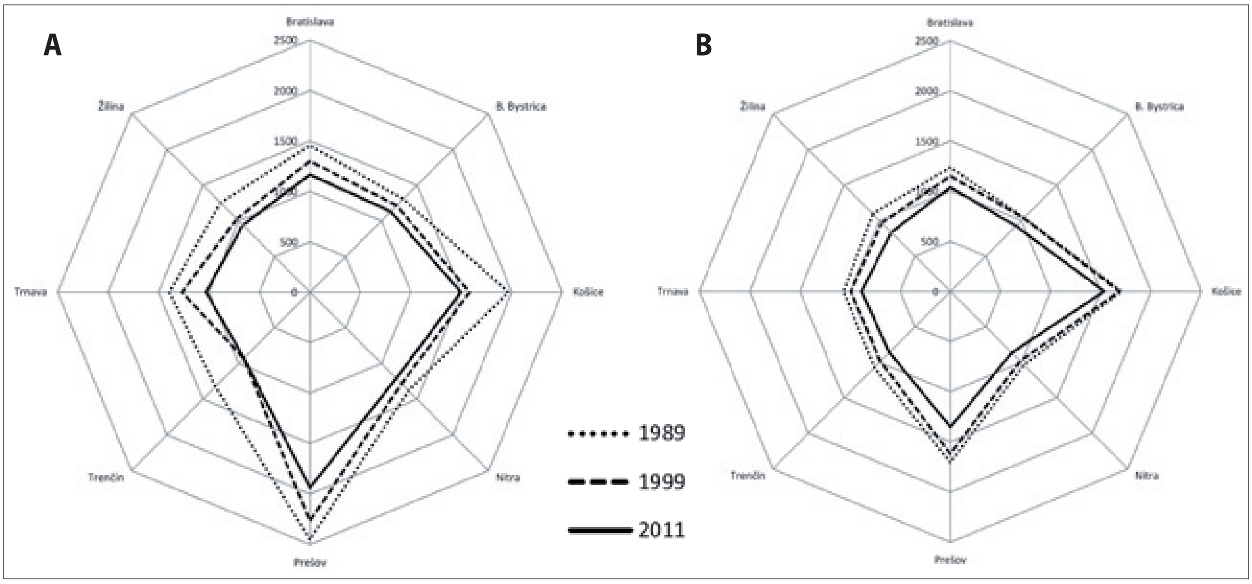

Fig. 2: Metric accessibility (in minutes) of the regional centres in Slovakia by public transport (A) and individual transport (B) in 1989, 1999 and 2011
Sources: Authors' calculations based on bus and train time-schedules (1989, 1999: official printed versions of time-schedules; 2011: www.cp.sk, accessed in November, 2011); Google Maps database (accessed in November 2011); Autoatlas ČSSR (1989); Podrobný autoatlas – Slovenská republika (1999).

		Public transport							
	From/To	Bratislava	B. Bystrica	Košice	Nitra	Prešov	Trenčín	Trnava	Žilina
Individual transport	Bratislava	**x**	0.78	0.79	0.74	0.85	0.72	0.82	0.78
	B. Bystrica	0.89	**x**	1.00	0.80	0.92	1.03	0.67	0.89
	Košice	0.93	0.95	**x**	0.81	0.74	0.63	0.65	0.82
	Nitra	0.83	0.83	0.92	**x**	0.88	1.14	0.76	1.00
	Prešov	0.79	0.80	1.00	0.80	**x**	0.58	0.92	0.61
	Trenčín	0.86	0.93	0.81	0.83	0.75	**x**	0.55	0.59
	Trnava	0.99	0.87	0.93	0.97	0.78	0.83	**x**	0.61
	Žilina	0.66	1.00	0.86	0.73	0.80	0.64	0.62	**x**

Tab. 2: Change of metric accessibility rates among the regional centres of Slovakia, 1989–2011 (index 2011/1989)
Source: Authors' calculations based on bus and train time-schedules (1989, 1999: official print versions of time-schedule; 2011: www.cp.sk, accessed in November 2011); Google Maps database (accessed in November 2011), Autoatlas ČSSR (1989), Podrobný autoatlas – Slovenská republika (1999)

individual transport. However, they can hardly affect the shape and condition of the current transport infrastructure that allows trains and buses to reach travel times comparable with travelling by passenger car. Nevertheless, both railway and road networks of Slovakia have experienced considerable changes in terms of quality and length throughout the recent two decades, which could have brought positive effects on travel times (Table 2).

Individual transport travel times have either remained stable or improved due to continual enhancement of highway and motorway networks. In some connections (such as Bratislava–Žilina or Banská Bystrica–Trnava) we can see a considerable effect of motorway construction realized by 2011. In other directions (Banská Bystrica–Trenčín or Banská Bystrica–Košice), only slight improvements of highways (e.g. building of bypass roads for transit traffic) may have changed travel times for individual transport.

In some connections (Trnava–Trenčín, Žilina–Trenčín), one can see an extremely positive change of public-transport travel times, too. This may result from both infrastructure enhancements as well as from the modifications of time-schedules of public transport services. In some cases, the time has been cut down due to the introduction of the IC/EC category of trains with only a few stops from the starting point to the destination, which may improve travel times significantly (e.g. by 45% in the Trnava–Trenčín connection). On the other hand, connections where bus links represent the only direct public transport (e.g. Trenčín–Nitra or Trenčín–Banská Bystrica), have recorded slightly increased travel times as a result of bus-schedule modification aimed at using the potential of passengers from smaller towns situated between the bus service starting point and destination.

The topological weight accessibility (detected via daily public transport interconnections, see Fig. 3) differs markedly between the capital city of Bratislava and the other cities. In spite of the extremely peripheral position of Bratislava, the city still dominates the public transport networks due to its central role in the political and economic system of the country, while the low number of daily direct links to other regional centres documents the peripheral position of Prešov within the public transport networks. Generally, the frequency of daily links has grown since 1989 within the group of centres; nevertheless, the highest frequency growth has been recorded in the eastern regional centres of Košice and Prešov (by 51% and 130%, respectively).

Surprisingly, the series of schematic maps in Fig. 4 suggests that the quality of public services (with respect to simplifications in the methods applied) connecting the main regional centres in Slovakia has been increasing. As to the capital city, four public transport links (out of seven in total) connecting Bratislava with the other regional centres were fully competitive in 1989, with six and five public transport links being fully competitive in 1999 and 2011, respectively.

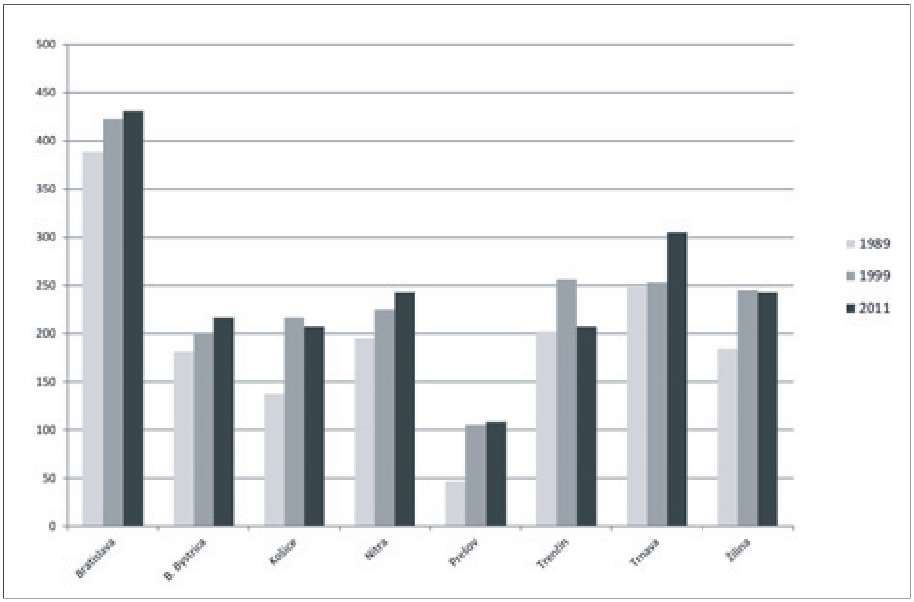

Fig. 3: The topological weight accessibility (public transport, per 24 hours) among the eight regional centres of Slovakia (1989, 1999, 2011)
Source: Authors' calculations based on bus and train time-schedules (1989, 1999: official print versions of time-schedule; 2011: www.cp.sk accessed in November 2011)

The second regional centre of Košice improved its interconnections from two fully competitive links in 1989 up to five in 1999 and 2011. Trnava improved its position, too, with only three fully competitive links in 1989, but six in 2011. One can see an evident improvement of Nitra´s position within the network, with no fully competitive link in 1989 and three fully competitive links in 1999 and 2011. The position of four cities has changed slightly. Banská Bystrica had two fully competitive public transport links and three partially competitive links in 1989. The shift to three fully competitive connections and two partially competitive links in 2011 indicates only a partial change. Similarly, Prešov showed a slight change, gaining only one fully competitive link in 1989–2011. On the other hand, Trenčín recorded a moderate impairment of its interconnections, keeping four fully competitive links throughout the whole period, but losing two partially competitive links. Žilina´s connections with the other regional centres were quite stable, displaying five fully competitive links out of seven in total throughout the surveyed years.

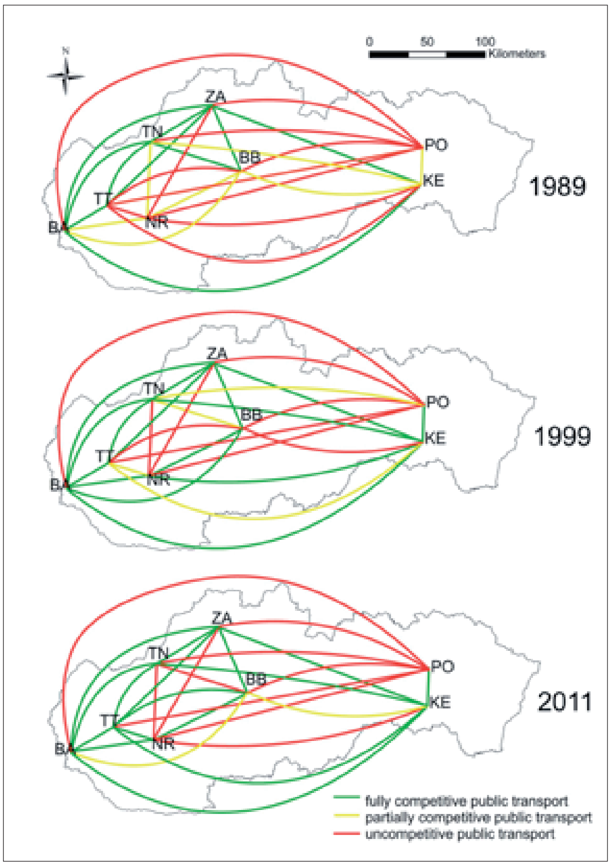

Fig. 4: Competitiveness of city-to-city public transport links among the regional centres of Slovakia (BA = Bratislava, TT = Trnava, TN = Trenčín, NR = Nitra, ZA = Žilina, BB = Banská Bystrica, PO = Prešov, KE = Košice)
Source: Authors' calculations based on bus and train time-schedules (1989, 1999: official print versions of time-schedule; 2011: www.cp.sk, accessed in November 2011); Google Maps database (accessed in November 2011), Autoatlas ČSSR (1989), Podrobný autoatlas – Slovenská republika (1999)

Generally, according to our methodology, we can see a slight improvement of public transport networks in connecting the regional centres of Slovakia after 1989. Out of 28 possible city-to-city interconnections, one can see 11 noncompetitive public transport links in 1989, compared to 10 in 2011. The decreased number of partially competitive links is even more informative: from seven in 1989 down to two in 2011. Although the methods that we used to identify the competitiveness of public transport compared to individual transport might be subject to discussion, we assume that the gradual enhancement of the existing road infrastructure and the modernization of railways in Slovakia are positive for public transport interconnections. This may not be true for regional transport, but that was not the subject of this research. The importance of regional centres, however, forces the public transport operators to do their best to run time-efficient and competitive bus and train links among these major cities.

5. Conclusions

There is no doubt that both public and individual means of passenger transport have shown considerable improvement in travel times since the collapse of the socialist regime in Slovakia. Although the motorisation rate of the population grew from 165 vehicles per 1,000 inhabitants in 1990 to 324 in 2011 (Statistical Office of the Slovak Republic) and the population's dependence on passenger cars has accelerated rapidly, public transport still maintains its strong position of a cheap and ecological alternative to individual transport. As shown by this analysis, improvements in the fleet of vehicles and in the network of motorways do not necessarily devalue the importance of public transport.

The results of this research may be expressed in the following four major conclusions:

1. Within the group of eight regional centres, most of the public transport interconnections are covered with both trains and buses. Not surprisingly, in many cases trains are faster that buses, in spite of the fact that the technical conditions of the Slovak railway network are not perfect. However, the cities located along the principal railway corridor Bratislava–Žilina–Košice (being gradually modernized and upgraded to 160 km.h^{-1}) profit from such a position and take advantages of fast and comfortable long-distance train services. Due to the somewhat problematic accessibility of high-capacity

railway corridors, interconnections with the rest of the regional centres (Nitra, Banská Bystrica and Prešov) are more efficiently covered by bus services.

2. Undoubtedly, travelling by a passenger car is still faster than travelling by bus or train. Both individual and public means of transport have shortened their travel times, but public transport links have generally manifested a more progressive time reduction in the period 1989–2011. We can assume that road network upgrading may have a positive impact on the accessibility of major regional centres by passenger car, but on the other hand, public transport operators still have a significant organizational reserve to cut the travel-times of buses and trains. Greater liberalization of the railway market and opening the passenger market for several independent long-distance train operators could prime the use of this organizational reserve. At present, there is no long-distance passenger railway operator in Slovakia and the current Slovak government is unlikely to allow any other carriers to penetrate the market and compete with the special-privilege monopoly of the state-owned passenger-train company.
3. Of the eight regional centres, Bratislava has the primary position considering the frequency of public-transport interconnections with the other cities. Regardless of the fact that the frequency of links has grown in all regional centres, Prešov still occupies last place mainly due to its eccentric and peripheral position, being shaded by the nearby larger city of Košice, which can be related to the historical development of the two cities.
4. The synthetic comparison of public transport links and individual transport with a focus on changes after 1989 showed a slightly surprising public transport competitiveness growth. The improvement of public transport services should not be seen as absolute, since public transport schedules are subject to change every year. We can assume that it is mainly the current condition of Slovak railway networks, which inhibits the speed (and capacity) of public transport. Nevertheless, the introduction of new segments of services (especially IC and EC trains in the late 1990s and low cost flights between Bratislava and Košice after 2000), was probably highly stimulating and induced an unprecedented struggle for customers. The decline of freight transport within the Slovak railway network after 1989 allowed more capacity for passenger transport, which may also have contributed to the acceleration of passenger trains in some parts of the railway network. As a result, one can find faster trains and buses offering extra-fast services connecting mainly Bratislava and the other regional capitals. In the context of a national transport policy, the complete modernization of main railway corridors in the future might induce highly attractive travel times among the regional capitals, such that no passenger car will be able to compete.

We are fully aware of the fact that the selection of only two basic parameters cannot fully cover the motivation of an individual to use one or another mode of transport. We have omitted principally the parameter of travel cost that may affect the final decision of a traveller in reality. The role of travel expenses and other factors (such as income, car ownership, trip purposes, waiting environment, vehicle characteristics, etc.) may be inspiring for further geographical or interdisciplinary research on public and private transport systems.

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References:

Act No. 56/2012 Coll. on Road Transportation

Autoatlas ČSSR (1989) 1:400 000, Praha.

BAXTER, R. S., LENZI, G. (1975): The measurement of relative accessibility. Regional Studies, Vol. 9, No. 1, p. 15–26.

BEIRĂO, G., SARSFIELD CABRAL, J. A. (2007): Understanding attitudes towards public transport and private car: A qualitative study. Transport Policy, Vol. 14, No. 6, p. 478–489.

BORNDÖRFER, R., GRÖTSCHEL, M., PFETSCH, M. E. (2007): A Column-Generation Approach to Line Planning in Public Transport. Transportation Science, Vol. 41, No. 1, p. 123–132.

BORUTA, T., IVAN, I. (2010): Public Transport in Rural Areas of the Czech Republic – Case Study of the Jeseník Region. Moravian Geographical Reports, Vol. 18, No. 2, pp. 9–22.

BUSSIECK, M. R. (1998): Optimal Lines in Public Rail Transport. Ph.D Thesis, Technische Universität Braunschweig, 133 pp.

CHARLTON, C., VOLWES, T. (2008): Inter-Urban and Regional Transport. In: Knowles, R., Shaw, J., Docherty, I. [ed.]: Transport Geographies – Mobilities, Flows and Spaces, Oxford, Blackwell Publishing, p. 120–136.

COUTO, A., GRAHAM, D. J. (2008): The impact of high-speed technology on railway demand. Transportation, Vol. 35, No. 1, p. 111–128.

CUDNY, W. (2011): Model przemian miasta postsocjalistycznego – przykład Łodzi. Studia Miejskie, No. 4, p. 153–159.

CUDNY, W. (2012): Socio-Economic Changes in Lodz – Results of Twenty Years of System Transformation. Geografický časopis, Vol. 64, No. 1, p. 3–27.

DOLINAYOVÁ, A. (2011): Factors and determinants of modal split in passenger transport. Horizons of railway transport. Scientific papers. Vol. 2, No. 1, p. 33–39.

DŽUPINOVÁ, E., HALÁS, M., HORŇÁK, M., HURBÁNEK, P., KÁČEROVÁ, M., MICHNIAK, D., ONDOŠ, S., ROCHOVSKÁ, A. (2008): Perifernosť a priestorová polarizácia na území Slovenska. Bratislava, Geografika, 186 pp.

Europe in Figures – Eurostat Yearbook 2011. Luxembourg, Eurostat, 692 pp.

FAITH, P. (2008): Passenger Road Transport Trends in the Slovak Republic. Communications, Vol. 10, No. 3, p. 33–39.

FELLESSON, M., FRIMAN, M. (2008): Perceived satisfaction with public transport services in nine European cities. The Journal of Transportation Research Forum, Vol. 47, No. 3, p. 93–103.

GAŠPARÍK, J., DOLINAYOVÁ, A., MAŠEK, J., HALÁS, M. (2012): Objednávanie výkonov vo verejnom záujme v železničnej doprave v SR. In: Kvizda, M., Tomeš, Z. [eds.]: Konkurence na železnici – budoucnost pro 21. století nebo destrukce sítě? Proceedings of the international seminar Telč 2012, Brno, Masaryk University, p. 15–21.

HINE, J., SCOTT, J. (2000): Seamless, accessible travel: users´ views of the public transport journey and interchange. Transport Policy, Vol. 7, p. 217–226.

HORŇÁK, M. (2004): Súčasný stav a perspektívy vývoja dopravnej infraštruktúry Slovenskej republiky. Prace Komisji Geografii Komunikacji Polskiego Towarzystwa Geograficznego, Tom X, p. 231–250.

HORŇÁK, M., DŽUPINOVÁ, E. (2009): Aspects of Marginality in Border Regions of Slovakia – a Case Study. In: Wilk, W. [ed.]: Global Changes: their Regional and Local Aspects, Proceedings of the 6th Polish-Czech-Slovak Geographical Seminar, Warszawa, Uniwersytet Warszawski, p. 123–129.

CHMELÍK, J., KVĚTOŇ, V., MARADA, M. (2010): Evaluation of Competitiveness of Rail Transport on Example of Connection among Regional Capitals in Czechia. Národohospodářský obzor, Vol. 10, No. 1, p. 5–20.

IVAN, I. (2010a): Advantage of carpooling in comparison with individual and public transport. Case study of the Czech Republic. Geographia Technica, Vol. 9, No. 1, p. 36–46.

IVAN, I. (2010b): Simulation of commuting by carpooling in the Czech Republic. In: Horák, J. et al. [eds.]: Advances in Geoinformation Technologies 2010. Ostrava, VŠB – Technical University of Ostrava, p. 151–161.

JAKÓBCZYK-GRYSZKIEWICZ, J. (2011): Łódź u progu XXI wieku. Studia Miejskie, No. 4, p. 131–138.

KEJÍKOVÁ, A. (2008): Výkony vo verejnom záujme v osobnej doprave. Železničná doprava a logistika, Vol. 3, p. 34–36.

KOMORNICKI, T. (2005): Specific Institutional Barriers in Transport Development in the Case of Poland and Other Central European Transition Countries. IATSS Research, Vol. 29, No. 2, p. 50–58.

KOMORNICKI, T. (2008): Changes of car ownership and daily mobility in selected Polish cities. Geografický časopis, Vol. 60, No. 4, p. 339–362.

KRAFT, S. (2012): A transport Classification of Settlement Centres in the Czech Republic Using Cluster Analysis. Moravian Geographical Reports, Vol. 20, No. 3, p. 38–49.

KRAFT, S., VANČURA, M. (2009): Transport Hierarchy of Czech Settlement Centres and its Changes in the Tranformation period: Geographical Analysis. Moravian Geographical Reports, Vol. 17, No. 3, p. 41–52

LIMTANAKOOL, N., DIJST, M., SCHWANEN, T. (2006): The influence of socioeconomic characteristics, land use and travel time considerations on mode choice for medium- and longer-distance trips. Journal of Transport Geography, Vol. 14, p. 327–341.

LOPÉZ-PITA, A., ROBUSTÉ, F. (2005): Impact of High-Speed Lines in Relation to Very High Frequency Air Services. Journal of Public Transportation, Vol. 8, No. 2, p. 17–35.

MARADA, M., KVĚTOŇ, V. (2010): Diferenciace nabídky dopravních příležitostí v českých obcích a sociogeografických mikroregionech. Geografie – Sborník ČGS, Vol. 115, No. 1, p. 21–43.

MARADA M., KVĚTOŇ V., VONDRÁČKOVÁ P. (2010): Doprava a geografická organizace společnosti v Česku. Praha, Česká geografická společnost, Praha, 168 pp.

MICHNIAK, D. (2006): Dostupnosť okresných a krajských miest na Slovensku. In: Falťan, Ľ., Štrbavá, J. [eds.]: Regionálna diferenciácia Slovenska v podkladových štúdiách. Subtéma 3: Typológia regionálnej diferenciácie v slovenských podmienkach – Dimenzia civilizačno-infraštruktúrna. Bratislava, Sociologický ústav SAV, p. 148–166.

MICHNIAK, D. (2007): Direct International Public Transport Connections of Regional Centres in Slovakia. Europa XXI, Vol. 16, p. 87–100.

NUTLEY, S. (1998): Rural areas: the accessiblity problem. In: Hoyle, B., Knowles, R., [eds.]: Modern Transport Geography, Chichester, John Wiley and Sons, p. 185–215.

PAULLEY, N., BALCOMBE, R., MACKETT, R., TITHERIDGE, H., PRESTON, J., WARDMAN, M., SHIRES, J., WHITE, P. (2006): The demand for public transport: The effects of fares, quality of service, income and car ownership. Transport Policy Vol. 13, No. 4, p. 295–306.

Podrobný autoatlas – Slovenská republika (1999) 1:100 000, Harmanec.

PŠENKA, T. (2011): Diaľková vlaková doprava na Slovensku. Železničná doprava a logistika, Vol. 1, p. 57-61

PUCHER, J., BUEHLER, R. (2005): Transport Policies in Central and Eastern Europe. New Brunswick NJ, Rutgers University, 19 pp.

RIETVELD, P., BRUINSMA, F. R., VAN VUUREN, D. J. (2001): Coping with unreliability in public transport chains: a case study for Netherlands. Transportation Research Part A: Policy and Practice, Vol. 35, No. 6, p. 539–559.

SEIDENGLANZ, D. (2005): Přímá železniční spojení z Prahy a Bratislavy (vliv politických a společenských změn). Acta Facultatis Rerum Naturalium Universitatis Comenianae, Geographica, Suppl. No. 3, p. 535–542.

STEG, L. (2003): Can public transport compete with the private car? IATSS Research, Vol. 27, No. 2, p. 27–35.

STEPNIAK, M., ROSIK, M. (2013): Accessibility improvement, territorial cohesion and spillovers: a multidimensional evaluation of two motorway sections in Poland. Journal of Transport Geography, Vol. 31, p. 154–163.

TOLMÁČI, L. (1999): Spádové regióny krajských miest na základe ich asymetrickej váženej dostupnosti. Folia geographica, Vol. 3, p. 305–314.

TOLMÁČI, L. (2002): Dostupnosť miest Slovenska. Bratislava: MAPA Slovakia, 66 pp.

TOO, L., EARL, G. (2010): Public transport service quality and sustainable development: A community stakeholder perspective. Sustainable Development, Vol. 18, No. 1, p. 51–61.

VAN DE VELDE, D. (2009): Long distance bus services in Europe: Concession or free market? Discussion paper No. 2009/21, Joint Transport Research Centre, OECD, 21 pp.

VAN VUGT, M., MEERTENS, M. R., VAN LANGE, P. A. M. (1995): Car versus public transportation? The role of social value orientations in a real-life social dilemma. Journal of Applied Social Psychology, Vol. 25, No. 3, p. 258–278.

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MORAVIAN GEOGRAPHICAL REPORTS

Aims and Scope of the Journal

Moravian Geographical Reports [MGR] is an international peer-reviewed journal, which has been published in English continuously since 1993 by the Institute of Geonics, Academy of Sciences of the Czech Republic, through its Department of Environmental Geography. It receives and evaluates articles contributed by geographers and by other researchers who specialize in related disciplines, including the geosciences and geo-ecology, with a distinct regional orientation, broadly for countries in Europe. The title of the journal celebrates its origins in the historic land of Moravia in the eastern half of the Czech Republic. The emphasis at MGR is on the role of 'regions' and 'localities' in a globalized society, given the geographic scale at which they are evaluated. Several inter-related questions are stressed: problems of regional economies and society; society in an urban or rural context; regional perspectives on the influence of human activities on landscapes and environments; the relationships between localities and macro-economic structures in rapidly changing socio-political and environmental conditions; environmental impacts of technical processes on bio-physical landscapes; and physical-geographic processes in landscape evolution, including the evaluation of hazards. Theoretical questions in geography are also addressed, especially the relations between physical and human geography in their regional dimensions,

Instructions for authors

The journal, Moravian Geographical Reports, publishes the following types of papers:

(1) **Original scientific papers** are the backbone of individual journal issues. These contributions from geography and regionally-oriented results of empirical research in various disciplines normally have theoretical and methodological sections and must be anchored in the international literature. We recommend following the classical structure of a research paper: introduction, including objectives (and possibly the title of the general research project); theoretical and methodological bases for the work; empirical elaboration of the project; evaluation of results and discussion; conclusions and references. Major scientific papers also include an Abstract (up to 500 characters) and 3 to 8 keywords (of these, a maximum of 5 and 3 of a general and regional nature, respectively). With the exception of purely theoretical papers, each contribution should contain colour graphic enclosures such as photographs, diagrams, maps, etc., some of which may be placed on the second, third or fourth cover pages. For papers on regional issues, a simple map indicating the geographical location of the study region should be provided. Any grant(s) received to support the research work must be acknowledged. All scientific papers are subject to the peer-review process by at least two reviewers appointed by the Editorial Board. The maximum text size is 40 thousand characters + a maximum of 3 pages of enclosures. The number of graphic enclosures can be increased by one page provided that the text is shortened by 4 thousand characters.

(2) **Scientific communications** are published to inform the public of continuing research projects, scientific hypotheses or findings. This section is also used for scientific discussions that confront or refine scientific opinions. Some contributions may be reviewed at the discretion of the Editorial Board. Maximum text length for these scientific communications is 12 thousand characters.

(3) **Scientific announcements** present information about scientific conferences, events and international co-operation, about journals with geographical and related issues, and about the activities of geographical and related scientific workplaces. The scientific announcements are preferably published with colour photographs. Contributions to jubilees or obituaries on prominent scientific personalities are supplied exclusively on request from the Editorial Board. The maximum text length of the scientific announcements is 5 thousand characters.

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Fig. 4: Three scenarios of the future development of agricultural landscape in the Liptovská Teplička village (A – present state/optimal land use, B – abandonment of agricultural land, C – disintegration trend of TAL connected with tourism development, D – disintegration trend of TAL connected with the intensification of agriculture)

Illustrations related to the paper by J. Špulerová, M. Dobrovodská, Z. Izakovičová, P. Kenderessy, F. Petrovič, and D. Štefunková