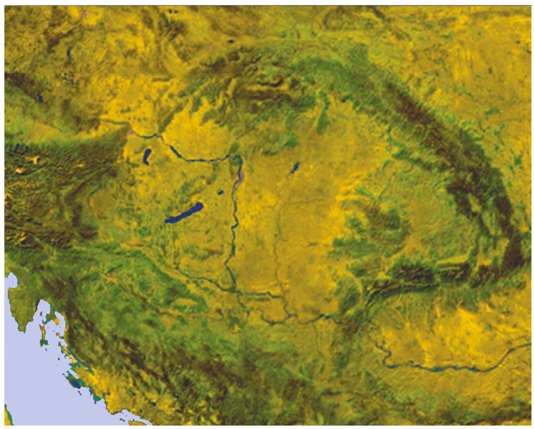
Hungarian Geographical Bulletin



Földrajzi Értesítő

Volume 67 Number 1 2018

MTA
Research Centre
for Astronomy and
Earth Sciences
GEOGRAPHICAL
INSTITUTE

HUNGARIAN GEOGRAPHICAL BULLETIN 67 2018 (1)

CONTENT

Book review section

Chronicle

Leaf area index in a forested mountain catchment

Ladislav PALÁN[1], Josef KŘEČEK[1] and Yoshinobu SATO[2]

Abstract

Leaf area index (LAI) belongs among the catchment characteristics widely used in hydrological models but still associated with great uncertainties. In a mountain forest catchment, the leaf area affects retention and evapotranspiration loss, and it could be significantly modified by forestry practices. In this study, LAI in mature stands of Norway spruce *(Picea abies)* and European beech *(Fagus sylvatica)* was analysed in headwater catchments of the Jizera Mountains (Czech Republic) between 2012 and 2016. A comparison evaluation of LAI in harvested site with dominant herbaceous vegetation was taken into account by applying direct ground investigation what was compared with hemispherical canopy photography (Gap light analyser GLA-V2) and satellite remote sensing (Sentinel-2 mission). While the direct ground measurement includes only the foliage (leaves or needles), the Gap light analysis is affected by trunks and branches, and the remote sensing techniques by herbaceous understory. The results of the Gap light analyser underestimated the ground based LAI values by 52–76 per cent, and satellite interpretations by 29–73 per cent. The remote sensing is capable to provide effective information on the distribution of LAI within the time and space. However, in a catchment scale, the satellite detection underestimated average LAI values approx. by 42–62 per cent. Changes in the observed rainfall interception reflected well the LAI variation.

Keywords: mountain watershed, forest canopy, leaf area index, gap light analyser, satellite remote sensing

Introduction

Leaf area index (LAI) belongs to the canopy characteristics often used in hydrological and environmental studies (Jones, H.G. 1992; Cowling, S.A. and Field, C.B. 2003). Leaf area affects the canopy storage capacity (amount of water retained in the canopy), an important parameter of many interception models (Gash, J.H.C. *et al.* 1980). In practical forestry, density of a forest stand is quantified by the number of stems per hectare, the basal area per hectare, eventually, by the crown closure percentage identified at aerial photographs (Watts, S.B. and Tolland, L. 2005). In hydrological models, LAI is used to estimate water budget of the vegetative canopy by calculating the deposited precipitation (rain, snow, fog etc.) (Federer, A. 1993; Allen, R.G. *et al.* 2005; Punčochář, P. *et al.* 2012; Křeček, J. *et al.* 2017). Watson, D.J. (1947) considered the leaf area index as the total one-side area of leaves per unit ground surface. To estimate LAI, both direct and indirect methods were developed (Cowling, S.A. and Field, C.B. 2003). The direct methods are more accurate but laborious and destructive, and representing a patch scale; while indirect methods based on the transmission of solar radiation through the canopy can provide approximates over large areas (Anderson, M.C. 1971). In the last years, several remote sensing algorithms of LAI have been evolved (Weiss, M. and Baret, F. 2016); the European Space Agency (ESA 2017) has developed an algorithm to calculate LAI based on the data of the satellite mission Sentinel 2 and direct ground measurements.

[1] Department of Hydrology, Czech Technical University in Prague, Thákurova 7. CZ-166 29 Prague 6, Czech Republic. E-mail: josef.krecek@fsv.cvut.cz (Correspondent author.)

[2] Department of Science and Technology for Biological Resources and Environment, Ehime University, 10-13, Dogo-Himata, Matsuyama, Ehime 790-8577, Japan.

Across the large amount of observed data, LAI estimates correlate with the vegetation type, geography and environmental circumstances. Concerning the herbaceous vegetation, Gosa, A.G. *et al.* (2007) reported LAI between 0.7 and 4.5, while Ramiréz-García, J. *et al.* (2012) summarized LAI of meadows between 2 and 3. For higher vegetation, LAI between 1.5 and 5.7 is reported for shrubs and between 4.5 and 10.6 for forests (Gosa, A.G. *et al.* 2007). Lovett, G.M. and Reiners, W.A. (1986) found in spruce stands the surface area index between 5 and 6, Breda, N.J.J. (2003) reported LAI variations in forests between 3.5 (pine) and 7.5 (spruce). However, the specific LAI estimates show relatively high divergences (up to 100%), Brenner, A.J. *et al.* (1995). Therefore, it is evident that the extrapolation of the reported LAI data is limited and for a specific research field it is necessary to estimate the LAI parameter by the existing methodology. The aim of this paper is to compare the direct and indirect methods to estimate LAI values for environmental investigations of the acid atmospheric deposition in headwater catchments of the Jizera Mountains, Czech Republic (Křeček, J. and Hořická, Z. 2010; Křeček, J. *et al*. 2010). This study focused on stands of Norway spruce (*Picea abie*) and European beech (*Fagus sylvatica*), as well as on the herbaceous vegetation growing at clear-cut areas.

Material and methods

This study was performed in the upper plain of the Jizera Mountains located in a humid temperate climate (subarctic region Dfc of the Köppen climate zonation; Tolasz, R. 2007). The analysis of LAI was performed in headwater catchments Jizerka (J-1), Josefův Důl (JD) and Oldřichov (O) in 2012 (*Figure 1*).

In five forest plots (J-1-A, J-1-B, J-1-C, JD-A, O-A, squares of 30×30 metres), LAI was estimated by both direct and indirect methods. These studied forest stands are even-aged and single-storied with negligible herb layer, the plot J-1-C represents a harvested area (clear-

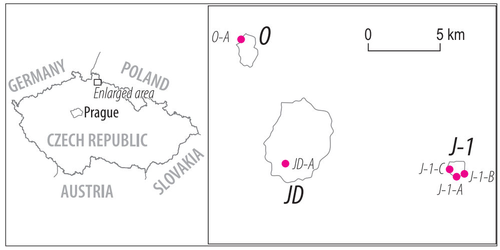


Fig. 1. Investigated headwater catchments of the Jizera Mountains with marked plots of LAI ground observations. – J-1 = Jizerka; JD = Josefův Důl; O = Oldřichov

cutting) with the forest regrowth retarded by a rapid development of herbaceous understory. Common characteristics of the stands were estimated by standard forest inventory according to Shiver, B.D. and Borders, B.E. (1996). The allometric relationship between stem diameter (DBH, measured in the breast height of 1.3 m) and foliage area was used in spruce stands (JD-A, J-1-A, J-1-B, J-1-C) by a destructive sampling of needles at harvested trees (Breda, N.J.J. 2003; Fehrmann, L. and Kleinn, C. 2006). The leaf area was measured on a sub-sample of leaves to calculate the specific leaf area (SLA, m^2 g^{-1}) in ratio to its dry mass. Finally, the total dry mass of leaves collected within a known ground-surface area is converted into LAI by multiplying by the SLA. According to Watson, D.J. (1947), LAI is understood here as a one-sided area of photosynthetically active canopy surface per unit of horizontal ground area.

In the beech forest (O-A), the non-destructive method of collecting leaves below the canopy was applied during the autumn leaf fall (Breda, N.J.J. 2003). Collected litter was dried at 60–80 °C for 48 hours) and weighed to calculate compute the dry mass. The leaf area of herbaceous understory was estimated by harvesting ten 0.25×0.25 m squares per each stand. The surface area of sampled leaves was measured by the portable leaf area meter ELE 470-010/01.

Simultaneously, two indirect methods were applied: the hemispherical canopy photography (Gap light analyser GLA-V2, Frazer, G.W. *et al.* 1999) and remote sensing (Sentinel-2 mission, ESA 2017). The gap fraction – based methods depend on the leaf-angle distribution. According to Campbell, G.S. (1986), LAI may be express by the equation (1):

$$LAI = \frac{1}{G(\theta)} \ln (P(\theta)) \cos(\theta), \quad (1)$$

where LAI = leaf area index, θ = zenith angle of the view, $P(\theta)$ = gap fraction, $G(\theta)$ = G-function corresponding to the fraction of foliage projected on the plane normal to the zenith direction.

Digital hemispherical photographs were collected under different sky brightness conditions. In July 2012, a camera Nikon CoolPix 4500 with FC-E8 fish-eye lens was employed and ten photos were managed in each investigated forest plot (corresponding with the spots of rain collectors installed under the canopy). Photographs were taken skyward from the forest floor with a 180° hemispherical lens to record the size, shape, and location of gaps in the forest overstory. The free imaging software GLA Version 2.0 (Frazer, G.W. 1999) was used to analyse the canopy (to extract the canopy structure and gap light transmission indices from true-colour fisheye photographs), and to estimate LAI values by the zenith angle 0–60° (LAI 4), (*Figure 2*).

For an aerial extrapolation of the ground observations, data of the European Space Agency satellite mission Sentinel 2 with a 10 m resolution (ESA, 2017) were employed. These data might lead to a better result in comparison with the 30 m resolution of the Landsat imagery archive (Křeček, J. *et al*. 2017), particularly, by the strongly non-linear relationship of LAI and reflectance, reported by Garrigues, S. *et al*. (2006). However, the data of Sentinel 2 mission could be easily compared to Landsat mission; Sentinel 2 contains 12 bands (0.43 μm – 2.28 μm). The data of Sentinel 2 – L1C (Level 1C, representing a top of the atmosphere reflectance in cartographic geometry, Mueller-Wilm, U. *et al.* 2016) were collected in the vegetation period 2016 (April–October) and post-processed into L2A (Level 2A, representing atmospheric corrected product and the 'bottom of atmosphere reflectance in cartographic geometry') following procedure of Mueller-Wilm, U. *et al.* (2016) to ensure a correct computation of LAI. However, in this period, only 23 images (with less than 50% cloudiness) were acceptable. Then, the LAI calculation was performed by the Biophysical Processor (S2ToolBox Level 2: estimation of biophysical variables) based on a trained neural network (Weiss, M. *et al.* 2000; Weiss, M. and Baret, F. 2016).

Based on an analysis of a maximal physical range of inputs and outputs, each calculation enables to indicate potentially invalid values of determined LAI (due to the water surface, cloud contamination, poor atmospheric correction, shadow, etc.). To avoid uncertainties in a single point analysis, grids of 5×5 m cells were created in the GIS application on the investigated plots (see *Figure 1*). All gathered LAI values were processed by standard statistical methods, only valid values were kept. Possible changes of the canopy between 2012 and 2016 were controlled by the Landsat imagery according to Křeček, J. and Krčmář, V. (2015).

Additionally, in three two-week periods (June–August, 2012), rainfall penetration within the canopy of investigated stands were registered in daily intervals. Only rain events enough to saturate the canopy storage in days without any significant fog or low cloud occurrence were included in the calculation of canopy interception according to Křeček, J. *et al*. (2017):

$$I = \sum_{i=1}^{n} P - \left(\sum_{i=1}^{n} P_t + \sum_{i=1}^{n} P_s \right), \quad (2)$$

where I = interception storage in mm, P = open field (gross) precipitation in mm, P_t = through-fall under the canopy in mm, P_s = steam-flow, interception loss of the canopy (I), n = number of rainy days.

Three forest stands (J-1-A, JD-A, O-A) were instrumented by ten modified Hellmann rain gauges and stem-flow was collected by plastic tubing (fixed around the stem circumfer-

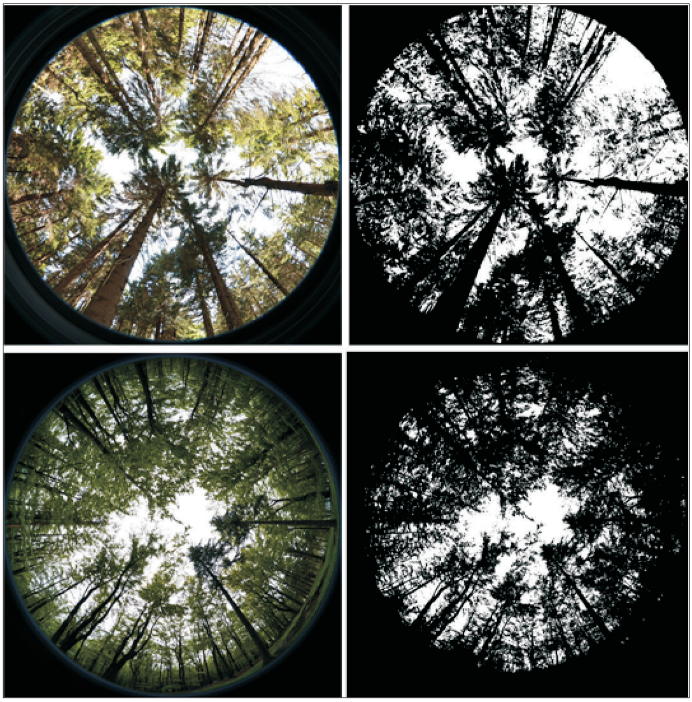


Fig. 2. An example of digital hemispherical photographs taken in investigated plots: Norway spruce (*Picea abies*) – top, and European beech (*Fagus sylvatica*) – bottom. Images registered – left, and processed – right.

ence) at two random tree trunks per each plot (*Figure 3*). The gross precipitation was observed in nearby forest openings (distance between 50 and 200 metres).

Results and discussion

Basic characteristics of the investigated forest stands are given in *Table 1*. From the analysis of sampled trees, the values of specific leaf area (SAI) were found: 17.2, 7.8 and 3.4 m^2/kg for beech, spruce and grass, in a good agreement with data reported by Horntvedt, R. (1993), Breda, N.J.J. (2003), and Liu, Ch. and Westman, C.J. (2009). Regressions between the leaf area LA (m^2) and DBH (cm) in investigated spruce stands were found by a = 0.74, b = 22.8 (correlation coefficient R = 0.82, R_{crit} = 0.75, p = 0.05, n = 5). On the harvested plot (J-1-C), there is a seasonal change in the leaf area described in *Figure 4*. The foliage and LAI values are included in *Table 2*.

Alternatively, LAI values detected by the Gap light analyser are in *Table 3*, and, the seasonal course of LAI provided by the satellite (Sentinel 2) during the vegetation period of 2016 is described in *Figure 5*. Evidently, applications of the Gap light analyser underestimated the ground based LAI of the investigated spruce and beech canopy by 52–76 per cent.

Similarly, Chen, J.M. *et al.* (1991) and Brenner, A.J. *et al.* (1995) reported an underestimation of LAI by hemispherical photographs approx. by 50 per cent (in comparison with the direct destructive methods). Zhang, Y. *et al.* (2005) identified the main LAI errors in just in the automated camera exposure leading to underestimating LAI in a relatively dense canopy and overestimating it in a sparse vegetation cover.

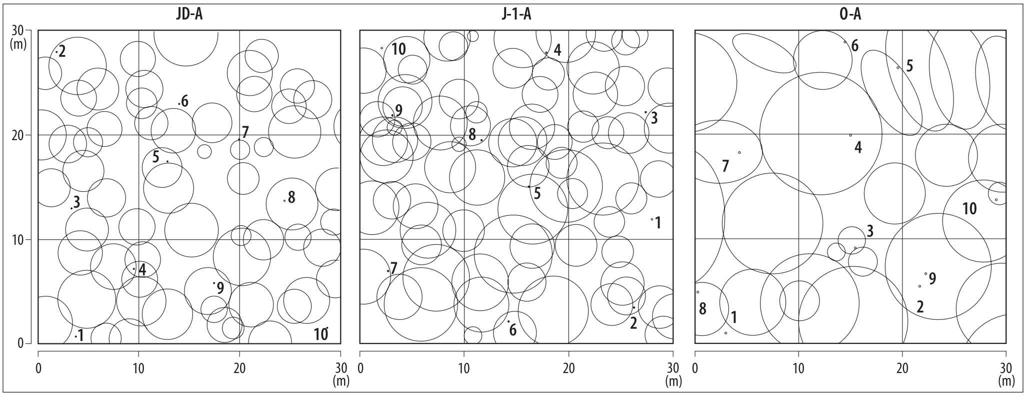


Fig. 3. Crown projection of trees in investigated stands of spruce (JD-A, J-1-A) and beech (O-A) with installed rain collectors (numbers 1–10)

Table 1. Forestry characteristics of the investigated plots

Stand	Dominant canopy	Age class, years	Elevation, m	Number of trees	DBH, cm	Mean height, m
JD-A	Spruce	80–100	745	54	27	24.0
J-1-A	Spruce	80–100	975	68	27	23.0
J-1-B	Spruce	80–100	945	27	36	23.0
J-1-C*	Grass	1–20	918	72	–	0.5
O-A	Beech	>141	506	28	37	25.0

*J-1-C plot represents harvested area overgrown by herbaceous vegetation (*Calamagrostis sp.*); this plot was reforested, but new seedlings still does not create a significant canopy.

Similarly, the satellite estimates underestimated LAI by 29–73 per cent by preferring the herb layers. It is evident that those remote sensing observations are more likely sensitive to an 'effective leaf area index' by reflecting heterogeneity in the leaf distribution. These uncertainties can cause the discrepancies in LAI values, particularly, the differences between the direct ground methodology and remote sensing applications. Chen, J.M. *et al.* (2005) suggested quantifying differences between actual and effective LAI by the clumping index between 0.5 for a fully closed canopy, and 1 for a sparse canopy with randomly distributed leaves.

Remote sensing techniques enable an easy and fast extrapolation of LAI in a catchment scale. However, the comparison of various plots can be affected by possible cloud appearance. The satellite LAI approximation within three selected headwater catchments in the Jizera Mountains is demonstrated in *Figure 6*. It is evident that there are relatively

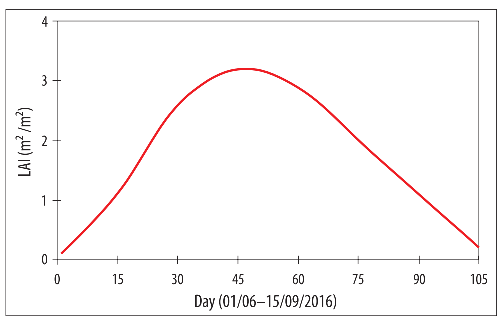


Fig. 4. Seasonal changes of the herbaceous canopy in the stand J-1-C.

Table 2. LAI found by the ground observation (plots of 30 x 30 m)

Stand	Basal area, m²/ha	Crown closure, %	Dry leaf mass, kg	Foliage area, m²	LAI
JD-A	41	92	842	6,570	7.3
J-1-A	46	78	773	6,030	6.7
J-1-B	32	61	417	3,253	3.6
J-1-C	–	6	900	2,880	3.2
O-A	41	89	296	5,040	5.6

Table 3. LAI estimated by the Gap Light Analyser (GLA-V2)

Stand	LAI										
	1	2	3	4	5	6	7	8	9	10	Mean
JD-A	1.53	2.39	2.38	1.79	2.77	1.86	2.06	2.08	2.39	2.41	*2.17*
J-1-A	1.69	1.64	1.75	1.81	1.73	1.34	1.27	1.83	2.14	1.22	*1.64*
J-1-B	1.84	1.64	1.77	1.84	1.56	1.68	1.62	1.85	1.72	1.64	*1.72*
O-A	1.59	1.34	1.28	1.54	1.35	1.37	1.55	1.41	1.34	1.78	*1.46*

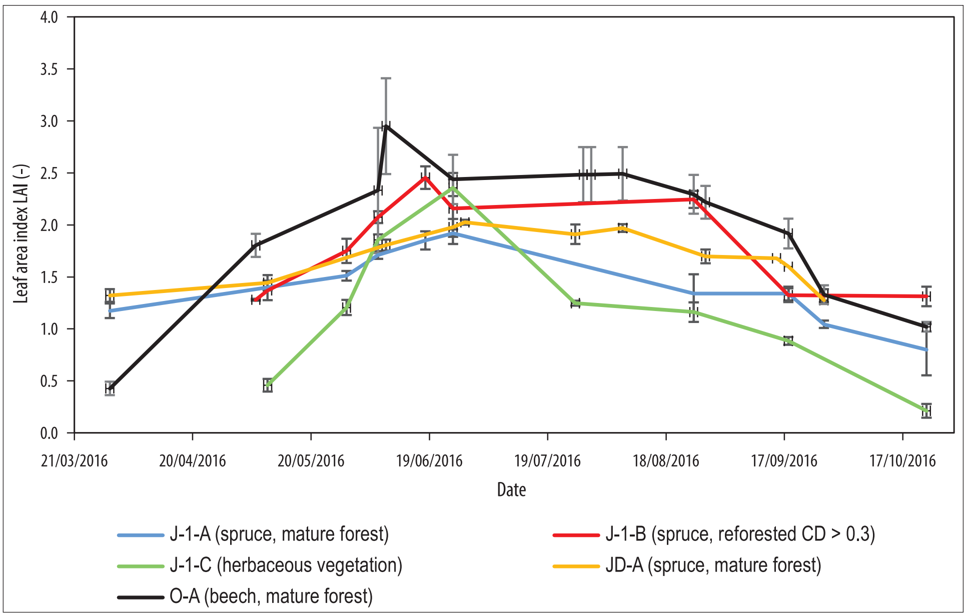


Fig. 5. Satellite estimates of LAI: values provided by the Sentinel 2 mission during the summer months of 2016.

high LAI values in spots of sparse tree occurrence just because of a high sensitivity of the satellite method to the herbaceous canopy. Therefore, the remote sensing method of Sentinel 2 can detect a vegetative surface but not very well the exact density and a foliage area of the canopy. In comparison with the aerial approximation of the direct ground LAI measurements and forest stands detected by LANDSAT imagery (*Figure 7*), the satellite remote sensing underestimates mean catchment LAI values by 42–62 per cent.

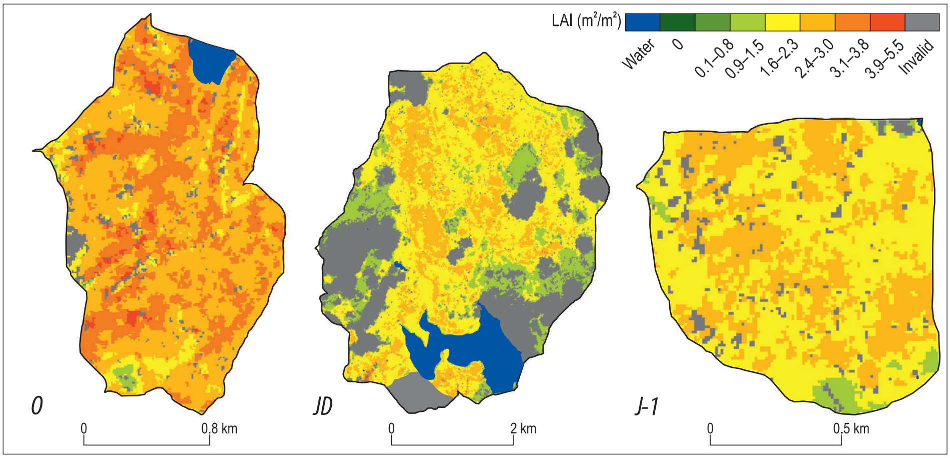


Fig. 6. Satellite LAI values in focused catchments on 25th June 2016. – O = Oldřichov; JD = Josefův Důl; J-1 = Jizerka

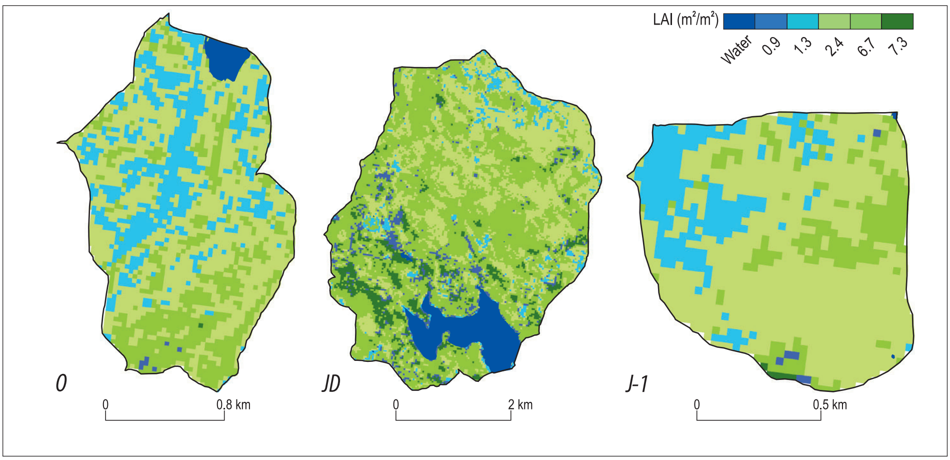


Fig. 7. LAI interpolation according to results of the direct ground observation and detection of forest stands by LANDSAT imagery, 2016. – O, JD, J-1 = for explanation see *Fig. 6.*

In the investigated six-week period of 2012, 16 rainy days without a significant fog occurrence and rainfall enough to saturate the canopy (above the canopy storage capacity) were registered, and the data are presented in *Table 4*.

Both rainfall interception (intercepted percentage of rainfall, *I)* and canopy storage capacity *(C_s)* correspond well with changes in observed LAI values: correlation coefficient R = 0.97 (R_{crit} = 0.95, n = 3, p = 0.05), and we can consider a linear relationship between the canopy storage capacity C_s and leaf area index *LAI*:

$$C_s = 0.395\ LAI - 0.084, \qquad (3)$$

where C_s = canopy storage capacity, *LAI* = leaf area index.

Table 4. Rainfall interception in the studied plots

Indicator	JD-A	J-1-A	O-A
Rainfall interception (I), %	37.0	34.0	26.0
Canopy storage capacity (C_s), mm	2.1	1.7	1.4
Rain to fill canopy storage (R_s), m	3.4	2.8	2.5
Leaf area index (LAI)	7.3	6.7	5.6

With regard to the relatively limited number of interception plots, the relationship (3) has only an informative value, but still can provide us with possible changes in the canopy storage within the extend of investigated LAI values.

Conclusions

The direct ground LAI measurement included the foliage (leaves or needles) of the forest canopy, while indirect LAI estimated are affected also by trunks and branches. Remote sensing techniques reflect all the green parts including the herbaceous understory. In headwater catchments of the Jizera Mountains, the estimates of the Gap light analyser underestimate the ground based LAI values by 52–76 per cent, and satellite interpretations by 29–73 per cent The remote sensing can provide fast and inexpensive information on the distribution of LAI within time and space in focused headwater catchments, and, enables a comparison of relative values among focused plots. However, in a catchment scale, the analysed satellite data underestimated average LAI values approx. by 42–62 per cent. A more valuable output could be considered by the interpolation of direct ground LAI measurements with only a detection of characteristic canopy classes from the both free available satellite imagery Landsat and Sentinel 2. In three plots instrumented with through-fall and stem-flow collectors, there was confirmed a significant relation between the canopy storage capacity and LAI values.

***Acknowledgements*:** This research was supported by the Earthwatch Institute (Oxford, UK, Project on Mountain Waters of Bohemia), the Ministry of Education of the Czech Republic (INTER-EXCELLENCE: INTER-COST LTC 17006) and the Czech Technical University in Prague (SGS 16/140/OHK1/2T/11).

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. 2005. *Crop evapotranspiration*. FAO Irrigation and Drainage Paper 56. Rome, Food and Agriculture Organization.

Anderson, M.C. 1971. Radiation and crop structure. In *Plant photosynthetic production, manual of methods.* Eds.: Šesták, Z., Čatský, J. and Jarvis, P.G., Hague, Dr. W. Junk, 77–90.

Breda, N.J.J. 2003. Ground-based measurements of leaf area index: a review of methods, instruments and current controversies. *Journal of Experimental Botany* 54. 2403–2417.

Brenner, A.J., Cueto Romero, M., Garcia Haro, J., Gilabert, M.A., Incoll, L.D., Martinez Fernandez, J., Porter, E., Pugnaire, F.I. and Younis, M.T. 1995. A comparison of direct and indirect methods for measuring leaf and surface areas of individual bushes. *Plant, Cell and Environment* 18. 1332–1340.

Campbell, G.S. 1986. Extinction coefficients for radiation in plant canopies calculated using an ellipsoidal inclination angle distribution. *Agricultural and Forest Meteorology* 36. 317–321.

Cowling, S.A. and Field, C.B. 2003. Environmental control of leaf area production: Implications for vegetation and land-surface modeling. *Global Biogeochemical Cycles* 17. 1–11.

ESA, 2017. *Sentinel-2*. https://sentinel.esa.int/web/sentinel/missions/sentinel-2 Accessed on 24.03.2017.

Federer, A. 1993. *BROOK 90: A simulation model for evapotranspiration, soil water and streamflow*. Durham (US), USDA Forest Service.

Fehrmann, L. and Kleinn, C. 2006. General considerations about the use of allometric equations for biomass estimation on the example of Norway spruce in central Europe. *Forest Ecology and Management* 236. 412–421.

Frazer, G.W., Canham, C.D. and Lertzman, K.P. 1999. *Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, user's manual and program documentation.* Burnaby (British Columbia) – Millbrook (N.Y.), Simon Fraser University – Institute of Ecosystem Studies.

Garrigues, S., Allard, D., Baret, F. and Weiss, M. 2006. Influence landscape spatial heterogeneity on the non-linear estimation of leaf area index from moderate spatial resolution remote sensing data. *Remote Sensing of Environment* 105. 286–298.

Gash, J.H.C., Wright, I.R. and Loyd, C.R. 1980. Comparative estimates of interception loss from three coniferous forest in Great Britain. *Journal of Hydrology* 48. 89–105.

Gosa, A.G., Schaepman-Strub, G., Kooistra, L., Schaepman, M. and Pellikka, P. 2007. Estimation of leaf area index using optical field instruments and imaging spectroscopy. In *Proceeding 5th Earsel Workshop on Imaging Spectroscopy*. Bruges, Belgium, 1–12.

Horntvedt, R. 1993. Crown density of spruce trees related to needle biomass. *Forest Ecology and Management* 59. 225–235.

Chen, J.M., Black, T.A. and Adams, R.S. 1991. Evaluation of hemispherical photography for determining plant area index and geometry of a forest stand. *Agricultural and Forest Meteorology* 56. 129–143.

Chen, J.M., Menges, C.H. and Leblanc, S.G. 2005. Global mapping of foliage clumping index using multi-angular satellite data. *Remote Sensing of Environment* 97. 447–457.

Jones, H.G. 1992. *Plant and microclimate*. 2nd edition. Cambridge (UK), Cambridge University Press.

Křeček, J. and Hořická, Z. 2010. Recovery of headwater catchments and lakes affected by the acid atmospheric deposition. In *Integrated watershed management*. Eds.: Beheim, E. *et al.* Dordrecht, Springer, 200–207.

Křeček, J. and Krčmář, V. 2015. Landsat imagery applications to identify vegetation recovery from acidification in mountain catchments. *Hungarian Geographical Bulletin* 64. (2): 121–126.

Křeček, J., Nováková, J. and Hořická, Z. 2010. Ellenberg's indicator in water resources control: the Jizera Mountains, Czech Republic. *Ecological Engineering* 36. 1112–1117.

Křeček, J., Palán, L. and Stuchlík, E. 2017. Acid atmospheric deposition in a forested mountain catchment. *iForest* 10. 680–686.

Liu, Ch. and Westman, C.J. 2009. Biomass in a Norway spruce – Scots pine forest: a comparison of estimation methods. *Boreal Environment Research* 14. 875–888.

Lovett, G.M. and Reiners, W.A. 1986. Canopy structure and cloud water deposition in subalpine coniferous forests. *Tellus B* 38. 319–327.

Mueller-Wilm, U., Devignot, O. and Pessiot, L. 2016. *Sen2Cor Configuration and User Manual.* France, ESA.

Punčochář, P., Křeček, J. and Van de Griend, A. 2012. Interception storage in a small Alpine catchment, In *Integrated watershed management*. Eds.: Křeček, J. *et al.* Dordrecht, Springer, 200–207.

Ramiréz-García, J., Quemada, M. and Almendros, P. 2012. Ground cover and leaf area index relationship in a grass, legume and crucifer crop. *Plant, Soil and Environment* 58. 385–390.

Shiver, B.D. and Borders, B.E. 1996. *Sampling techniques for forest resource inventory*. London, John Wiley & Sons.

Tolasz, R. 2007. *Climate atlas of the Czech Republic*. Prague, Czech Hydro-meteorological Institute.

Watson, D.J. 1947. Comparative physiological studies on the growth of field crops: I. Variation in net assimilation rate and leaf area between species and varieties, and within and between years. *Annals of Botany* 11. 41–76.

Watts, S.B. and Tolland, L. 2005. *Forestry Handbook for British Columbia. Vancouver.* Faculty of Forestry, University of British Columbia.

Weiss, M. and Baret, F. 2016. *S2ToolBox Level 2 products: LAI, FAPAR, FCOVER, Version 1.1.* Paris, French National Institute for Agricultural Research (INRA).

Weiss, M., Baret, F., Myneni, R.B., Pragnère, A. and Knyazikhin, Y. 2000. Investigation of a model inversion technique to estimate canopy biophysical variables from spectral and directional reflectance data. *Agronomie* 20. 3–2.

Zhang, Y., Chen, J.M. and Miller, J.R. 2005. Determining digital hemispherical photograph exposure for leaf area index estimation. *Agricultural and Forest Meteorology* 133. 166–181.

DOI: 10.15201/hungeobull.67.1.2 Hungarian Geographical Bulletin **67** 2018 (1) 13–27.

Landscape changes in a 19th century wood pasture and grazing forest

Petra BARTUS[1], Csaba BARÁZ[2] and Ákos MALATINSZKY[1]

Abstract

The Bükk Mountains were covered by continuous forests even in the 18th century. First plans for exploitation originate from the late 1700's; thus, this is the time when planned forest management in the Bükk Mountains started. Our aim is to shed light on land use and historical land cover changes of the grazing forest and wood pasture on the Magas Hill Forest (Ózd–Egercsehi Basin, NE-Hungary) since the 18th century, describe its current state (based on ethnographical data, maps, and field research), and give suggestions on its reconstruction and conservation management. The hills around Egercsehi and Mikófalva villages were once covered by 808.5 ha continuous grazing forest. This forest has almost totally disappeared, and one-time oak forests show no continuity with today's black locust stands, despite for a 35.3-ha patch in the southern slope of Magas Hill. This remnant is a various mosaic of closed forest, degraded grazing forest, wood pasture, clearing, and grassland, with old (150–200 year) veteran trees. As a consequence of no management (abandonment of forest grazing), original vegetation has almost totally been abolished by invasive alien species. Area of mowed, open grassland is 5.3 ha, while 20.1 ha commemorates on the one-time wood pasture, the remaining is shrubby (spontaneously) with afforestation. The area is not listed in the Hungarian cadastre of wood pastures. This register lists 6 wood pastures in Heves County; this current one is the 7th. The unique stand of veteran trees is still visible and the process of scrub encroachment might by stopped by adequate management, therefore, valuable habitats can be conserved. In favour of reconstruction of the wood pasture – grazing forest mosaic and maintenance of the desirable state, we suggest beef and sheep grazing, combined with mowing, depending on the state of afforestation.

Keywords: wood pasture, grazing forest, landscape change, forest use, landscape history, Bükk Mountains

Introduction

Wood pastures and grazing forests have been determinant characters of the European landscape (Gillet, F. 2008; Garbarino, M. *et al*. 2011), and play significant role in biotope networks and biodiversity conservation, as they host plant and animal species that are tied to natural or semi-natural, and agricultural areas as well (Jose, S. 2012). Their high biodiversity is ensured basically by old veteran trees, dead trees, shrubs, and non-intensive grasslands (Szabó, M. *et al*. 2007; Hartel, T. *et al*. 2013). According to Plieninger, T. *et al.* (2015), wood pastures are archetypes of High Nature Value areas, and cover about 203,000 km² throughout the European Union. They highlight the landscape value, dynamic character and genetic resources as well as aesthetic, recreational, cultural values and role in traditional ecological knowledge. Wood pastures and grazing forests are well organised systems, but cannot exist without human activities and thus, are sensitive to management intensity (Saláta, D. *et al*. 2007; Barczi, A. and Nagy, V. 2016).). Due to changes in management regimes, they are endangered in many European countries (Bergmeier, E. *et al*. 2010), especially in those areas where the climax vegetation is any kind

[1] Szent István University, Faculty of Agricultural and Environmental Sciences, Department of Nature Conservation and Landscape Ecology. H-2103 Gödöllő, Páter K. u. 1. E-mails: petra.bartus16@gmail.com, malatinszky.akos@mkk.szie.hu

[2] Bükk National Park Directorate, Department of Education and Nature Studies. H-3304 Eger, Sánc u. 6. E-mail: eger.barazcsaba@gmail.com

of forest that accelerates natural succession in case of abandonment (Vandenberghe, C. *et al.* 2007; Demény, K. and Centeri, Cs. 2008). In the United Kingdom, an action plan serves their research, maintenance and protection (Haw, K. 2012), while their detailed classification system and management principles were elaborated for Scotland by Holl, K. and Smith, M. (2002).

Our aim is to shed light on land use and historical land cover changes of the grazing forest and wood pasture on the Magas Hill (Ózd–Egercsehi Basin, NE-Hungary) Pannonian vegetation region (Fekete, G. *et al.* 2017), since the 18th century, based on ethnographical data and historical maps; as well as to describe its current state via field research, and give suggestions on its reconstruction and conservation management. The area belongs to the Csornó Valley Hills, which is situated among Egercsehi, Bekölce and Mikófalva villages, surrounded by the Villó Valley and the valley of the Eger Stream *(Figure 1).* The forested area belongs to Egercsehi and Mikófalva villages since the 18th century. Until the late 19th century, Mikófalva used to be a village of nobles, while Egercsehi was inhabited by villeins (Soós, I. 1975).

Hungarian wood pastures were first observed from a nature conservation aspect by Haraszthy, L. *et al*. (1997), who stated that this habitat type belongs to the most endangered ones in Hungary, due to abandonment or not suitable use. Similar processes are described by Zagyvai, G. and Bartha, D. (2015). Geiger, B. *et al*. (2011) supply a suitable methodology (Pető, Á. *et al.* 2008) for reconstructing land use history based on literature and archives sources, while Nagy, D. (2008), Saláta, D. *et al*. (2013) and Selmeci, M. *et al*. (2013) gave practical examples for investigations on historical maps. Our suggestions on favourable management of the studied habitats are based on the work of Kenéz, Á. *et al*. (2007) who draw attention to the animal load and productivity of the grassland.

Grazing forests, characteristics of the Bükk Mountains, had suffered from the process of transforming copyholder tenure, and even more the drastic measure of the year 1853, which ceased the traditional communal land ownerships and obliged to separate forests and pastures owned by the former villeins from those owned by the former squire (Andrásfalvy, B. 2004). The village community possessed the wood independently. Village people were allowed to collect construction wood and firewood with the permission of the community. Wood pastures and grazing forests originate from this time, to ensure forage for livestock. These areas, as well as open pastures (without trees) were cared by the local inhabitants. Degradation and disappearance of wood pastures and grazing forests speeded up due to stricter rules on forest management, and separation of forests. Forest grazing was finally banned by the Act VII. of 1961, which made the subsistence of these unique land use forms impossible.

About 5,500 ha of wood pasture and grazing forest has remained in Hungary till date, but their extension still decreases due to afforestation and wood cutting. The project "Landscape Ecological Vegetation Mapping of Hungary" states that the wood pastures and grazing forests are among the eight most endangered wooded habitat types in Hungary (Molnár, Zs. *et al*. 2008).

Various nature conservation problems affected the wood pastures and grazing forests. One of them is the temporary anarchic liaisons in properties. These areas belonged to the villages and commonages until 1945, only a few percent belonged to private owners. During the socialist-type agricultural industrialization they become state-owned (or co-operative). After the change of regime, as the co-operatives ceased, their status has become unclear and most of them remained unmanaged (at least temporarily). This time, illegal wood cuttings were regular, which were difficult to handle due to unclear property rights. A third significant group of problems is tied to economic use, such as lagging grazing and mowing. By mowing in due time, weed infestation (introduced via grazing) is prevented; however, if its date is not well determined, it interferes with seed dispersal of protected plants. Overgrazing may cause a similar problem, but it is un-

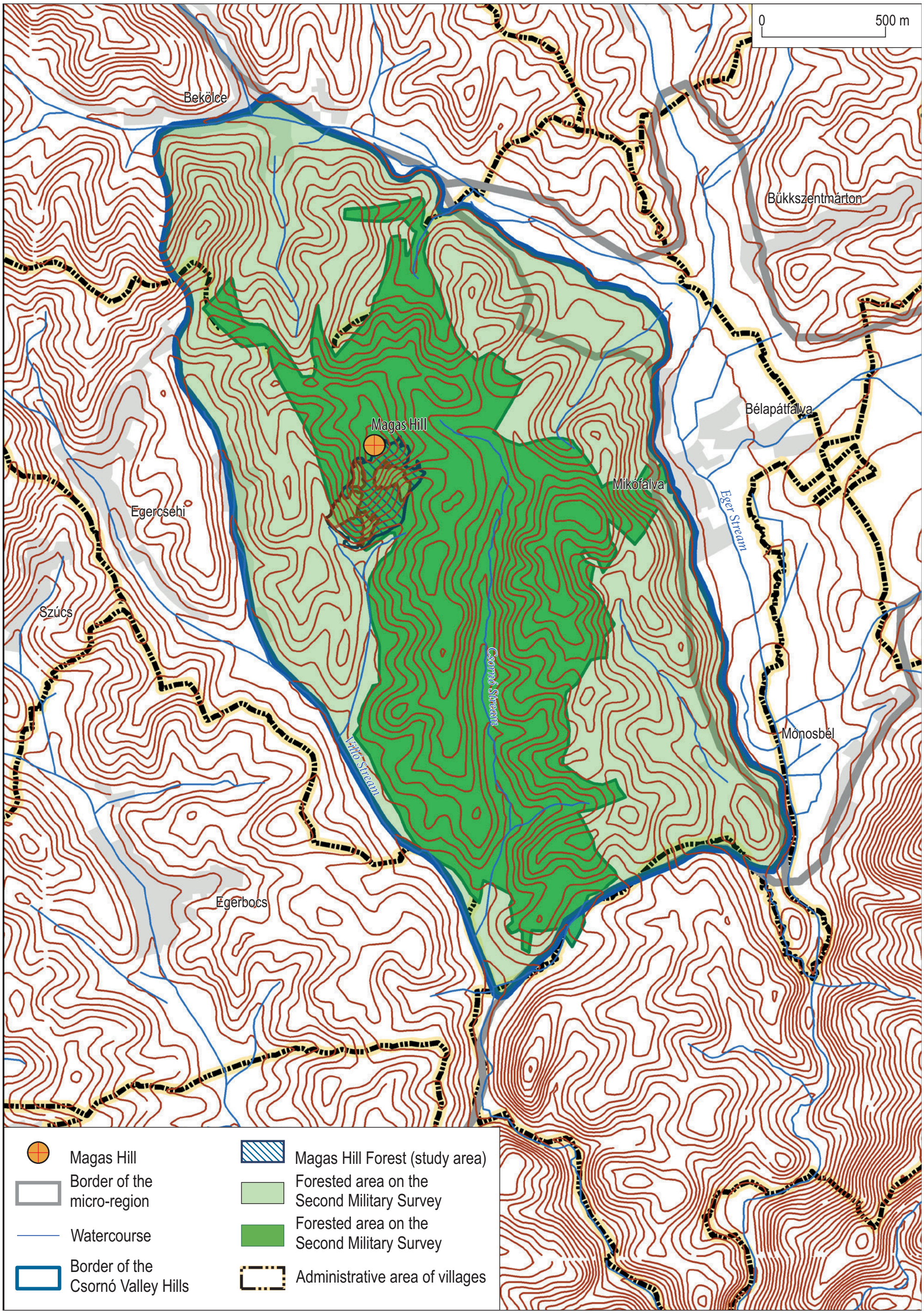


Fig. 1. The Csornó Valley Hills and the forest shown by the 2nd Military Survey

likely in Hungary due to changes in livestock keeping habits. Applying non-professional management methods may also harm grazing forests and wood pastures, and even destroy them in a long term. Some examples for this are: storing animal manure in a not sufficient place; spring burning of the grassland; abandonment of mowing; not sufficient substitution of dead trees. These rare habitats are endangered by land use change, too. Due to less grazing livestock, there is less need for pastures, and thus, the owners enable natural re-forestation, or create a forest by planting fast growing tree species, or convert it to arable land (Haraszthy, L. *et al*. 1997).

One of the main reasons for the origin of grazing forests was the lack of pastures. As the main function of forests used to be livestock keeping in the past, Hungarian forests were grazed (by sheep, cow, and horse) and acorn consumed (by pigs) during several centuries, thus, changes in legislation (Forest Act in 1791, then the transformation of copyholder tenure, and separation of forests and pastures of villeins from squires after 1853) have become the main reasons for several later problems (Téglás, K. 1902).

Material and methods

We name the hilly territory lying between the Eger Stream and the Villó Stream as Csornó Valley Hills, because the Csornó Stream divides it into two parts from north to south. This hilly territory of two ridges did not have a geographical name that covers the total area. Maps of the Third Military Survey (1869–1887) and 1:25,000-scale maps of the Hungarian Kingdom (1869–1887) name the western ridge (which contains the Magas Hill, 455 m) as "Csornóhegy" (the village cadastre map from 1863 names it as "Nagylápa-dűlő", signed with XXIII on the map), while the eastern ridge that belongs to Mikófalva village is named as "Szőlőmege bérc".

According to the present geographical system, this hilly area which contains the Csornó Valley Hills and is built up mainly by sedimentary rocks belongs to the Ózd–Egercsehi Basin. The microregion's Pannonian foothill was slashed by erosion and deflation during the Pleistocene. Its climate is moderately cool and moderately dry, with an average yearly temperature of 8.0–9.0 °C and annual precipitation of 580–620 mm. Due to this climate, hills and ridges are covered by forests, surrounded by less heat-demanding agricultural crops. Dominant soil type is luvisol, changed by fluvisols in the stream valleys. The mosaic-like and diverse vegetation evolved due to severe forest uses and cuts, with clearings and planted forests (Dövényi, Z. 2010). The Magas Hill Forest is the remnant of a huge 19th century grazing forest and wood pasture, surrounded by open grasslands. As a consequence of the abandonment of grazing, scrub encroachment and afforestation processes are visible.

We reconstructed land use history based on literature and archives sources:

– First Military Survey – Ministry of Defence, Institute and Museum of Military History, Map Archives, section XX/13, year 1783, scale 1:28,800, digital edition Arcanum (2004);
– Second Military Survey – Ministry of Defence, Institute and Museum of Military History, Map Archives, section XXXVII/45, year 1858, scale 1:28,800, digital edition Arcanum (2004);
– Hand-script maps, cadastre maps and copyholder tenure maps: based on the Map Archives of the National Archives of Hungary, and documents at the Heves County Archives (Hungaricana Hungarian Cultural Heritage Portal, http1): Mikófalva village with Ughfalva in Heves County, 1888 (National Archives of Hungary, score: S 78 120. téka Mikófalva 001-011), cadastre map of Csehi village administrative area, 1961 (Heves County Archives, score: Heves U 83), Csehi village with Ördögfalva cadastre map, 1863 (National Archives of Hungary, score: S 78 Heves m. Egercsehi 001-004). The latter one contains description with land use types, too;
– 1:10,000-scale topographical map (Institute of Geodesy Cartography and Remote Sensing, 1989);

– Aerial photographs: years 1991 and 2005, Institute of Geodesy Cartography and Remote Sensing (accessed in the GIS database of the Bükk National Park Directorate, and the website of the service managed by the mentioned institute: http2);
– Maps and data of forestry management plans;
– Data of the national CORINE (CLC50) database;
– Orienteering maps (scale 1:15,000) from the years 1993 (Baglyas-hát, Kín-hegy) and 2001 (Villó-tanya): they present the hills along the Csornó Stream, but do not cover the Magas Hill Forest. We used them to find out (based on the signs), whether similar forest remnants might be found in the surroundings or not, but they illustrate only black locust stands.

Orienteering maps were provided by the orienteering clubs of Eger and Miskolc cities. They were scanned and digitalized, then georeferenced with the ArcMap software, and shape files were created to present vegetation cover. This process was done for every orienteering map (from different years) and thus, we were supplied by generalized, universal maps. The same software was used for processing maps of the Second Military Survey and cadastre maps from the 19th century, then polygons were drawn based on the different vegetation cover types. Creation of shape files followed this stage, which were the bases for creating maps for comparisons. Conclusions were formed based on these maps on the changes of vegetation during the ages.

Orienteering maps are detailed topographic maps, with scale 1:15,000. They show every object in the field that may influence the reading of the map, or choose of the route. Hardness of running in forests is divided into four categories (based on speed), and it is shown via the vegetation cover. If the vegetation of the forest floor is very lush, the map is darker green. Open areas (without trees) are yellow coloured, and spots that are easy to run are distinguished from those that are hard to pass (Guszlev, A. and Zentai, L. 2000).

Field investigations were done four times during 2016, from April till September. We compared the different markings of orienteering maps from different years, and validated aerial photographs and cadastre maps on the spot with current circumstances. Our route was registered by GPS device. Pictures were taken on the state of vegetation, and overview of the area. Exact spots of the veteran oak trees in the remnant forest were registered one by one. We measured trunk perimeter of the biggest trees at our breast height, with registering also the tree species. In case of plant names nomenclature follows the work of Király, G. (2009). Field data were further processed with ArcGIS software: exact ranges were measured (and thus, conclusions formed) via the attribute table.

Results

Formation of the Magas Hill Forest, and landscape management history of its surroundings

The study area was covered by continuous forests surrounded by meadows and arable lands during the 18th and 19th century according to the First and the Second Military Surveys. The extension of the forest was 808.5 ha on the Second Military Survey map *(Figure 2).*

18th century descriptions on Egercsehi, that reflect to the "ancient" state, before water regulation works and severe landscape changes (column XIX, segment 13), also contain some reference on the forest along the Csornó Stream: "Surrounding forests comprise high oak and beech trees", and "the road to Mikófalva leads through a high ridge, in forest, and can be used only in emergency." Descriptions on Mikófalva mention: "The adjacent forest comprise oak and beech trees" (Csiffáry, G. and B. Huszár, É. 1999).

The cadastre map of Egercsehi (1863) shows forest cover in the study area, and describes it as pasture in the joint table *(Figure 3).* An explanation for this variance is given by exploring the livestock keeping methods of the 18th and 19th centuries as well as the question on

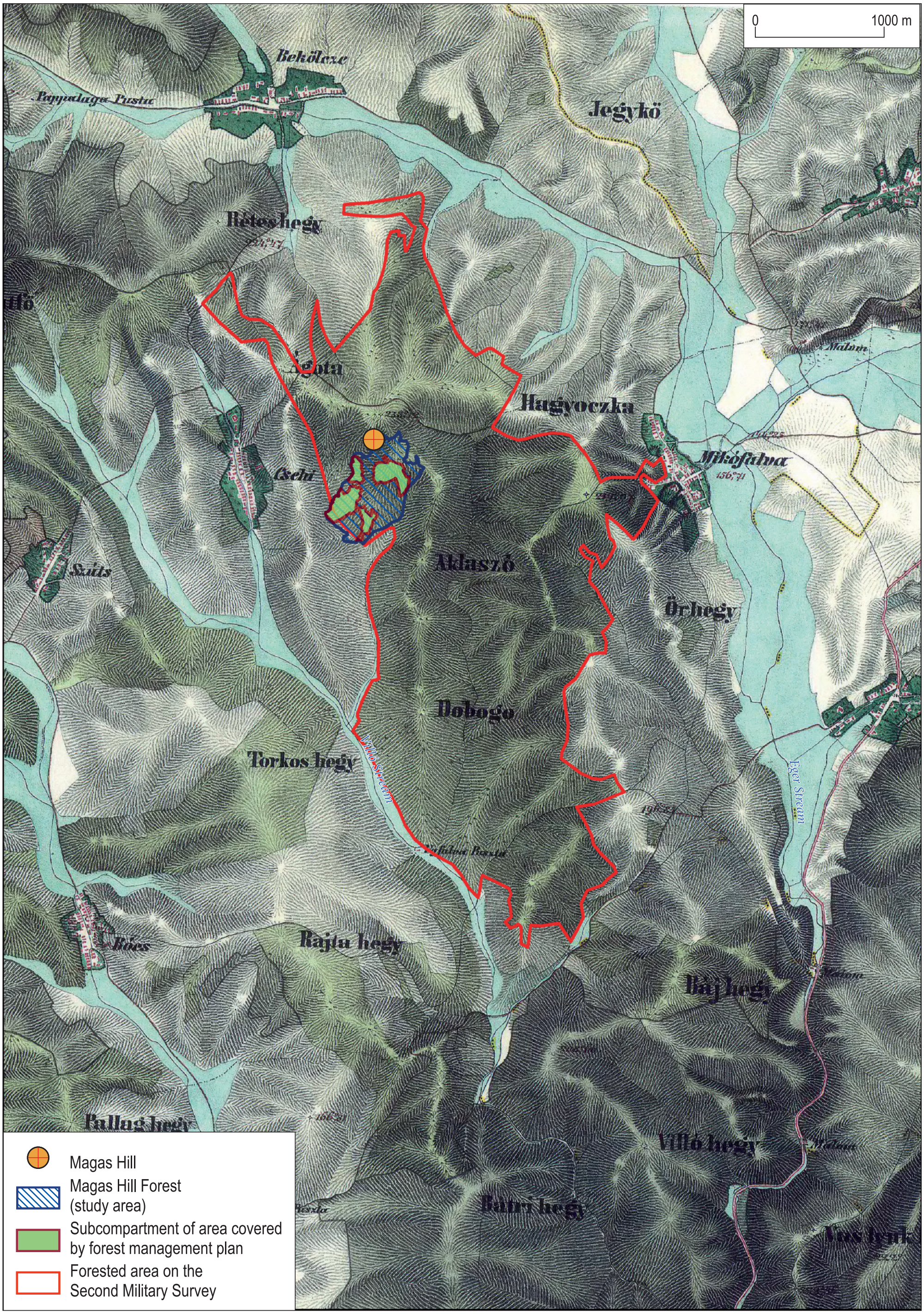


Fig. 2. The forest that covers Csornó Valley Hills still shown by the 2nd Military Survey

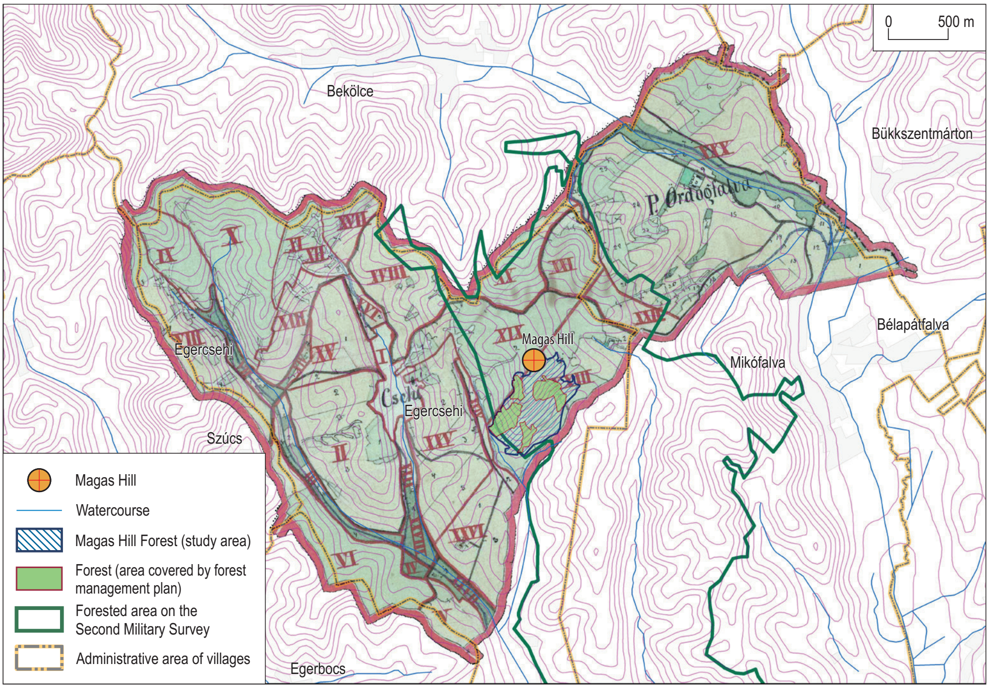


Fig. 3. The Magas Hill Forest, projected onto the cadastre map of 1863

pastures, forest ownerships, legal issues, use and management methods. The synthetic map of Hungarian forests (1896) does not show any forest between Mikófalva and Egercsehi.

Extended forests meant a main source of income for Mikófalva in the 18th century. A source from 1,700 mentions the forest as „forest of acorns", and writes about pigs consuming acorn there. Tenants had to pay significant services in return for the squires (Bakó, F. 1965).

In the documentation of a legal action (connected to use of pastures) in 1818, taxpaying tenants and cotters complain about nobles converting some parts of the common pasture to cropland. These common pastures were situated in their own forests, but they considered them as commons, and thus, complained about illegitimate occupation (Bakó, F. 1965). Land arrangement, or regulation, happened during 1829–1830. The administrative area of the village was regulated, but the pasture still remained common (Bakó, F. 1965; Soós, I. 1975).

According to the 2nd Military Survey, the surrounding hills were still totally covered by forests. Forest grazing went on in the area; mainly sheep grazed in the forests around Egercsehi and mainly pigs consumed acorns around Mikófalva. Thus, the forest functioned as a grazing forest, giving home for forest shepherding. This time, the registered land use type on the administrative area of Mikófalva was mainly forest. After the previously mentioned drastic measure of 1853, the process of separating forests and pastures owned by the former villeins from those owned by the former squire has finished until the late-1870s (Petercsák, T. 2002). This process has led to dramatic changes in the 800-ha big forest of the Csornó Valley Hills: the forests thinned and ceased due to uncontrolled grazing (forest shepherding) and wood-cuts (*Figure 4*).

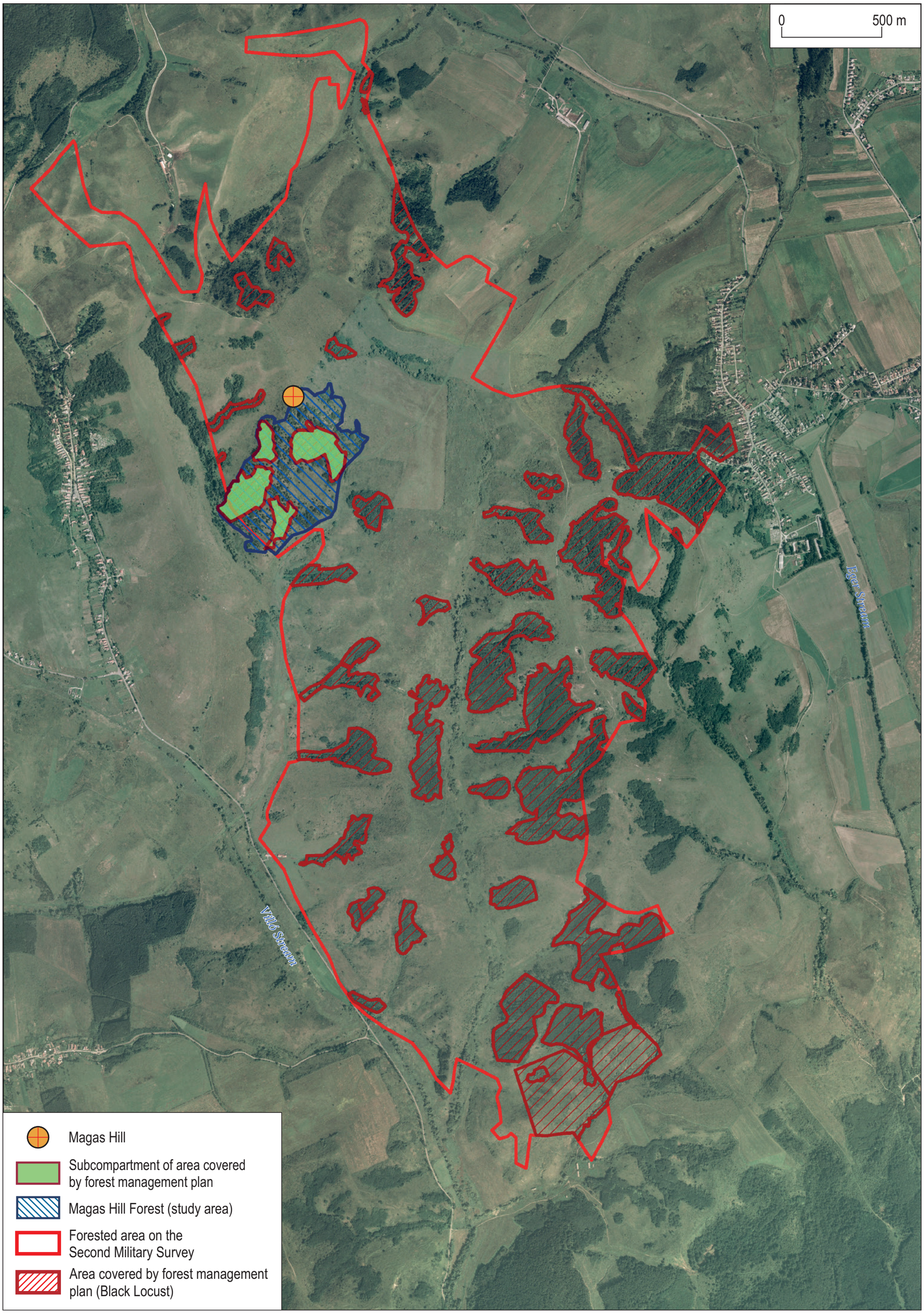


Fig. 4. Black locust stands replace today the 19th century 808.5 ha forest. These are not the remnants of one-time oak forests.

The current state

The size of the remained mosaic-like patch (closed forest, grazing forest, wood pasture, clearing, and grassland), i.e. the studied area is 35.3 ha. Understory is dominated by a mass of common hawthorn (*Crataegus monogyna*), dog-rose (*Rosa canina agg.*), sloe (*Prunus spinosa*) and wild privet (*Ligustrum vulgare*), the most problematic species being black locust (*Robinia pseudo-acacia*).

In the CORINE Land Cover database (CLC50) the Magas Hill Forest is covered by bushy woodland, natural regeneration area (3.2.4.3). 11.98 ha of the area was measured as forest during the forest management planning process in 2002, while 17.11 ha in 2013 *(Figure 5).* 6.58 ha of this belongs to forest land use type (compartments 5/E, 5/H and 5/I), while the rest is registered as pasture. Compartment 5 is surrounded by pasture, with several veteran trees in its upper region (within the area covered by forest management plan).

The main current processes on the remnant of the one-time wood pasture are scrub encroachment and afforestation. Northern slope of the Magas Hill is mowed by rotary mower or mower-conditioner. 5.61 ha of the area covered by forest management plan is registered in harvesting mode, the remaining 11.5 ha is registered as leave alone, i.e., total restriction (with soil protection purpose). Dominant tree species are downy oak (3.95 ha), Turkey oak (4.17 ha), and sessile oak (0.4 ha). Black locust has appeared about 25 years ago in the subcompartments 5/E, 5/G and 5/J (on 4.46 ha).

The area between Egercsehi and Mikófalva is dominantly covered by open grasslands. Relatively flat, round hilltops and slight hillsides dominate, with narrow and deep stretch-like valleys in between. The Csornó Stream passes from north towards south, with a wet, marshy stripe along.

Hilltops are bared with low grasslands, while hillsides are covered by groups of bushes and solitaire trees on the orienteering map from 1993. Scrubs are inter-related as a continuous patch in some places, and some patches of stingy weeds also occur on the mentioned map. Most of the open areas are low grasslands, maintained by mowing and/or grazing. Really impassable, dense scrubby vegetation is shown only in the deep valleys; these are young black locust stands according to our field investigations. Continuous closed forests comprise of black locust only, except for the Magas Hill oak grove and fringe vegetation along the stream.

Hilltop clearings start to decrease due to scrub encroachment from hillsides according to the orienteering map from 2001. The surrounding of solitaire trees, bushes and their groups has changed during the previous eight years. Scrubs compose a continuous web on the hillsides, and stingy weed patches cover greater area, as well. These scrub patches are mainly sloe (*Prunus spinosa*) stands according to our field investigations. Very dense and tall stands of black locust rule the valleys, characterized by sparsely vegetated forest floor. Black locust stands are surrounded by scrubby stripes, which further decrease the area of open grasslands. Thus, mowed and grazed grasslands represent a smaller area.

Average age of the oak trees are estimated between 61 and 73 years based on trunk perimeter at breast height; veteran trees, however, may be 150 to 250 years old based on the method of Radó, D. (1999). Over 200 veteran trees were measured during our field studies, with trunk perimeter between 200 and 260 cm; 14 of them are over 300 cm perimeter, the greatest one exceeding 420 cm. These veteran trees are living witnesses of the one-time forest that is presented on the 2nd Military Survey maps *(Figure 6, Photo 1).*

Discussion

The forest, which was continuous according to the military surveys and the related descriptions, comprised mainly oaks. At first roads were created on the area, later clearings were cut. The grazing forest has almost totally disappeared due to intensive grazing in the 19th and early 20th century (see the lack of pastures) and cuttings, only a small patch has

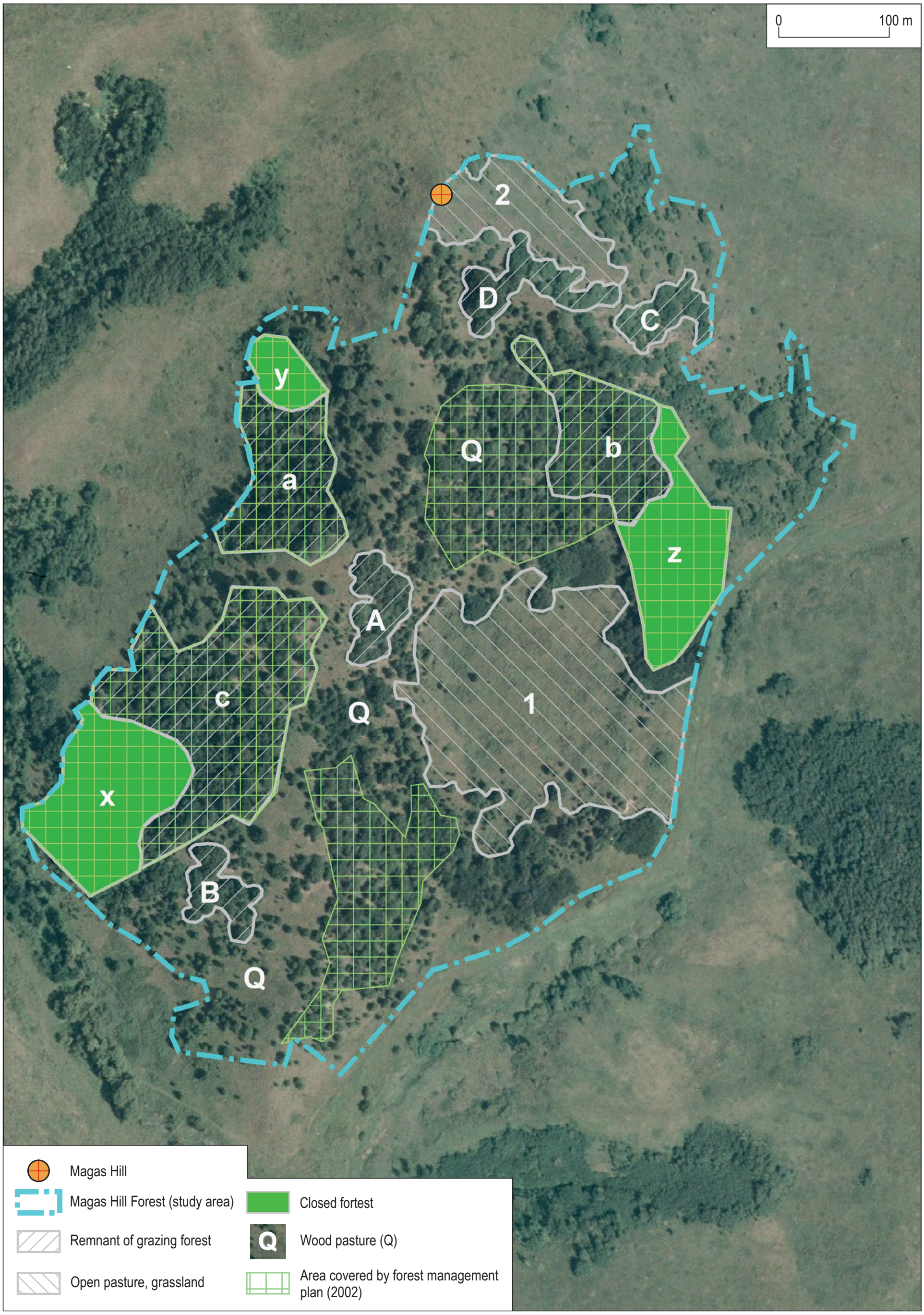


Fig. 5. Land cover categories and border of forest by planned management on the Magas Hill, projected onto aerial photo of 2005. – x, y, z = closed forest; A, B, C, D = remnant of grazing forest (outside forest); a, b, c = remnant of grazing forest (within forest); Q = remnant of wood pasture; 1, 2 = open pasture, grassland, meadow

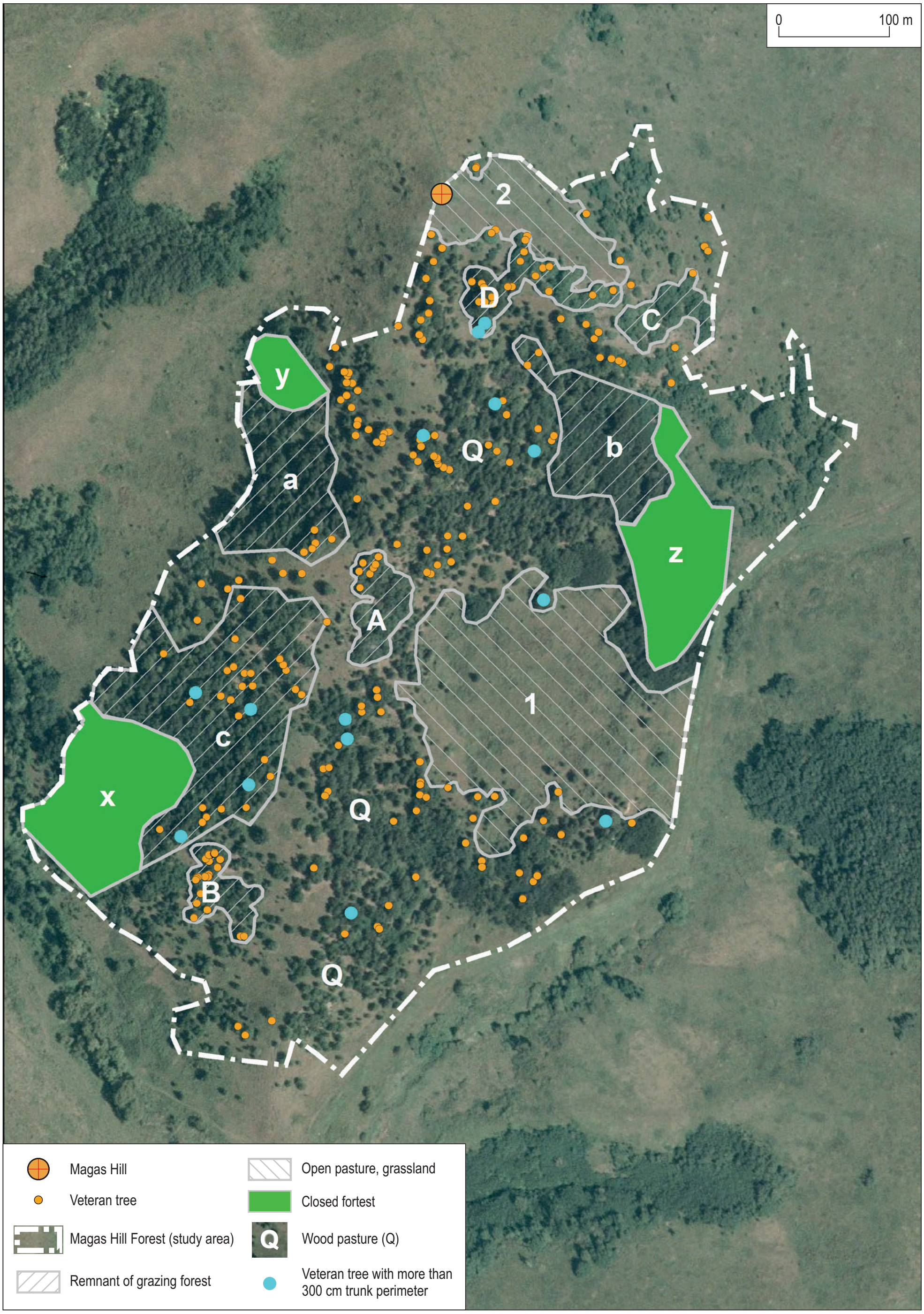


Fig. 6. Almost 200 years old veteran trees are the witnesses of the forest shown by the 2nd military survey map (compiled by Bartus, P. 28.08.2016). – A, B, C, Q, a, b, c, 1, 2 = for explanation see *Fig. 5.*

Photo 1. Situation of oak trees above 300 cm trunk perimeter (at breast height) in the Magas Hill Forest, projected onto aerial photo of 2005

remained near Egercsehi. As a consequence of the abandonment of forest grazing, and the decreasing number of grazing livestock in the past decades, even this remnant patch has severely changed: it has become shrubby and afforested. The original vegetation has almost totally been abolished by intensive scrub encroachment. Although the area is illustrated with forest cover on the 19th century maps, the geographical names refer to activities tied to livestock keeping and forest cutting.

The fact that the registered land use type of forests has become pasture after 1853 (according to the cadastre map of 1863) might be interpreted as an answer for forest protection measures. The deviation between the registered land use and the real land cover can be explained by the laws, changes in tenancy relations, and lack of pastures.

The fact that several veteran trees have got regular foliage refers to their open position 150 years ago and thus, being the remnants of an open wood pasture. Most of the oldest ones, however, have got irregular (asymmetric) foliage, referring to their growth in a less open grazing forest.

Rate of canopy in wood pastures is between 5 and 50 per cent. Abandoned wood pastures are affected by scrub encroachment and afforestation by young trees, leading to closing canopy. We estimate that 20.1 ha of the Magas Hill Forest (total 35.3 ha) can be handled as wood pasture remnant (56.9%).

Rate of canopy in grazing forests is between 50 and 80 per cent. Canopy of non-grazed forests can close until 100 per cent due to scrub encroachment and afforestation. This grove forest type covers only 6.8 ha in the Magas Hill Forest (19.3%). Thus, 76.2 per cent of the area can be considered as the degraded (afforested, closed) remnant of one-time forest shepherding. The remaining 23.8 per cent is open grassland, and closed young forest (dominated by black locust) *(Table 1, Photo 1).*

We experienced on the 2016 field studies that the state of the area has changed for the better compared to 2001. Sheep were grazing throughout every single time when we visited the study area, and we have also seen freshly mowed grasslands. Extension of the dense scrub patches (shown by the 2001 map) has also decreased. Fringe vegetation along the stream is well recognizable.

Although the orienteering maps are well detailed, their use is very rare in landscape history studies. An advantage of this method is that these maps are frequently corrected and improved due to regular orienteering contests and thus, one may gain detailed information even on tiny changes of a certain area. Its disadvantage is that the most important aim of these maps is easy readability (during orienteering, i.e., running), therefore, the only aspect of vegetation illustration is the hardness of running. Such maps ensure too little information for people without a routine, but an experienced orienteering run-

Table 1. Land cover categories in the Magas Hill Forest ("Nagy-lápa-dűlő")

Land cover	Area	
	ha	%
Closed forest (x, y, z) (rate of canopy 80–100%)	3.1	8.78
Remnant of grazing forest (A, B, C, D; a, b, c) (rate of canopy 50–80%)	6.8	19.26
Wood pasture (Q) (rate of canopy 5–50%)	20.1	56.94
Open pasture (1, 2)	5.3	15.02
Sum ("Nagy-lápa-dűlő")	*35.3*	*100.00*

ner can really imagine the area (and its true, actual state) even based on the map only.

Conclusions and suggestions

A mosaic-like, diverse, transitional landscape has evolved due to traditional livestock keeping, forest grazing (and acorn consumption). Wood pastures are the result of an organic management of the landscape (more than land use). The Magas Hill Forest is the remnant patch of a several century old 800-ha grazing forest, which evolved due to human shepherding activities. According to the evidence based by Military Surveys and their documentation, and ethnographical data, hills around Egercsehi and Mikófalva were once covered by an enormous continuous grazing forest. This has almost totally disappeared until nowadays, and there is no continuity between one-time oak forests and current black locust stands, except for a small 35.3-ha patch on the southern slope of the Magas Hill (called "Nagy-lápa-dűlő" in the past), a various mosaic of closed forest, degraded grazing forest, wood pasture, clearing, and grassland, with old (150–200 year) veteran trees. As a consequence of no management (abandonment of forest grazing), original vegetation has almost totally been abolished by invasive alien species.

Area of mowed, open grassland is 5.3 ha, while 20.1 ha commemorates on one-time wood pasture, the remaining area is shrubby (spontaneously) with afforestation.

The studied area is not listed in the Hungarian cadastre of wood pastures (Haraszthy, L. *et al.* 1997). This register lists six wood pastures in Heves County; this current one is the seventh, as it has only been 'discovered' during our filed investigations.

Wood pastures ensure a unique habitat for those species that live in the transition zone of forests and open areas. Their survival can be ensured only by maintaining the traditional way of management. Since they represent high landscape and nature value, and there is no chance to create similar habitats as a consequence of forest cuts, therefore, their reconstruction and conservation are essential, in line with the Sustainable Development Goals 15.1, 15.5 and 15.8 (Jancsovszka, P. 2016). It is obvious (based on literature sources that present the state of Hungarian wood pastures and grazing forests) that there is an urgent need for fast intervention and definite action. The Magas Hill Forest is privately owned and not protected by nature conservation laws. Therefore, it is vital to inform and advise the owner, investigate in research programs, meet the conditions for declaring the area as nature protected, develop management guidelines, complement law deficits, ensure maintenance costs, as well as reform the agricultural subsidy system.

The unique stand of veteran trees and the wood pasture landscape is still visible, and the process of scrub encroachment might by stopped by adequate management. The fight against them would cost millions of Euros (Demeter, A. *et al.* 2016). Thus, valuable habitats can be conserved. In favour of reconstruction of the wood pasture – grazing forest mosaic and maintenance of the desirable state, we suggest beef and sheep grazing, combined with mowing, depending on the state of afforestation, based on direct experience by the Bükk National Park Directorate.

***Acknowledgement*:** The authors give special thanks to the Bükk National Park Directorate for the opportunity to use its GIS software and aerial photographs, and Krisztián Kovács, head of Forestry Department for his valuable information. We are greatful to Imre Veres for the orienteering maps, and to Dr. György Rózsa, chief archivist at the Borsod-Abaúj-Zemplén County Archives as well as to the staff of Heves County Archives.

REFERENCES

Andrásfalvy, B. 2004. Hagyomány és környezet. Az elkülönözés és arányosítás következményei (Tradition and environment. Consequences of separation and scaling). *História* 26. (5): 19–20.

Bakó, F. 1965. Mikófalva (Village Mikófalva). *Az Egri Múzeum Évkönyve* 3. 181–243.

Barczi, A. and Nagy, V. 2016. Kurgans: Markers of the Holocene Climate Change(s). *Review of Faculty of Engineering Analecta Technica Szegedinensia* 10. (1): 47–52.

Bergmeier, E., Petermann, J. and Schröder, E. 2010. Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation. *Biodiversity and Conservation* 19. 2995–3014.

Csiffáry, G. and B. Huszár, É. 1999. *Heves megye II. József-kori katonai leírása (1783–1785)* (Military description of Heves County from the time of King Joseph the 2nd [1783–1785]). Eger, Heves Megyei Levéltár.

Demény, K. and Centeri, CS. 2008. Habitat loss, soil and vegetation degradation by land use change in the Gödöllő Hillside, Hungary. *Cereal Research Communications, Supplement* 36. 1739–1742.

Demeter, A., Sarlós, D., Skutai, J., Tirczka, I., Ónodi, G. and Czóbel, Sz. 2015. Kiválasztott özönfajok gazdasági szempontú értékelése – a fehér akác és a mirigyes bálványfa (Economic valuation of selected invasive species). *Tájökológiai Lapok / Journal of Landscape Ecology* 13. (2): 193–201.

Dövényi, Z. ed. 2010. *Magyarország kistájainak katasztere* (Inventory of microregions in Hungary). Bővített és átdolgozott kiadás, Budapest, MTA Földrajztudományi Kutatóintézet.

Fekete, G., Király, G. and Molnár, Zs. 2017. A Pannon vegetációrégió lehatárolása (Delineation of the Pannonian vegetation region). *Botanikai Közlemények* 104. (1): 85–108. DOI: 10.17716/BotKozlem.2017.104.1.85

Garbarino, M., Lingua, E., Martinez Subirá, M. and Motta, R. 2011. The larch wood pasture: structure and dynamics of a cultural landscape. *European Journal of Forest Research* 130. 491–510.

Geiger, B., Saláta, D. and Malatinszky, Á. 2011. Tájtörténeti vizsgálatok a kisgombosi fás legelőn (Studies on the landscape history of the wood pasture near Kisgombos). *Tájökológiai Lapok / Journal of Landscape Ecology* 9. (2): 219–233.

Gillet, F. 2008. Modelling vegetation dynamics in heterogeneous pasture-woodland landscapes. *Ecological Modelling* 217. 1–18.

Guszlev, A. and Zentai, L. 2000. *A tájfutótérképek nemzetközi szabványa* (International standard of orienteering maps). Budapest, ELTE Eötvös Kiadó.

Haraszthy, L., Márkus, F. and Bank, L. 1997. *A fás legelők természetvédelme* (Nature conservation of wood pastures). Budapest, WWF füzetek 12.

Hartel, T., Dorresteijn, I., Klein, C., Máthé, O., Moga, C.I., Öllerer, K., Roelling, M., Wehrden, H.V. and Fischer, J. 2013. Wood-pastures in a traditional rural region of Eastern Europe: Characteristics, management and status. *Biological Conservation* 166. 267–275.

Haw, K. 2012. Wood pasture: definition, restoration, creation – Practical Guidance. *WoodWise – Woodland Conservation News* 2012 / Winter, 1–15.

Holl, K. and Smith, M. 2002. *Ancient Wood Pasture in Scotland: Classification and Management Principles.* Scottish Natural Heritage Commissioned Report F01AA108.

Jancsovszka, P. 2016. Fenntartható fejlődési célok (Sustainable development goals). *Tájökológiai Lapok / Journal of Landscape Ecology* 14. (2): 171–181.

Jose, S. 2012. Agroforestry for conserving and enhancing biodiversity. *Agroforestry Systems* 85. 1–8.

Kenéz, Á., Szemán, L., Szabó, M., Saláta, D., Malatinszky, Á., Penksza, K. and Breuer, L. 2007. Természetvédelmi célú gyephasznosítási terv a pénzesgyőr–hárskúti hagyásfás legelő élőhely védelmére (Pasture management plan aiming nature conservation for the protection of the wood pasture between Pénzesgyőr and Hárskút). *Tájökológiai Lapok / Journal of Landscape Ecology* 5. (1): 35–41.

Király, G. ed. 2009). *Új magyar füvészkönyv. Magyarország hajtásos növényei. Határozókulcsok.* (Hungarian plant determination book). Jósvafő, Aggteleki Nemzeti Park Igazgatóság.

Molnár, Zs., Bölöni, J. and Horváth, F. 2008. Threatening factors encountered: Actual endangerment of the Hungarian (semi-)natural habitats. *Acta Botanica Hungarica* 50. 199–217.

Nagy, D. 2008. *A Gömör–Tornai-karszt történeti felszínborítása* (Historical land cover of the Gömör–Torna Karst). Jósvafő, ANP Füzetek 5.

Petercsák, T. 2002. Népi erdőbirtoklás és erdőhasználat (Rule and management of forests by the folk). In *A Bükki Nemzeti Park. Hegyek, erdők, emberek.* Ed.: Baráz, Cs., Eger, 467–474.

Pető, Á., Barczi, A., Joó, K. and Grónás, V. 2008. Phytolith analysis of modern soil profiles as a tool to demonstrate land use changes and anthropogenic impacts (Case study from the Bakony Mountains). *Cereal Research Communications* 36. 955–958.

Plieninger, T., Hartel, T., Martín-López, B., Beaufoy, G., Bergmeier, E., Kirby, K., Montero, M.J., Moreno, G., Oteros-Rozas, E. and Uytvanck, J.V. 2015. Wood-pastures of Europe: Geographic coverage, social-ecological values, conservation management, and policy implications. *Biological Conservation* 190. 70–79.

Radó, D. 1999. Bel- és külterületi fasorok EU-módszer szerinti értékelése (EU-standard evaluation of tree lines of inner parts and out skirts). *Lélegzet* 7–8. suppl.

Saláta, D., Pető, Á., Kenéz, Á., Geiger, B., Horváth, S. and Malatinszky, Á. 2013. Természettudományos módszerek alkalmazása tájtörténeti kutatásokban: Kisgombosi esettanulmány (Applying multidisciplinary approach in landscape history research: case study of Kisgombos wood pasture). *Tájökológiai Lapok / Journal of Landscape Ecology* 11. (1): 67 –88.

Saláta, D., Szabó, M., Kenéz, Á., Malatinszky, Á., Demény, K. and Breuer, L. 2007. Adatok a pénzesgyőr–hárskúti hagyásfás legelő tájtörténetéhez (Data to the landscape history of the wood pasture between Pénzesgyőr and Hárskút). *Tájökológiai Lapok / Journal of Landscape Ecology* 5. (1): 19–25.

Selmeci, M., Höhn, M. and Saláta, D. 2013. A lébényi Tölgy-erdő tájtörténeti kutatása (Studies on the landscape history of the Tölgy-erdő in Lébény). *Tájökológiai Lapok / Journal of Landscape Ecology* 11. (2): 261–277.

Soós, I. 1975. *Heves megye községei 1867-ig* (Villages of Heves County until 1867). Eger, Heves Megyei Tanács.

Szabó, M., Kenéz, Á., Saláta, D., Szemán, L. and Malatinszky, Á. 2007. Studies on botany and environmental management relations on a wood pasture between Pénzesgyőr and Hárskút villages. *Cereal Research Communications* 35. (2): 1133–1136. DOI: 10.1556/CRC.35.2007.2.242

Téglás, K. 1902. A legelőkérdés erdőgazdasági és közgazdasági szempontból (The pasture issue from management and economy aspects). *Erdészeti Lapok / Journal of Forestry* 41. (10): 1117–1142.

Vandenberghe, C., Freléchoux, F., Moravie, M.-A., Gadallah, F. and Buttler, A. 2007. Short-term effects of cattle browsing on tree sapling growth in mountain wooded pastures. *Plant Ecology* 188. 253–264.

Zagyvai, G. and Bartha, D. 2015. Nyírségi erdőtömbök és környezetük tájtörténeti vizsgálata (Landscape history research on notable forests and their surroundings in Nyírség). *Tájökológiai Lapok / Journal of Landscape Ecology* 13. (1): 59–72.

Map sources:

http1: Maps Hungaricana database. – https://maps.hungaricana.hu/hu/

http2: Aerial photographs (1959–2005). Budapest, Institute of Geodesy Cartography and Remote Sensing. –http://www.fentrol.hu/hu/

Military Surveys I (1764–1784); II (1806–1869); III (1869–1887). Mapire database. Budapest, Arcanum Database Ltd. – http://mapire.eu/hu/

DOI: 10.15201/hungeobull.67.1.3 Hungarian Geographical Bulletin **67** 2018 (1) 29–42.

Drought monitoring of forest vegetation using MODIS-based normalized difference drought index in Hungary

András GULÁCSI[1] and Ferenc KOVÁCS[1]

Abstract

In this paper, several spectral indices based on spectral reflectance data from the Terra satellite's Moderate Resolution Imaging Spectro-radiometer (MODIS) sensor were evaluated in terms of their practical applicability for quantifying drought intensity and its geographical effects to support the drought monitoring applications. A total number of 358 MODIS 8-day composite images for the period between 2000 and 2014 were acquired and processed for the analysis; the frequency of drought phenomenon was increased during this time period. Vegetation indices, water indices, and combinations of both, which were called drought indices, were used. To validate the results, regression analyses were performed and Pearson's r values were calculated. The Pálfai Drought Index (*PAI*) and the average annual yields of different crops were used as reference data. The Normalized Difference Vegetation Index (*NDVI*), the Difference Vegetation Index (*DVI*), the Normalized Difference Water Index (*NDWI*), the Difference Water Index (*DWI*), the Difference Drought Index (*DDI*), and the Normalized Difference Drought Index (*NDDI*) were found to be significant in quantifying drought intensity. Anomalies relative to the average of the period between 2000 and 2014 were calculated and standardized using the standard deviation, enabling the identification of above-average, drought-stricken areas. The results of this study can be used to create a cost-effective, near real-time and currently missing national drought monitoring system with high temporal resolution to detect regional climate changes, and to assess forest damage probability through changes in the chlorophyll and water content of forest vegetation.

Keywords: drought, monitoring, spectral index, MODIS, NDDI, PAI.

Introduction

Hungary is frequently impacted by droughts that severely affect agricultural production and cause substantial economic damage (145 million USD annually). Therefore, it is essential to investigate the possibility of artificial groundwater recharge, as well as water retention behind river dams, in order to moderate the decline of available water resources needed for irrigation in the region. Moreover, the possible effects of climate change must also be accounted for in order to implement an effective spatial planning for national climate adaptation. According to the guidelines of the International Commission on Irrigation and Drainage (ICID, 2016), when precipitation cannot satisfy water needs because there is a large deficit compared to normal or expected precipitation that extends over a long time period, then there is a drought.

Meteorological droughts are characterized by substantially reduced rainfall compared to the multi-year average, coupled with air temperatures exceeding the average and low relative humidity. The percentage of blocking-related warm temperature extremes exceeds 80 per cent in large continental regions north of 45° N (Shaw, A.T. *et al.* 2016). Most of the large drought events are caused by blocking anticyclones. The term "agricultural drought" refers to a shortage of water in the root zone of crops, such that the yield of plants is reduced considerably. Agricultural droughts can be observed and monitored effectively using satellite imagery and field measurements.

[1] Department of Physical Geography and Geoinformatics, University of Szeged, PO Box 653, H-6701 Szeged, Hungary. E-mails: guland@protonmail.com, kovacsf@geo.u-szeged.hu

The aims of this study were to monitor the effects of droughts through biophysical changes on forest vegetation, determine the practical applicability of spectral indices calculated from MODIS sensor data collected by NASA's Terra satellite, and calculate the trend in drought intensity. The results can be used to create a near real-time drought monitoring system to assess agricultural and forest drought damage.

This study is a culmination of our earlier methodological developments in drought assessment through changes in vegetation canopies and biomass (Kovács, F. 2007; Gulácsi, A. and Kovács, F. 2015).

Review of applied spectral indices

Multispectral vegetation indices – thanks for the AVHRR sensor – have been in use for decades in real-time monitoring of drought (Kogan, F.N. 1995). In general, greenness-related vegetation indices such as the Normalized Difference Vegetation Index (*NDVI*) and the Enhanced Vegetation Index (EVI) are used (Rouse, J.W. *et al.* 1973; Solano, R. *et al.* 2010). U.S. Drought Monitor (DM) uses the Vegetation Health Index (VHI) which is calculated using linearly-scaled *NDVI* and brightness temperature data from AVHRR.

However, there is a need to evaluate the sensitivity of water-related vegetation indices that use the short-wave infrared (SWIR) bands to assess the shortage of water and associated impacts (Bajgain, R. *et al.* 2015). Absorption by the chloroplasts of healthy vegetation is high in the visible wavelength range because of intensive photosynthesis. If the chlorophyll content decreases, the absorption will also decrease. In contrast, dry and unhealthy vegetation canopies with lower chlorophyll contents have lower *NDVI* values, because the reflectance in the visible red channel is increased at the same time that the reflectance in the NIR channel, which is located at the high reflectance plateau, decreases. EVI is an *NDVI* variant that includes correction factors for minimizing atmospheric effects and removing soil-brightness induced variations. Generally, EVI is more exact than *NDVI*, but surfaces covered with quasi-natural vegetation in regional scale can be evaluated better with *NDVI* (Li, Z. *et al.* 2010).

NDVI provides information on vegetation greenness or chlorophyll content, which are not directly related to vegetation water content (VWC) because, as summarized by Ceccato, P. *et al.* (2002), each species has its own characteristics in terms of chlorophyll content and water content. Thus, a decrease in chlorophyll content does not imply a decrease in water content, and a decrease in water content does not imply a decrease in chlorophyll content. However, numerous water indices have been developed that are suitable for quantifying VWC. Absorption by vegetation liquid water in the NIR channel is negligible, while in the SWIR channel it is very high. If VWC decreases, then reflectance in the SWIR channel increases significantly. Thus, the Normalized Difference Water Index (*NDWI*) value – that combines information from the NIR and the SWIR bands – decreases, reflecting dry vegetation that is experiencing drought stress (Gao, B-C. 1996). *NDWI* is one of the indicators implemented within the European Drought Observatory (EDO).

Ceccato, P. *et al.* (2001) demonstrated that remote sensing using the SWIR wavelength range is critical, but not sufficient, for retrieving VWC because two other leaf parameters (internal structure and dry matter) are also responsible for leaf reflectance variations in the SWIR channel. The NIR channel is needed to account for variations in leaf internal structure and dry matter. Thus, a combination of the SWIR and NIR channels is required to retrieve VWC. Ceccato, P. *et al.* (2002) developed and tested a NIR-SWIR-based index called Global Vegetation Moisture Index (GVMI). It was sensitive to the mass or volume of water, rather than to the fractional percentage of water in vegetation canopies.

Jackson, T.J. *et al.* (2004) used Landsat data-derived *NDVI* and *NDWI* values to map VWC in corn and soybean fields. Compared to *NDVI*, *NDWI* was found to be superior, based upon a quantitative analysis of the bias and standard error. Chen, D. *et al.* (2005) found that both $NDWI_{1640}$, which uses the SWIR band centred at 1,640 nm, and $NDWI_{2130}$, which uses the SWIR band centred at 2,130 nm, derived from MODIS data covering corn and soybean fields had potential for VWC estimation.

Gu, Y. *et al.* (2007, 2008) concluded that *NDWI* reacts more sensitively to drought conditions than *NDVI*. Gu, Y. *et al.* (2007) used MODIS surface reflectance data and introduced the Normalized Difference Drought Index (*NDDI*) by combining *NDVI* with *NDWI*.

Zhang, N. *et al.* (2013) proposed a MODIS-based visible and shortwave infrared drought index (VSDI) for monitoring both soil and vegetation moisture using the NIR channel, the visible blue channel, and the SWIR channel (centred at 2,130 nm), and proved the applicability of VSDI as a drought indicator.

The Normalized Multi-Band Drought Index (NMDI) combines the NIR and the SWIR channels centred at 1,640 nm and 2,130 nm from MODIS data (Wang, L. and Qu, J.J. 2007). They found that NMDI is well-suited to estimate the water content of soil and vegetation. Moreover, because it combines information from multiple NIR and SWIR channels, NMDI has an enhanced sensitivity to drought severity.

Data and methods

MODIS data processing and software used

MOD09A1 (Collection 5) 500-m resolution 8-day surface reflectance composite images (Surface Reflectance 8-Day L3 Global 500 m SIN Grid) provided the basis for this study. The MODIS data covering the 89th through the 273rd days of each year from 2000 to 2014 were downloaded from the Land Processes Distributed Active Archive System and accessed from the USGS Global Visualization Viewer (GLOVIS). A total number of 358 images were obtained.

The main advantage of using MODIS data is the high temporal resolution (daily images are available) and the composite image technology which enables to create an 8-day or 16-day composite from the highest quality pixels, that is, free of atmospheric effects like cloud cover and shadow. The disadvantages of MODIS are the moderate geometric resolution (250 or 500 meters) and the data is from 2000, so that we do not have more decades of available satellite imagery like Landsat does. For the specifications about the MODIS surface reflectance data (see Vermote, E.F. *et al.* 2011).

The data were processed as follows. (1) The MODIS HDF data were converted into GeoTIFF format and re-projected into WGS 84 and UTM zone 34N using the nearest neighbour resampling method, in order to keep the QA bit field values unchanged. (2) Cells with inaccurate or inconsistent values, which were mainly caused by cloud cover, were masked out using the Quality Control and State Flag bands; only the best quality cells were kept. (3) A subset of the data corresponding to the study area was selected. Data were re-projected to Hungarian National Projection (EOV). Finally, (4), the spectral indices were calculated.

The following programs were used for data processing, analysis, and mapping: SAGA GIS 2.1.2, QGIS 2.8.2-Wien (with Python 2.7.5 and GDAL 1.11.2), R 3.2.1 (R Core Team, 2013), LDOPE Tools 1.7 and the MODIS Reprojection Tool 4.1 (Roy, D.P. *et al.* 2002), and the authors' own programs that were written in the C language using the Code: Blocks 10.05 IDE. Processing was automated using Python and command line scripts.

Calculation of spectral indices

NDVI and NDWI were calculated according to equations (1) and (2):

$$NDVI = \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + \rho_{red}} , \quad (1)$$

and

$$NDWI = \frac{\rho_{NIR} + \rho_{SWIR}}{\rho_{NIR} - \rho_{SWIR}} , \quad (2)$$

where *NDVI* = Normalized Difference Vegetation Index, *NDWI* = the Normalized Difference Water Index, ρ_{red} = the visible red channel (620–670 nm), ρ_{NIR} = the near infrared channel (841–876 nm), and ρ_{SWIR} = one of the middle infrared channels (2,105–2,155 nm) measured by the MODIS sensor. Normalized Difference Drought Index (*NDDI*) is calculated from *NDVI* and *NDWI* according to equation (3) (Gu, Y. *et al.* 2007):

$$NDDI = \frac{NDVI - NDWI}{NDVI + NDWI} \quad , \tag{3}$$

In spite of the quality assessment, extreme negative and positive *NDDI* values may result from this calculation, but it only affects a small number of cells in cases with large open water surfaces and built-up areas. These have to be removed. Gu, Y. *et al.* (2007) removed spike points (e.g. abnormally high values) from *NDWI* time series by using a quality assurance (QA) mask before calculating *NDDI*. On the other hand, Renza, D. *et al.* (2010) rescaled *NDVI* and *NDWI* into the 8-bit interval (from 0 to 255) in order to force the *NDDI* values into the range of –1 and +1. This rescaling is unnecessary step, so it was not used here. Simple difference indices were calculated as well, according to equation (4):

$$DDI = DVI - DWI \,, \tag{4}$$

where *DDI* = Difference Drought Index, *DVI* = Difference Vegetation Index (Tucker, C.J. 1980), *DWI* = Difference Water Index (Zhang, D. *et al.* 2013). *DVI* = $\rho_{NIR} - \rho_{red}$, and *DWI* = $\rho_{NIR} - \rho_{SWIR}$. These difference indices are rarely used; because they lack a normalization step, they do not compensate for different irradiational conditions (Tucker, C.J. 1979).

To make different time periods directly comparable with each other on the same scale, standardization with the SD was applied to every cell separately. The resulting standardized spectral index is calculated according to equation (5):

$$Z_{ij} = \frac{x_{ij} - \bar{x}_{ij}}{SD_{ij}} \quad , \tag{5}$$

where Z_{ij} = the standardized spectral index (Z-score value), *i* and *j* = the row and column number of the current cell, x_{ij} = the current value of any given spectral index, $\bar{x}_{ij}$ = the average of the spectral index values for the reference period from 2000 to 2014, and SD_{ij} = the standard deviation of the spectral index values for the reference period.

It should be noted here that the anomalies are dependent on the time series available to calculate the mean values and the standard deviations. This period, which is currently 15 years, should be long enough to characterize the area where the index is being calculated.

Reference data and statistical analysis

The Pálfai Drought Index (*PAI*) is commonly used in Hungary, and it is an annual index aggregated at country level. Its base value (PAI_0) is calculated from daily temperature and precipitation time series using equation (6):

$$PAI_0 = \frac{T_{(Apr-Aug)}}{P_{(Oct-Aug)}} \cdot 100 \quad , \tag{6}$$

where PAI_0 = the base value of Pálfai Drought Index, the $T_{(Apr-Aug)}$ = the average temperature for the period between April and August, and $P_{(Oct-Aug)}$ = the monthly weighted sum of precipitation for the period between October and August. The units of this quantity are °C/100 mm. The corrected *PAI* value is obtained by multiplying PAI_0 with empirical correction factors, according to equation (7) (Pálfai, I. 1989):

$$PAI = PAI_0 \cdot c_t \cdot c_p \cdot c_{gw} \quad , \tag{7}$$

where c_t = the correction factor for temperature, c_p = the correction factor for precipitation, and c_{gw} = the correction factor for groundwater levels (not discussed in detail).

In addition to *PAI*, the annual average crop yields (kg/ha) of barley, corn, and wheat were also used as reference data. The source of these data is the Hungarian Central Statistical Office (HCSO). The whole-country aggregated mean of spectral indices were compared to the whole-country mean of *PAI* and crop yields data.

Unfortunately, the limited access to reference data confined our options in validating the results. Pearson's *r*-values were calculated and the Mann-Kendall test was used to assess the significance of the fitted trends.

Delineating forest vegetation for drought monitoring

Caution needs to be taken when using any sort of spectral indices for remote sensing of drought, because land cover changes resulting in removal of vegetation (such as the opening of surface mines, deforestation, forest fires, and harvest of arable land) may be confused with areas experiencing drought. Accurate drought monitoring can only be accomplished when we are able to accurately delineate cells with vegetation cover and exclude all the cells that are affected by land cover change. We decided to monitor drought over forest vegetation, because the chlorophyll and VWC of trees are highly sensitive to drought conditions; they are thus good indicators of drought. In addition to multi-year fluctuations, it may be possible to detect short-term effects of climate change on drought conditions via vegetation changes. However, a longer time period is needed to assert with certainty that these changes were indeed the result of alterations in climatic conditions. High-amplitude multi-year fluctuations in drought intensity can suppress the increasing trend in aridity.

Forest covered areas were delineated using the European Union's Corine Land Cover (CLC) datasets covering the years 2000, 2006, and 2012. The CLC is an inventory of land cover that includes 44 classes. It is presented as a cartographic product with a scale of 1:100,000 (EEA). Sub-setting was carried out as follows. For the period from 2000 to 2005, the CLC 2000 land cover database was used; for the period from 2006 to 2011, the CLC 2006 land cover database was used; and finally, for the period between 2012 and 2014, the CLC 2012 land cover database was used. The spatial resolution of the available satellite imagery did not allow the precise evaluation of the heterogeneous land cover characterizing the study area. To overcome this problem, only so called representative pixels were considered (Kovács, F. 2007). A pixel was representative if two third of its area was dominated by the same land cover. The class of forests was subdivided into deciduous, coniferous, and mixed forest categories.

Study area

Hungary is located in East Central Europe in the middle of the Carpathian Basin. According to the Köppen-Geiger climate classification system (Peel, M.C. *et al.* 2007), the country has a humid continental climate without a dry season and with warm summers. The annual mean temperature is between 10–11 °C, and the annual total precipitation is between 500–750 mm on average (Hungarian Meteorological Service). The study area is the Danube-Tisza Interfluve landscape, which is located within the lowlands of the Great Hungarian Plain, between the Danube and Tisza rivers *(Figure 1).* It has elevations below 200 m in elevation and has a total area of 15,000 km^2. It is an agricultural region with intensive forestry.

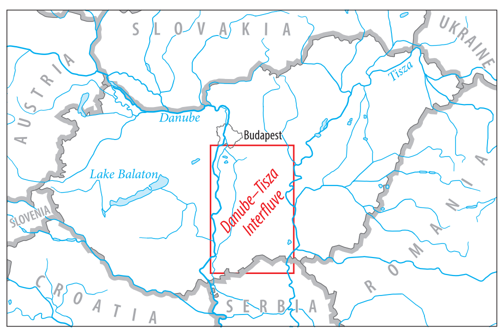


Fig. 1. The location of the study area inside Hungary

The Danube-Tisza Interfluve has been experiencing aridification during the past several decades, which has caused a decline of 250–300 cm in groundwater levels between the base period of 1956–1960 and the mid-1990s (VITUKI, 2006). The water balance of the landscape is persistently negative. It is estimated that, from the mid-1970s to 2003, there was a water deficit of 5 km^3 (Rakonczai, J. 2011). The central parts of the Danube-Tisza Interfluve are 40–80 m above river water levels; the effect of the rivers thus is only detectable in narrow regions around the rivers. The recharge of the water supply depends only on the precipitation the region receives. Based on regional hydrological models using MODFLOW, the decline in annual precipitation is contributing 80 per cent of the groundwater decline in the area (Völgyesi, I. 2000). Climate models project increasing drought hazard in the Carpathian Basin. More frequent and severe droughts have already caused significant agricultural yield losses in recent decades (Mezősi, G. *et al.* 2016).

The suggestion that alterations in climatic conditions may also occur over shorter time intervals (Kovács, F. 2007) might have some validity here because this landscape has considerable sensitivity to climate change. It is the reason why we chose this rapidly changing landscape as our study area.

Results

Monitoring drought intensity with NDDI and determining the trend in aridity

In 2000 the areas occupied by deciduous, mixed, and coniferous forest were 42,527 ha, 45,892 ha, and 16,528 ha, respectively. In 2006 the areas of deciduous, mixed, and coniferous forest were 58,234 ha, 45,827 ha, and 15,819 ha, respectively. Finally, in 2012, the areas of deciduous, mixed, and coniferous forest were 55,808 ha, 37,241 ha, and 9,917 ha, respectively. The area of deciduous forest increased from 2000 to 2012. The area of mixed forest was practically unchanged from 2000 to 2006. It subsequently declined by 19 per cent by 2012. An astonishing 37 per cent of the area covered by coniferous forests was deforested between 2006 and 2012. The base map of MODIS cells representing deciduous, mixed, and coniferous forests on the Danube-Tisza Interfluve in 2012 is shown in *Figure 2.*

After masking out cells with inappropriate values, the number of valid cells was reduced slightly. In addition, 16 large positive outliers (with Z-score values > 1.75) in the period between 2006 and 2011 were removed because of deforestation. In each of the five-year periods (2000–2005, 2006–2011, 2012–2014), the following numbers of cells were removed from the areas covered by each of the forest types: deciduous forests: none, 2, and 1; mixed forests: 4, 5, and 6; and coniferous forests: 1, 63, and 1, respectively (the removals had negligible effect on the results). The standardized *NDDI* images were reclassified as follows. Non-drought areas were indicated by Z-score values less than or equal to 0.0, whereas drought areas were indicated by Z-score values above 0.0.

Nonetheless, it should be noted that the drought phenomena may not have a clear-cut boundary. In addition, the low spatial resolution makes it impossible not to make abrupt boundaries. Positive deviations from the mean indicate higher likelihood of drought; negative deviations mean the opposite.

Based on *NDDI*, in the period between 2000 and 2005, 85.4 per cent of the cells (38,894 ha) exceeded the average of the reference period. This quantity was 20.3 per cent (11,827 ha) in the period between 2006 and 2011, and it was 17.2 per cent (9,573 ha) in the period between 2012 and 2014 for deciduous forests. In the case of mixed forests, 72.0 per cent (32,970 ha), 17.2 per cent (7,856 ha) and 22.0 per cent (8,178 ha) were above average, respectively. Finally, in the case of coniferous forests, 36.3 per cent (5,989 ha), 26.9 per cent (3,885 ha), and 18.7 per cent (1,846 ha) were above average, respectively. The areal coverage of drought is higher in deciduous forests than in coniferous forests. However, in the period between 2012 and 2014 the percentage of drought-stricken area is a little bit higher

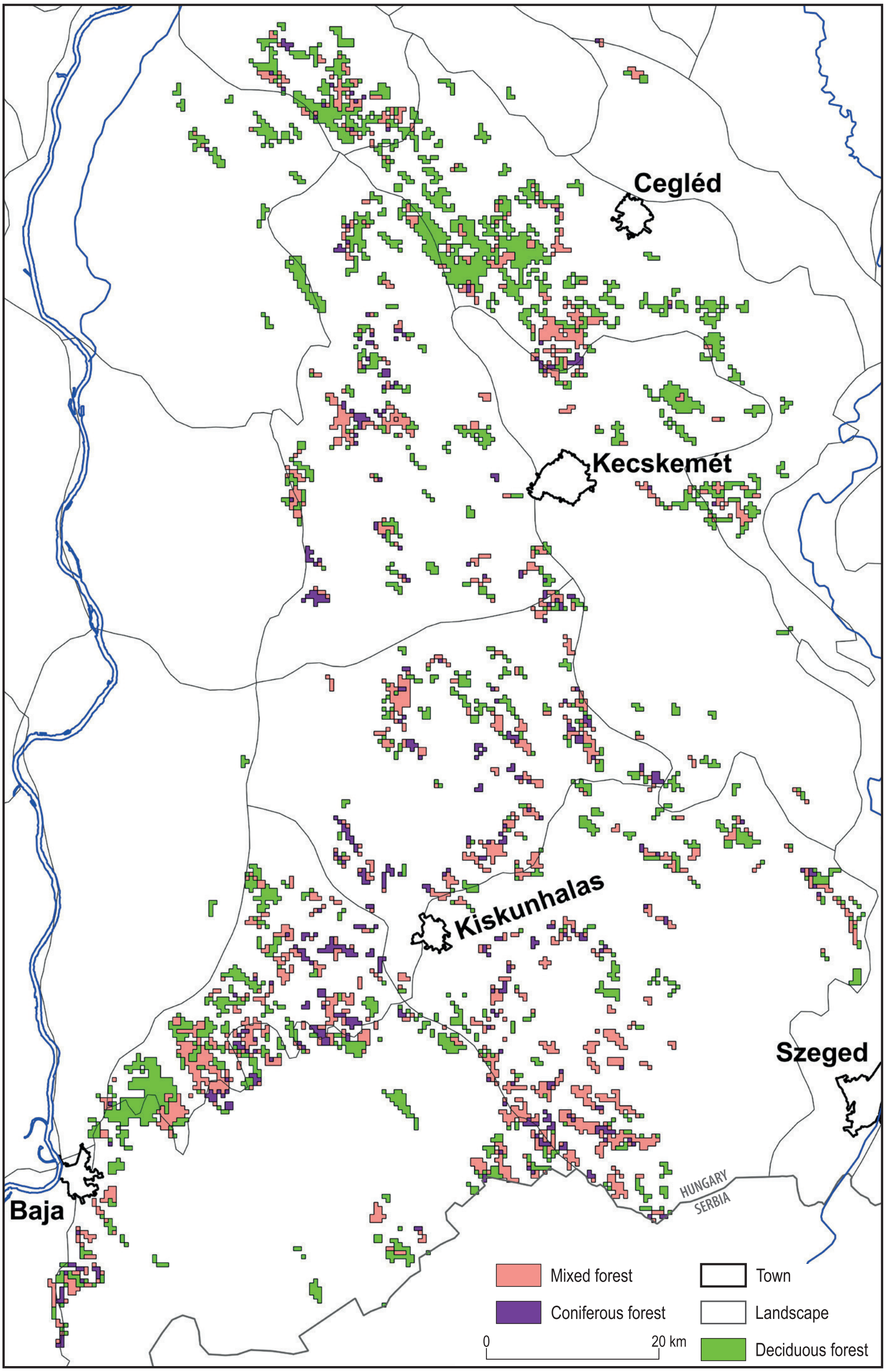


Fig. 2. Representative cells containing deciduous, mixed, and coniferous forests in the study area in 2012. Red lines indicate geographic landscape boundaries.

in coniferous forests than in deciduous forests. Drought-stricken areas of mixed forests slightly increased in the last period. These differences are not significant, and do not change the fact that coniferous forests (made up of *Pinus*) appear to be more drought-tolerant compared to deciduous forests (made up of *Robinia*, *Populus*) planted on the landscape.

The drought intensity was higher during the period between 2000 and 2005, since there were intense drought years (2000, 2001, 2002, and 2003). In particular, 2003 was one of the most severe droughts on record, based on the spectral indices and *PAI*. Since then, a decrease in drought intensity has been observed. In the box plot *(Figure 3)*, the period between 2000 and 2005 stands out, and the following periods of 2006–2011 and 2012–2014 reflects less intensive drought conditions. There were drought years (2007, 2009 and 2012) during these periods as well, but they were surpassed by the large droughts of the early 2000s in terms of their intensity.

Because of the lack of annual land cover assessment, changes in forest cover may not be fully accounted for by the Corine land cover assessments, which are made every 5 or 6 years. Therefore, even though outliers were removed, the median was used, since the arithmetic mean is sensitive to extreme values. It has been found that coniferous forests have larger mean *NDDI* values compared to the other forest types. Additionally, 2009 stands out as having the second highest median after 2003. Deciduous forests have the smallest medians; the second largest drought was in 2000. In the case of all three time series, the same drought pattern is observable but with a different ranking of drought years; however, 2003 has the largest median in every series. The drought years were 2000, 2001, 2002, 2003, 2007, 2009, 2011 and 2012. Interestingly, the coniferous forests reflect drought in 2011, rather than in 2012. Subsequent drought- and non-drought years (2003–2004, 2006–2007) have marked differences (22–30%) in median values *(Figure 4)*.

The significance of the fitted linear trends was evaluated by the Mann-Kendall test with no correction for autocorrelation, since the time series are not auto-correlated. It was concluded that, in the case of deciduous and mixed forests, *NDDI* does not show any significant monotonic decreasing trend ($p = 0.14$, $p = 0.06$, respectively) during the examined period. On the other hand, for coniferous forests, a decreasing trend was found to be significant at the $p < 0.05$ level. However, it was not accepted either, because the decreasing trend is likely an artefact of the large droughts of the early 2000s. Drought maps were also created for every year during the examined period *(Figure 5)*.

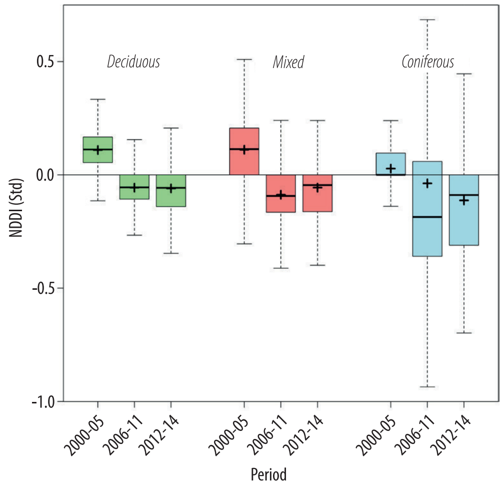


Fig. 3. Boxplot of standardized *NDDI* values for deciduous, mixed, and coniferous forests. Outliers were omitted from the graph. Crosses indicate the arithmetic mean values. Note the wide range of the whiskers in case of coniferous forests in 2006–2011. There are also substantial gaps between the arithmetic mean and median values. These gaps are caused by positive outliers, which were removed afterwards.

Validation of results

Linear regressions were applied to characterize the statistical connection between the annual average of spectral indices and the Pálfai Drought Index (*PAI*). In addition to Pearson's r values, the statistical significance levels were given as well. The normalized versions (*NDVI* and *NDWI*) performed better

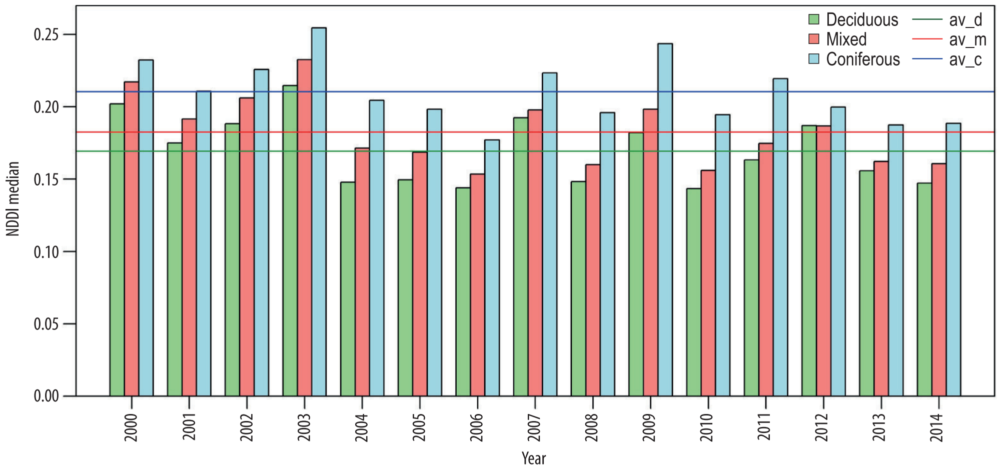


Fig. 4. Barplot showing the median of *NDDI* in the examined years for deciduous, mixed, and coniferous forests. Coloured lines indicate the average of the medians as the drought threshold limit (*av_d* is the average for deciduous forests, *av_m* is the average for mixed forests, and *av_c* is the average for coniferous forests).

(r is −0.90 and −0.92 with *PAI*, respectively). On the other hand, the drought indices performed worse. *DDI* shows a moderate correlation with *PAI*. However, *NDDI* showed the weakest correlation based on linear regression, although it incorporates information on the chlorophyll and VWC of the vegetation.

PAI is an indicator of meteorological drought. On the other hand, spectral indices represent agricultural drought. Therefore, they do not necessarily match every year. Lag effects must also be taken into consideration. For example, one year's recharge of groundwater and soil moisture can moderate agricultural drought in the following year, so that crops have sufficient water reserves. Under such circumstances, the groundwater level is elevated, enabling plants to utilize it. Thus, plants can grow normally, even if there is an ongoing meteorological drought *(Table 1).*

Connections with crop yield data obtained from HCSO were evaluated as well. A regression was performed for the 'Non-irrigated arable land' class (code 212) of the Corine Land Cover Database 2012 because, unfortunately, no data on the production area of different crops are available. The results of this analysis are shown in *Table 2.*

Table 1. Correlation matrix[a] between the spectral indices[b] and PAI for the period between 2000 and 2014.

Spectral index	Correlation with PAI
NDDI	0.64*
DDI	0.80***
NDVI	− 0.90***
DVI	− 0.81***
NDWI	− 0.91***
DWI	− 0.87***

[a]Pearson's r; [b]April-August average, including the 89th through the 273rd days of each year. Significance levels: *P ≤ 0.05, ***P ≤ 0.001, according to a two-tailed t-test.

For the period between 18 and 25 of June, *NDDI* and *DDI* have the highest correlations with barley, corn, and wheat yields. The vegetation and water indices have lower correlations with barley, corn, and wheat yields. For example, the vegetation indices have no significant connections with corn yields. *NDWI* displays a weak correlation with corn yields, but shows higher correlations with those of barley and wheat. On the other hand, for the period between 12 and 9 of July, *NDDI* and *DDI* have slightly lower correlations with crop yields compared to the vegetation and water indices. In the case of corn, the vegetation and water indices performed best. In

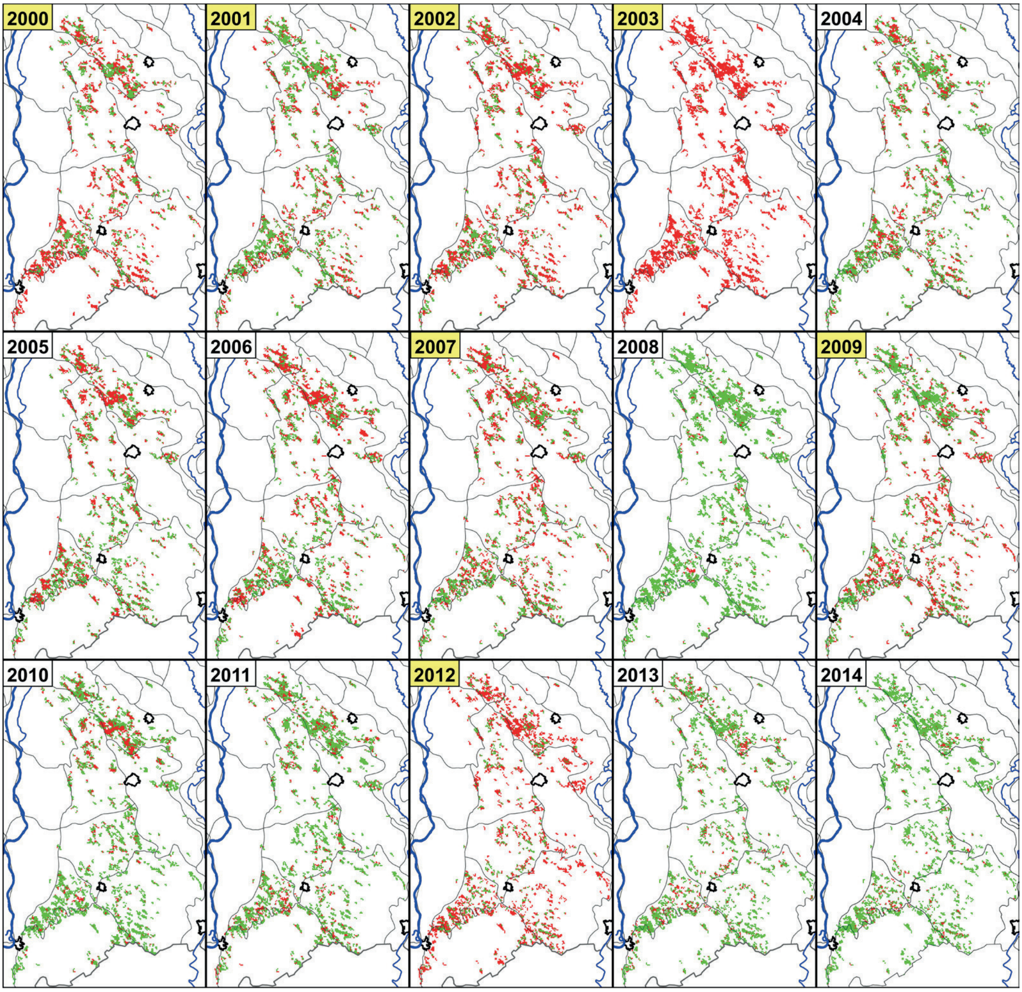


Fig. 5. Growing season *NDDI* averages, standardized and reclassified into drought and non-drought categories. Outliers have been removed. Drought years were highlighted with yellow background. Although large areas were drier than average in 2005 and in 2006, especially the northern parts of the study area had slightly positive anomalies, but overall, not as high as in 2007 which considered to be a drought year

contrast, in June, their performance was the weakest.

The *NDDI* was selected as the most appropriate method for agricultural drought monitoring. As an alternative, *NDVI* and *NDWI* can be used separately for the same task.

All spectral indices were found to be significant in quantifying drought intensity based on *PAI*, but normalized indices are preferred over difference indices. Further validation with ground truth data is needed to fully assess the performance of *NDDI*. These preliminary findings appear to be promising, however, the sample size is small, and only national averages were compared to each other. There is a pressing need to obtain more reference data to enable an extended calibration and validation process.

Table 2. Correlation coefficients[a] between the spectral indices and crop yields, and between PAI and crop yields, for the examined period[b]

Period	Index	Yields		
		barley	corn	wheat
18–25 June	NDDI	− 0.91***	− 0.69**	− 0.79***
	DDI	− 0.90***	− 0.69**	− 0.77**
	NDVI	0.57*	0.34	0.54*
	DVI	0.66**	0.51	0.63*
	NDWI	0.83***	0.60*	0.75**
	DWI	0.81***	0.63*	0.74**
12–19 July	NDDI	− 0.60*	− 0.63*	− 0.63*
	DDI	− 0.68**	− 0.68**	− 0.71**
	NDVI	0.63*	0.83***	0.66**
	DVI	0.67**	0.73**	0.67**
	NDWI	0.71**	0.80***	0.73**
	DWI	0.73**	0.76**	0.73**
Whole year	PAI	− 0.61*	− 0.93***	− 0.66**

[a]Pearson's *r*; [b]Spectral index averages for the 8-day periods between 18 and 25 of June and between 12 and 19 of July were used. Significance levels: *P ≤ 0.05, **P ≤ 0.01 and ***P ≤ 0.001, according to a two-tailed t-test. Notes: In the case of the 8-day period in June, there was one missing data point in 2001. Because of high cloud cover, it could not be replaced by the previous or the following 8-day period. In 2010, the average of the previous 8-day period between 10 and 17 of June was used instead, due to high cloud cover. In the case of the 8-day period in July in 2000, 2002, 2004, and 2012, the mean values of the spectral indexes for the 8-day period between 4 and 11 of July were used, due to high cloud cover. The harvest period starts at the end of June.

Discussion and conclusions

No indicator can fully capture the multi-scale, multi-impact nature of drought, so the combination of many different parameters, indicators or indices (remote sensing data included) in a single drought classification product is required (Hayes, M.J. *et al.* 2012). To look at the international level, the composite indicator approach is used by the USDM (U.S. Drought Monitor), which was initiated in 1999 and is globally considered the state-of-the-art drought monitoring tool. It produces weekly maps (Svoboda, M. *et al.* 2002). The European Drought Observatory (EDO) also created a composite called Combined Drought Indicator which is composed from Standard Precipitation Index (SPI), soil moisture and fraction of absorbed photosynthetically active radiation data (EDO 2013).

Our index product (*NDDI*) and cannot alone serve a basis of a national drought monitoring system, since additional in situ measurements depicting the major components of the hydrologic cycle (like temperature, precipitation, soil moisture, streamflow, snow water equivalent) are also needed to fully capture the nature of drought in its complexity. Nonetheless, *NDDI* can be particularly useful for vegetation monitoring, since vegetation stress is may be the most detrimental consequence of drought.

The standardized *NDDI* was proven to be sensitive to land cover changes (afforestation or deforestation). As a result of this, a false drought signal is observed. Our results indicate that this false signal is small and only affects a few cells that can be excluded from the analysis based on standard deviation values. Therefore, it has a marginal effect on the results, but it must not be ignored. Moreover, with the use of an improved land cover assessment, the false drought signal can be minimized even more.

Interestingly, it has been found that lower positive standardized *NDDI* values most likely represent drought, or at least a change in drought intensity, from the chosen reference period. On the other hand, large positive deviations (even 10+ Z-scores) are artefacts of deforestation in the examined periods, especially in the case of coniferous forest during the period between 2006 and 2011. Moreover, afforestation or reforestation can also cause large negative deviations from the mean. This is the result of our limited capability to delineate areas with forest cover. A clear, unbiased climatic signal can only be obtained and used for detecting regional climatic trends through changes in forest vegetation canopy when we are able to minimize the effect of land cover changes.

It was concluded based on our validation process that all the spectral indices calculated from the MODIS spectral reflectance data collected by the Terra satellite in this paper were proven to be applicable for the remote sensing of drought, confirming our previous results (Gulácsi, A. and Kovács, F. 2015). The normalized difference indices (*NDDI*, *NDWI*, and *NDVI*) are preferred over the simple difference indices (*DDI*, *DWI*, and *DVI*). Basically, all of the spectral indices are only different versions of the same index or a combination of them. Chlorophyll and VWC information can be fused into one single index, the *NDDI*. Because of this, the use of *NDDI* is preferred by the authors. Using *NDVI* and *NDWI* separately is also a viable option.

These satellite indices can be computed on a real-near-time basis which largely contributes to regional drought monitoring and makes decadal-scale time series analysis possible to assess changes in drought severity.

Further research is needed to carry out an extended validation of the spectral indices using other ground truth data, such as the SPI (McKee, T.B. *et al.* 1993), which is calculated from precipitation data collected at measuring stations.

Successful drought monitoring of vegetation can only be achieved when we are able to accurately delineate vegetation cover. Because we use the Corine Land Cover database and remove outliers, land cover change has only a minor effect on the results. Drought intensity shows a slight downward trend during the examined period, as the result of the large droughts that occurred in the early 2000s.

In the study, the basis of a cost-effective, near-real-time, MODIS-based drought monitoring system of vegetation was laid down. *NDDI* can be used as a sensitive drought assessment tool for water management, agriculture, and conservation of natural areas.

***Acknowledgement*:** This paper was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences. The research was supported by the Interreg-IPA Cross-border Cooperation Programme Hungary-Serbia and co-financed by the European Union (IPA) under the project HUSRB/1602/11/0057 entitled WATERatRISK (Improvement of drought and excess water monitoring for supporting water management and mitigation of risks related to extreme weather conditions)

REFERENCES

Bajgain, R., Xiao, X., Wagle, P., Basara, J.B. and Zhou, Y. 2015. Sensitivity analysis of vegetation indices to drought over two tallgrass prairie sites. *ISPRS Journal of Photogrammetry and Remote Sensing* 108. 151–160. Doi:10.1016/j.isprsjprs.2015.07.004

Ceccato, P., Flasse, S. and Gregoire, J. 2002. Designing a spectral index to estimate vegetation water content from remote sensing data: Part 2. Validation and applications. *Remote Sensing of Environment* 82. 198–207.

Ceccato, P., Flasse, S., Tarantola, S., Jacquemoud, S. and Grégoire, J-M. 2001. Detecting vegetation leaf water content using reflectance in the optical domain. *Remote Sensing of Environment* 77. 22–33.

Chen, D., Huang, J. and Jackson, T.J. 2005. Vegetation water content estimation for corn and soybeans using spectral indices derived from MODIS near- and short-wave infrared bands. *Remote Sensing of Environment* 98. 225–236. Doi:10.1016/j.rse.2003.10.021

Gao, B-C. 1996. NDWI – A Normalized Difference Water Index for Remote Sensing of Vegetation Liquid Water From Space. *Remote Sensing of Environment* 58. 257–266.

Gu, Y., Brown, J.F., Verdin, J.P. and Wardlow, B. 2007. A five-year analysis of MODIS NDVI and NDWI for grassland drought assessment over the central Great Plains of the United States. *Geophysical Research Letters* 34. Doi:10.1029/2006GL0291

Gu, Y., Hunt, E., Wardlow, B., Basara, J.B., Brown, J.F. and Verdin, J.P. 2008. Evaluation of MODIS NDVI and NDWI for vegetation drought monitoring using Oklahoma Mesonet soil moisture data, *Geophysical Research Letters* 35 (L22401). Doi:10.1029/2008GL035772

Gulácsi, A. and Kovács, F. 2015. Drought monitoring with spectral indices calculated from MODIS satellite images in Hungary. *Journal of Environmental Geography* 8. (3–4): 11–20. Doi:10.1515/jengeo-2015-0008

Hayes, M.J., Svoboda, M.D., Wardlow, B.D., Anderson, M.C. and Kogan, F. 2012. Drought Monitoring. In *Remote Sensing of Drought. Innovative Monitoring Approaches.* Eds.: Wardlow, B.D., Anderson, M.C. and Verdin, J.P., Boca Raton, CRC Press, 1–19.

Jackson, T.J., Chen, D., Cosh, M., Li, F., Anderson, M., Walthall, C., Doriaswamy, P. and Hunt, E.R. 2004. Vegetation water content mapping using Landsat data derived normalized difference water index for corn and soybeans. *Remote Sensing of Environment* 92. 475–482.

Kogan, F.N. 1995. Droughts of the late 1980s in the United States as derived from NOAA polar-orbiting satellite data. *Bulletin of the American Meteorological Society* 76. (5): 655–668.

Kovács, F. 2007. Assessment of Regional Variations in Biomass Production Using Satellite Image Analysis between 1992 and 2004. *Transactions in GIS* 11. (6): 911–926. Doi:10.1111/j.1467-9671.2007.01080.x

Li, Z., Li, X., Wei, D., Xu, X. and Wang, H. 2010. An assessment of correlation on MODIS-NDVI and EVI with natural vegetation coverage in Northern Hebei Province, China. *Procedia Environmental Sciences* 2. 964–969.

McKee, T.B., Doeskin, N.J. and Kleist, J. 1993. The Relationship of Drought Frequency and Duration to Time Scales. In *Proceedings of 8th Conference on Applied Climatology,* Anaheim, CA, USA, January 17–22, 1993. Boston, MA, USA, American Meteorological Society, 179–184.

Mezősi, G., Blanka, V., Ladányi, Zs., Bata, T., Urdea, P., Frank, A. and Meyer, B. 2016. Expected mid- and long-term changes in drought hazard for the South-Eastern Carpathian Basin. *Carpathian Journal of Earth and Environmental Sciences* 11. (2): 355–366.

Pálfai, I. 1989. Az Alföld aszályossága (Drought in the Great Hungarian Plain). *Alföldi Tanulmányok* 13. 7–25. (In Hungarian)

Peel, M.C., Finlayson, B.L. and McMahon, T.A. 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences* 11. 1633–1644. Doi:10.5194/hess-11-1633-2007

R Core Team 2013. *R: a Language and Environment for Statistical Computing.* Vienna, R. Foundation for Statistical Computing.

Rakonczai, J. 2011. Effects and Consequences of Global Climate Change in the Carpathian Basin. In *Climate Change – Geophysical Foundations and Ecological Effects*. Eds.: Blanco, J. and Kheradmand, H. Rijeka, InTech, 297–322.

Renza, D., Martinez, E., Arquero, A. and Sanchez, J. 2010. Drought Estimation Maps by Means of Multidate Landsat Fused Images. In *30th EARSeL Symposium Remote Sensing for Science, Education, and Natural and Cultural Heritage*. Proceedings, May 31–June 3, 2010. Ed.: Reuter, R., Paris, UNESCO, 775–782.

Rouse, J.W., Haas, H.R., Schell, A.J. and Deering, W.D. 1973. Monitoring vegetation systems in the Great Plains with ERTS. In *Third Earth Resources Technology Satellite-1 Symposium. Volume 1: Technical Presentations, section A*. Proceedings, December 10–14, 1973. Eds.: Freden, S.C., Mercanti, E.P. and Becker, M.A., Washington, D.C., USA, NASA, 309–317.

Roy, D.P., Borak, J.S., Devadiga, S., Wolfe, R.E., Zheng, M. and Descloitres, J. 2002. The MODIS Land Product Quality Assessment Approach. *Remote Sensing of Environment* 83. 62–76.

Shaw, A.T., Baldwin, M., Barnes, E.A., Caballero, R., Garfinkel, C.I., Hwang, Y., Li, C., O'Gorman, P.A., Rivière, G., Simpson, I.R. and Voigt, A. 2016. Storm track processes and the opposing influences of climate change. *Nature Geoscience* 9. 656–664. Doi:10.1038/NGEO2783

Solano, R., Didan, K., Jacobson, A. and Huete, A. 2010. *MODIS Vegetation Index User's Guide (MOD13 Series).* Tucson, The University of Arizona, Vegetation Index and Phenology Laboratory.

Svoboda, M., LeComte, D., Hayes, M., Heim, R., Gleason, K., Angel, J., Rippey, B., Tinker, R., Palecki, M., Stooksbury, D., Miskus, D. and Stephens, S. 2002. The Drought Monitor. *Bulletin of the American Meteorological Society* 83. (8): 1181–1190.

Tucker, C.J. 1979. Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sensing of Environment* 8. (2): 127–150. Doi:10.1016/0034-4257(79)90013-0

Tucker, C.J. 1980. A spectral method for determining the percentage of green herbage material in clipped samples. *Remote Sensing of Environment* 9. (2): 175–181. Doi:10.1016/0034-4257(80)90007-3

Vermote, E.F., Kotchenova, S.Y. and Ray, J.P. 2011. *MODIS Surface Reflectance User's Guide. Version 1.3.* MODIS Land Surface Reflectance Science Computing Facility. http://modis-sr.ltdri.org/guide/MOD09_UserGuide_v1_3.pdf

VITUKI 2006. *A Duna-Tisza közi hátság hidrometeorológiai, felszíni és felszín alatti vizeinek mennyiségére vonatkozó mérő- és megfigyelőrendszer működtetése és értékelése. Zárójelentés* (The operation and evaluation of the hydrometeorological, the surface water and the underground water quantity-related measuring and monitoring system in the Danube-Tisza Interfluve. Final report). Budapest, VITUKI Kht. (In Hungarian)

Völgyesi, I. 2000. *A Homokhátság felszínalatti vízháztartása. Vízpótlási és vízvisszatartási lehetőségek* (The groundwater balance of the Sand Ridge. The possibilities of water supply and water retention). Budapest, VÖLGYESI Mérnökiroda Kft. (In Hungarian)

Wang, L. and Qu, J.J. 2007. NMDI: A normalized multi-band drought index for monitoring soil and vegetation moisture with satellite remote sensing. *Geophysical Research Letters* 34. (20): Doi: 10.1029/2007GL031021

Zhang, D., Li, H. and Zheng, X. 2013. The Moisture Content Prediction Model of Surface Sediment in Intertidal Flat by Hyperspectral Remote Sensing. *Geo-information Science* 15. (4): 581–589. Doi: 10.3724/SP.J.1047.2013.00581

Zhang, N., Hong, Y., Qin, Q. and Liu, L. 2013. VSDI: a visible and shortwave infrared drought index for monitoring soil and vegetation moisture based on optical remote sensing. *International Journal of Remote Sensing* 34. (13): 4585–4609. Doi:10.1080/01431161.2013.779046

Other sources

CORINE Land Cover Database. http://www.fomi.hu/portal/index.php/projektjeink/foldfelszin-monitorozas-corine

DM (United States Drought Monitor). http://drought-monitor.unl.edu/

EDO (European Drought Observatory): http://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000

EEA (European Environmental Agency). https://www.eea.europa.eu/publications/COR0-landcover

GLOVIS (USGS Global Visualization Viewer) https://glovis.usgs.gov/

HCSO (KSH in Hungarian). http://www.ksh.hu/

HMS (OMSZ in Hungarian). http://met.hu/en/idojaras/

ICID http://www.icid.org/wg_drought.html

WMO (World Meteorological Organization). http://www.wmo.int/pages/prog/wcp/ccl/faqs.php

DOI: 10.15201/hungeobull.67.1.4 Hungarian Geographical Bulletin **67** 2018 (1) 43–60.

Visible minorities in remote areas: a comparative study of Roma in Hungary and Indigenous people in Australia

Andrew TAYLOR[1], Patrik TÁTRAI[2] and Ágnes ERŐSS[2]

Abstract

The present study argues that Hungarian Roma and Australian Indigenous are non-immigrant visible minorities which are overrepresented and concentrated in remote areas. Based on this premise, we investigate and compare the general living circumstances and socioeconomic status of these visible minorities. The key hypothesis is that visible minorities living remotely face common social, economic, demographic and political difficulties compared to the dominant majority in developed countries. This hypothesis is examined by analysing and comparing a range of statistical indicators for fertility, health, education, labour market, income and living conditions. We found that, independent from the geographical location and the social context, patterns of social and spatial exclusion are alike across the studied developed nations. The data show there are substantial gaps in fertility, health, education, income, labour market, household internet and car ownership indicators between visible minorities and the majority society. Furthermore, gaps exist between remote living and non-remote people as well. Overall, the disadvantaged position of Roma and Indigenous people can be grasped along three dimensions: spatial remoteness, socioeconomic remoteness and ethnic differentiation.

Keywords: visible minorities, remoteness, social exclusion, peripheralization, Australia, Hungary

Introduction

In developed nations substantial regional disparities in living standards, health indicators and general wellbeing persist, with remote or peripheral areas faring most poorly relative to others (Taylor, A. *et al.* 2011; Lang, T. 2015; Nagy, E. 2015). Both regional disparities and social exclusion are commonly discussed as issues in contemporary social sciences literature, but research relating the two is rather limited, despite social exclusion invariably characterizing peripheral populations (Bock, B. *et al.* 2014). In remote areas of developed countries, disparities between the socio-economic status of sub-populations (e.g. titular/majority vs. minority ethnic groups) are in many cases extreme (see for example, Abu-Saad, I. and Creamer, C. 2012; Australian Government 2015; Wang, J-H. 2015).

Generally, 'visible minorities' living in remote areas face similar problems in terms of sub-standard living circumstances in fields such as education, employment, health status and wealth accumulation. In remote areas, opportunities for transitioning socio-economically in situ, as opposed to leaving the region temporarily or permanently, can be limited. Economic and other theorists have suggested that, under conditions of a bifurcated society, gaps between the 'have's' and 'have not's' tend to increase (Taylor, A. *et al.* 2011). This contributes to the dual effect of those remaining in such locations having neither the social or other capital to move to areas where they might be able to improve their socio-economic lot (i.e. they become 'stuck') and the inter-generational occurrence of poor social conditions, resulting in long lasting negative effects. These ongoing

[1] Northern Institute, Charles Darwin University. 0909 Darwin, Australia. E-mail: andrew.taylor@cdu.edu.au
[2] Geographical Institute, Research Centre for Astronomy and Earth Sciences of the Hungarian Academy of Sciences. H-1112 Budapest, Budaörsi út 45. E-mails: tatrai.patrik@csfk.mta.hu, eross.agnes@csfk.mta.hu

issues have and continue to be the focus of special or targeted development policies and programs by governments (for example, KIM 2011; Australian Government 2015).

In this paper we use the term 'visible minority' to describe the status of Roma in Hungary and Australian Indigenous reflecting their ethnic/racial differentiation and their social exclusion in both countries. The term originally emanated as a Canadian statistical category for non-white groups calling attention to their disadvantaged socio-economic position and discrimination against them in the labour market. Members of visible minorities were defined as "…persons, other than Aboriginal peoples, who are non-Caucasian in race or non-White in colour" (Hou, F. and Picot, G. 2004, 9). In the Canadian context, the term reflected the increasing and changing nature of migration (especially the growing numbers of non-European immigrants), with the main cultural cleavage previously based on linguistic and religious characteristics, which are inconspicuous or 'invisible'. A similar term, 'person of colour' is applied in the United States to all non-White groups. While this term is not a statistical category, the concept reflects the hierarchical racial categories, where the reference colour is the white and therefore non-Whites become racialized (Galabuzi, G. 2006; White, P.A. 2008).

In Australia, public policy in relation to immigration and society has promoted the nation as culturally pluralistic and tolerant, and overseas migration contributes a substantial portion of national population growth. In 2014–2015, for example, 53 per cent of the nation's population growth came from immigration (ABS 2015). The most overt labelling of non-white residents has been applied to Australia's original inhabitants, for whom there is a history of negative stereotyping (Pedersen, A. and Walker, I. 1997). In East Central European and especially in Hungarian context, the term 'visible minority' is appropriate for Roma as they have been a part of the population for many generations and are the only visibly different group of significant size. Their members are usually exposed to ethnic distinctions, face stigmatization and discrimination in many fields of the life (Molnár, E. and Dupcsik, C. 2008).

In light of this context, the term 'visible minority' refers in this study to those groups (Aboriginal and Roma) whose members have a different skin tone or lineament to the majority society, but have no migrant background.[3] Although these groups are autochthonous, however, with significant differences regarding their autochthony, they remain excluded from the white majority society as inherited from the colonial era. In post-socialist Central and Eastern Europe (including Hungary), as in the Canadian case, the traditional divisions evolved along linguistic lines so the only traditional visible minority are the Roma, who generally adopted the local majority society's language and religion. We argue that using the term 'visible minority' is appropriate to describing the contemporary social, economic and community status of the two groups as distinct them from other minorities with migrant backgrounds.

Although there are attempts in the literature to reveal the relationships between remote living visible minorities and substandard living circumstances, these papers generally focus on the national or subnational level (e.g. Virág, T. 2006; Pásztor, I.Z. and Pénzes, J. 2012), and the range of literature documenting regional disparities through the comparison of minority residents from non-adjacent nations is less comprehensive. Only a few studies apply cross-country comparison in order to provide a better understanding of the interconnection between some aspects of ethnicity, peripheralization and social-economic exclusion (e.g. Gregory, R. and Daly, A. 1997; Ladányi, J. and Szelényi, I. 2001; Milcher, S. 2006; Lee, K.W. 2011).

[3] Naturally, Roma, migrated to Central and Southeast Europe since the late Middle Ages, is literally a migrant ethnic group who cannot be described as 'indigenous', still, the term 'non-migrant background' expresses the long-rooted presence of Roma in this region.

We use the comparison of Hungarian Roma with Australian Indigenous people in remote areas to demonstrate the above interconnectedness. Australia and Hungary are non-adjacent, developed nations with significant differences in their size, economics, political systems, societies and economies. However, by comparing and contrasting the socio-economic characteristics of Roma and Australian Indigenous people we attempt to present that peripheralization and marginalization are common phenomena for non-migrant visible minorities, in spite of specific national contexts and different geographical scale. We also claim that the two societies are connected by similar basic social standards, living circumstances and health conditions.

From the point of view of spatiality, we also argue that Hungarian Roma and Australian Indigenous are overrepresented and concentrated in remote areas. Based on this premise, we investigate and compare the general living circumstances and socioeconomic status of these visible minorities. In doing so, we aim to explore the relationship between remoteness, marginalization and social exclusion for these groups. Comparing visible minorities' position along three dimensions (spatial remoteness, socio-economic status and ethnic differentiation) we intend to reveal whether the two countries with significant differences in geographical, demographical, socioeconomic and political characteristics show similarities and the types and extent of these where they exist.

Who are Roma/Australian Indigenous people?

The groups which are the focus in this paper, the Roma and Australian Indigenous people, are defined differently, making the question of 'who are Roma or Indigenous' key. The question incorporates both theoretical and practical elements. The former is primarily important for the academic sphere, while exact definitions are required in other areas to improve the effectiveness of programs supporting Roma (Fleck, G. and Messing, V. 2010) or to assist in defining the scope Indigenous people eligible under land rights legislation (for example, Taylor, A. and Bell, B. 2013).

The Roma issue has been highly politicized in the last decades in post-socialist countries, thus, the number of Roma is a debated issue not only among scholars but among the public and politicians as well. The number of ethnic Roma by self-identification (for example, the numbers provided in censuses) has always been far fewer than the number of Roma estimated by experts (see e.g. Kocsis, K. and Kovács, Z. 1991; Ladányi, J. and Szelényi, I. 2001; Kemény, I. and Janky, B. 2005; Hablicsek, L. 2008; Pásztor, I.Z. *et al.* 2016). Consequently, census results regarding the number of Roma have been considered 'unreliable' and, in order to fill the gap, there have been many surveys to measure their numbers and characteristics since the 1970s. Most have classified someone as Roma according to way of life and physical appearance, as well as by ethnic descent (Kemény, I. and Janky, B. 2005) claiming that Roma ethnicity and social stratification can be surveyed by applying clear methods (Havas, G. *et al.* 2000, 194). However, ethnicity and ethnic groups are conceived as a social construct by other scholars who claim that surveys cannot objectively report the number of Roma because the survey method based on external classification reveals more about the classifiers than the subjects (Ladányi, J. and Szelényi, I. 2001).

Being aware of the above mentioned debates about the number of Roma, in this study we use the ethnic data from the Hungarian census based on self-identification. First, this is the only available dataset for the number of Roma in the level of settlements; second, the methodology of census (self-identification) is more appropriate than diverse methodologies of external ethnic classification; and third, this dataset represents those living in poverty and exclusion, but underrepresents upwardly mobile Roma people with successful integration strategies. Thus, this dataset can be used efficiently to define the number and territorial distribution of population subject to receive social transfers (Ladányi, J. and Virág, T. 2009).

In modern times, the term Indigenous or First Australian refers to those people who have self-identified as being of either of Aboriginal or Torres Strait Islander origin in relevant data collections such as the five-yearly Census. In similarity to the Roma, representation in official statistics by self-identification makes Indigenous status a social construct (Rowse, T. 2006). The contemporary use of self-identification differs from the post-colonial and subsequent periods up the 1970s during which times First Australians were distinguished as 'natives' based on the proportion of patrimonial lineage. For example, in the Australian Census right up until the 1970s, the term 'native' was used to distinguish individuals with a certain percentage of direct Indigenous lineage (often labelled 'full blood') while those with less were considered to be 'mixed race' and outcasts (often labelled 'half-cast'). Natives were subsumed under protection acts, which sought to assimilate them into white society. The most blatant marker of the assimilation era was the forced removal of children from their families into the 'care' of missions and other organisations, a practice which continued right up until the 1970s.

In recent decades, successive national governments have established legislation, policies and programs to recognise Indigenous people as traditional owners of the lands and to improve their socio-economic status. As a result, Indigenous Australian's have obtained gains in the areas of land rights and land ownership, as well as improvements in key quality of life indicators like life expectancies and socio-economic status (Australian Government 2015). This has generated significant increases in self-declarations and therefore high population growth for this minority group (Hoddie, M. 2006).

Methods

The key hypothesis of this study is that visible minorities living remotely face similar difficulties with common social, economic, demographic and political positions compared to the dominant majority in developed countries. However, defining where or who is remote depends on local, national and international contexts, and accordingly definitions and the application of these vary between nations and continents. Thus, a basic question of this study is how to define remoteness in the two countries under study.

In Australia, remoteness is primarily analysed in spatial terms. The size and low population density of the Australian continent means that substantial proportions of the landmass can be considered as remote *(Figure 1).* For the collection and dissemination of official statistics, and policy and program initiatives with specific redress to remote populations, the classification of remoteness is based on the Accessibility/Remoteness Index of Australia, known as ARIA+. This provides an accessibility score to each populated locality based on road distances to five levels of service centres. The locality indexes are interpolated to provide a remoteness index value for one-kilometre grids of the continent (Australian Population and Migration Research Centre 2014).

In Hungary, the relatively small size of the landmass means most of the countryside is accessible in few hours from the capital Budapest. Nevertheless, both the literature and governmental policies define remoteness based on economic, social and demographic indicators (Faluvégi, A. and Tipold, F. 2012; Pénzes, J. 2013). These collectively delimit the underdeveloped regions with complex economic and social disadvantages as being remote. As a consequence, geographical peripheries measured by accessibility and backward areas measured by complex economic-social indices are highly overlapping in Hungary (Lőcsei, H. and Szalkai, G. 2008), and on that basis it may be argued as being remote. Thus, we define remote areas in Hungary as those suffering from both social, economic and infrastructural backwardness as well as high unemployment (thus, receiving dedicated state financial support).

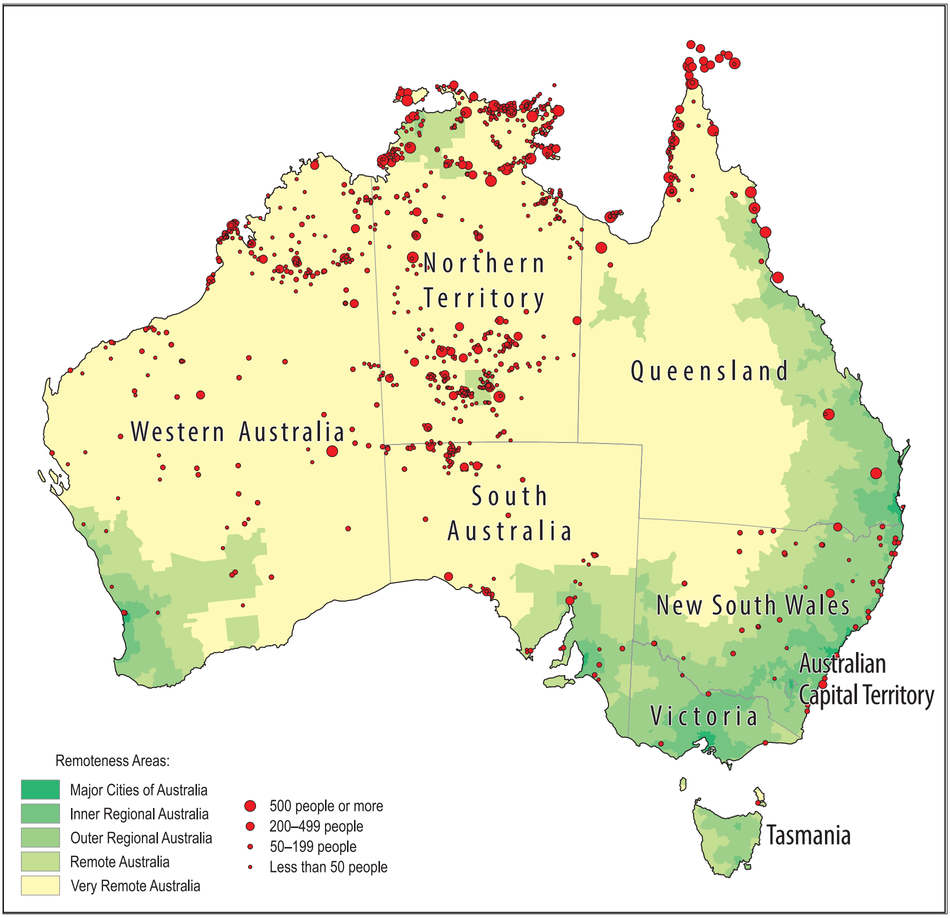


Fig. 1. Australia's remoteness areas and Indigenous communities. Circles indicate relative size of Indigenous communities. *Source*: ABS 2007.

These areas cover mostly the north-eastern and south-western peripheries and some adjoining inner peripheries *(Figure 2)*.

While the contexts for remoteness in Australia and Hungary differs similar living circumstances prevail for Roma and Indigenous populations making remoteness a suitable lens for comparing and contrasting visible minorities.

The verity of this key hypothesis is examined by analysing and comparing a range of statistical indicators. Data includes comparisons and investigation of fertility, health, education, labour market, income and living conditions. We compare and contrast indicators between the two groups, between remote and non-remote areas and between visible minorities and others. This comparison should underpin that (1) visible minorities live under worse circumstances than the dominant ethnic group (both in remote and non-remote areas), (2) remote living visible minorities face more significant challenges in various facets (access to health care, employment, education, etc.) compared to non-remote co-ethnics, and (3) visible minorities in remote areas across developed nations can be characterized by similar attributes described by similar values of indices.

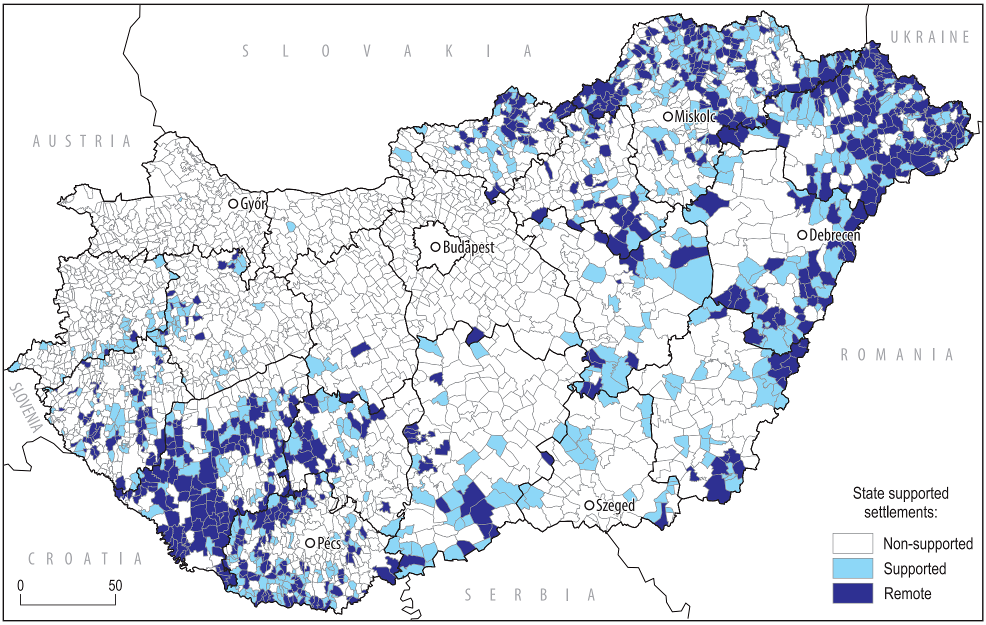


Fig. 2. State supported areas in Hungary. *Source*: Authors' edition based on the 105/2015 (IV. 23.) Government Regulation.

Data for Roma are limited; beside the available census data on the national level indicated as 'Roma average' in the tables, detailed territorial data for Roma is not accessible. Consequently, an indirect analysis is applied. This includes presenting the indicators from the 2011 Census for remote areas by settlement categories classified by the share of Roma in the total population. Analysis of the demographic distribution and socio-economic situation for Australian Indigenous people in remote areas are primarily based on 2011 Census data.

We constructed custom data tables using the software ABS Table Builder. We also used data from a range of other collections including the National Aboriginal and Torres Strait Islander Social Survey and a range of demographic collections provided by the Australian Bureau of Statistics (ABS). Data sources are denoted next to relevant results.

Results

Number and territorial distribution of Roma and Indigenous people

According to the 2011 census in Hungary, the number of ethnic Roma population, based on self-identification, increased by 63 per cent in ten years to 309,000 persons. The aggregate number of those who declared Roma affiliation[4] exceeded 315,000 persons or 3.2 per cent of the total population.[5] As it is possible to

[4] Based on at least one of the census categories reflect ethnic belonging. These are ethnicity, mother tongue and spoken language.

[5] According to surveys, Roma in Hungary counted around 600,000 in the first half of the 2000s (Kemény, I. and Janky, B. 2005). Nowadays, their number approaches the 700,000 (Hablicsek, L. 2008), or, based on the detailed territorial data by Pásztor, I.Z. *et al.* (2016), can reach 870,000.

declare multiple ethnic identities since the 2001 census, most of those expressing Roma affiliation self-identified Roma and Hungarian ethnicity simultaneously. At the same time, only 54,000 persons declared Roma mother tongue due to their long-standing linguistic assimilation.[6]

The salient increase in the number of Roma in the recent decades is the consequence of both the above-mentioned changes in census methodology, and the high fertility rate of the Roma outstripping the respective data of any other ethnic groups. However, the growth in their number was much higher than their estimated fertility would have generated (Hablicsek, L. 2008), thus, we argue that the census number of Roma depends primarily on the subjective nature of self-identification influenced by the diverse Roma identity constructions and the contemporary social conditions (including their stigmatized being, discrimination, etc.) (Csepeli, G. and Simon, D. 2004; Tátrai, P. *et al.* 2017).

The majority of Roma (53% and much higher than for the total population at 31%) live in rural areas in the country although to a decreasing extent since internal migration flows are towards urban areas (Pénzes, J. *et al.* 2018). Additionally, a significant number of Roma live in municipalities with less than 500 inhabitants, where living circumstances are at their worst in the Hungarian context. Furthermore, residential segregation and the peripheral geographical location of villages with high Roma populations also contributes to segregation (Ladányi, J. and Szelényi, I. 2001) based on segregated settlements within the locality or a ghettoized villages, particularly in the north-eastern and south-western peripheries (Kocsis, K. and Kovács, Z. 1991; Virág, T. 2006). Despite these issues, the proportion of the Roma within the municipalities is still quite low. Although migration and urbanization process have reshaped their geographical distribution, the ethnic geography of Roma has hardly changed in the last hundred years. About 60 per cent of the Roma live in Northeast and Southwest Hungary which coincides with the regions with high number of small villages. Because of urbanisation in the second half of the 20th century, a significant number of Roma live in the central region, in the Budapest agglomeration.

Comparing the share of Roma with the remoteness on the level of localities we found significant overlap *(Figure 3).* Although "only" 30.4 per cent of Roma live in territories considered as remote, this is much higher than the respective data of total population (6.3%). Likewise, Roma constitute 14.9 per cent of total remote population, while the national average is only 3.1 per cent. The above data refers to Roma's concentration and overrepresentation in remote areas *(Table 1).*

The 2011 Census count of Indigenous people in Australia was 548,369, or 2.5 per cent of the national population (ABS 2016). In the 2006 Census, the count was 455,031 Aborigines and Torres Strait Islanders, a 20 per cent growth in number in five years. Two-thirds of this growth was through demographic factors (natural increase) and one-third by the changing identifications (ABS 2013a).[7] In 2011, around 130,000 (22%) lived in remote areas where they comprised a quarter of the population (ABS 2016). In some remote areas there are high concentrations of Indigenous Australians, notably in and around discrete remote communities found across in the North of the country (denoted by the black dots in *Figure 1*).

Nevertheless, Indigenous population growth in urban areas in the South of the country is far outstripping growth in remote areas (Taylor, A. and Bell, B. 2013), and eroding the remote share significantly. During 2006 to 2011, for example, the Indigenous population of northern Australia grew by 12 per cent compared to 24 per cent for the

[6] Already the 1971 national survey documented that Hungarian is the mother tongue of about 70 per cent of the Roma (Kemény, I. and Janky, B. 2005). According to the 2011 census only about quarter of the Roma can speak one of the Roma dialects.

[7] Similarly to the Roma case, estimates highly rose Indigenous number both in 2006 (517,000; 14% difference compared to census) and 2011 (670,000; 22%) (ABS 2013a).

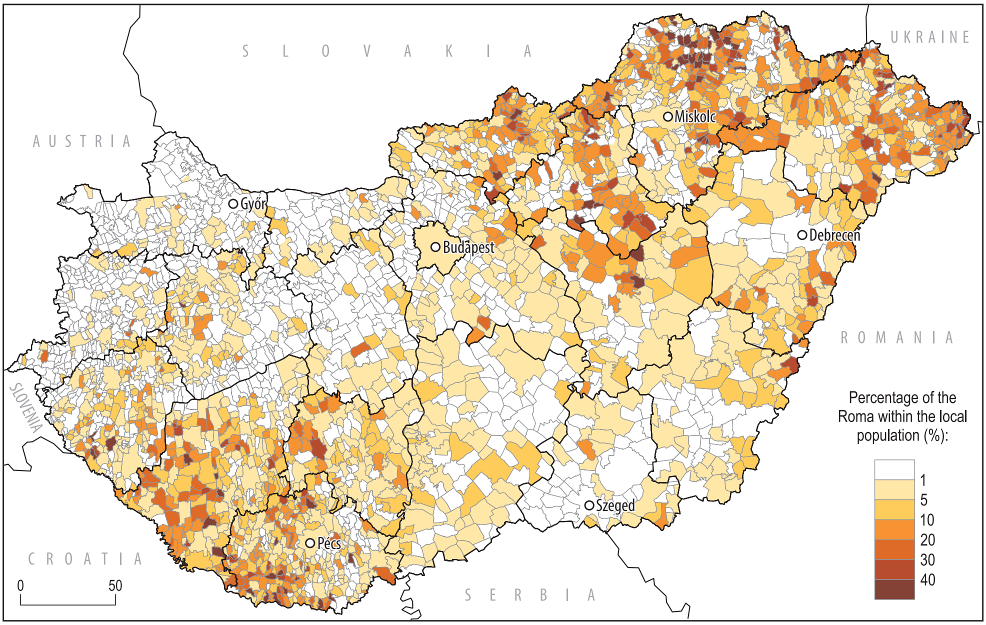


Fig. 3. Territorial distribution of the ethnic Roma population in Hungary (2011). *Source*: Authors' edition based on the 2011 Census data.

Table 1. Settlement data on remote areas in Hungary, 2011

Proportion of Romas in settlements, %	Number of municipalities	Average size of municipalities, persons	Population in 2011, persons	Population change in per cent (1990 = 100%)	
				1990–2001	2001–2011
0–1	75	355	26,622	91.0	86.6
1–5	115	929	106,851	96.5	90.7
5–10	122	949	115,785	98.3	91.3
10–20	173	1,249	216,072	98.4	92.5
20–30	94	1,078	101,293	101.7	94.9
30–40	45	890	40,036	102.8	98.3
40 and over	38	636	24,178	107.2	99.8
Total remote	*662*	*953*	*630,837*	*98.7*	*92.7*
Total non-remote	*2,492*	*3,735*	*9,306,791*	*98.3*	*97.8*
Roma average	–	–	*308,957*	*133.2*	*162.6*

Source: Authors' calculation based on the 2011 Census data.

southern Australia. There are a number of complex and interconnected explanations for this. Firstly, progressively more people in southern parts are identifying as Indigenous (when they did not previously) as societal acceptance has improved. Secondly, high rates of mixed patterning in southern cities (where one person in the relationship is Indigenous but the other is not), which invariably leads offspring being declared as Indigenous on the birth certificate. Migration from North to South and changing Census procedures and population estimation methods are also contributing (Taylor, A. and Bell, B. 2013).

Despite the governmental policies to improve conditions for Australia's Indigenous population since the 1980s resulting in improving life quality indicators and growth in numbers, there remain significant gaps in the socio-economic status of Indigenous and other Australian's. Similarly, health indicators highlight there are gaps in key indicators remaining (Australian Government 2015). In remote and northern areas, these gaps are far higher, although difficult to measure accurately, despite concerted policies and programs being in place for a number of decades aimed at reducing such gaps.

The spatial distribution of Indigenous Australians, against many preconceptions, is towards the urban areas in the more populous States (Taylor, A. and Bell, B. 2013). However, in proportional terms, concentrations in the population are far higher outside of large urban centres and particularly in the remote regions of the nation *(Figure 4)*. This shows a similar pattern to Roma in Hungary as far as there is an inverse relationship between the proportion of the population which is Indigenous for individual communities and the size of these *(Table 2)*. However, Indigenous representation in remote Australia is far higher than for Roma with around half of all communities having a 50 per cent or greater Indigenous share in their population.

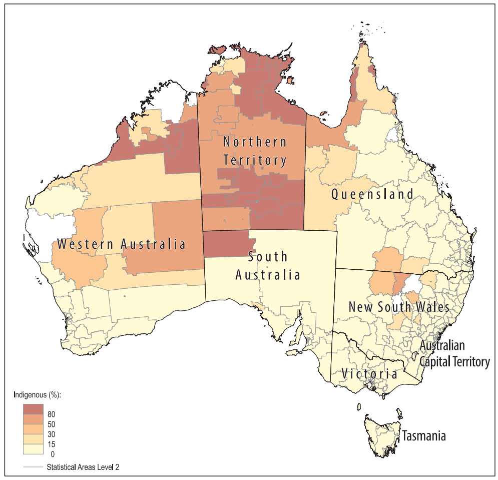


Fig. 4. Proportion of the population who identified as Indigenous in 2011. *Source:* Custom data extracted by the authors from ABS Table Builder, 2011 Census.

Table 2. Settlement data for remote Indigenous Australians, 2011

Proportion of Indigenous, %	Number of communities	Average size in persons
0–10	71	1,809
10–30	57	3,407
30–60	40	1,145
60–85	35	2,651
85–95	112	1,693
95 and over	89	10,106
Total remote	*404*	*3,832*
Non-remote	*710*	*28,585*

Source: Custom data extracted by the authors from ABS Table Builder, 2011 Census.

Results for comparative statistical indicators

The demographic indices for the Roma are considerably different from non-Roma in Hungary and throughout Central and Eastern Europe. Roma is the only ethnic group in Hungary characterized by high fertility rates, positive natural growth and young age structure (with an average age 15 years lower than the total population) (Tátrai, P. 2015). Although fertility rates for Roma are still much higher than the national average *(Table 3)*, they have been slowly decreasing for decades (Kemény, I and Janky, B. 2005).[8]

Comparing the elements of natural growth in remote and central parts of the country, both birth and death rates are higher in remote areas. Throughout the country, higher Roma share is associated with higher fertility and lower death rate. The latter can be explained by the low number of elder Roma age

[8] Some studies call attention to the possible interrelation between high fertility and the residential segregation of Roma (e.g. Janky, B. 2006; Ladányi, J. and Szelényi, I. 2006; Durst, J. 2010).

Table 3. Main demographic indicators of remote and non-remote areas in Hungary, 2011

Proportion of Romas in settlements, %	Annual live birth rate	Annual death rate	Annual natural increase rate	Annual net migration rate	Ageing index	Live birth per 100 women aged 15–x years
	2001–2011					
0–1	8.0	17.5	–9.5	–4.0	190	183
1–5	10.1	16.4	–6.3	–2.9	150	182
5–10	10.7	17.1	–6.3	–2.2	131	184
10–20	12.4	15.1	–2.7	–4.6	112	187
20–30	14.2	13.4	0.8	–5.7	87	199
30–40	16.1	13.1	2.9	–4.6	67	211
40 and over	20.0	12.0	8.0	–8.2	45	221
Total remote	*12.3*	*15.3*	*–3.0*	*–4.2*	*111*	*190*
Roma average	–	–	–	–	*14*	*233*

Source: Authors' calculation based on the 2011 Census data.

groups.[9] Consequently – the unfortunately unavailable – age-specific death rates would be the adequate index to describe Roma mortality.[10] Using data of settlements with more than 40 per cent Roma population as proxy for Roma suggests there are no significant differences in Roma demography between remote and non-remote areas *(Table 3).* While municipalities with Roma local majority are characterized by the highest natural growth, they also have the highest migration loss due to their unfavourable position in the settlement hierarchy and the poor economic opportunities. Furthermore, the high (and rising) share of Roma can speed up emigration of the young, well-educated, non-Roma people with higher human capital, which is partly counterbalanced by the immigration of poor people, mostly Roma (Virág, T. 2006).

Fertility rates for Indigenous Australians are also much higher than for the general population. In 2014 the national Indigenous total fertility rate was 2.22, compared to 1.87 for the overall population (ABS 2015). The median age of Indigenous mothers, at 24.5 years, was much lower than the overall population for whom the median age was 30.8 in 2014. Babies born to Indigenous mothers are twice as likely to be of low birthweight and, while there have been large declines in Indigenous infant mortality rates in the past four decades, they remain at almost twice that of non-Indigenous infants. Separate fertility data is only available at the State and Territory level in Australia, however, using the Northern Territory as a proxy for remote Australia suggests Indigenous fertility in remote areas to be around the same (2.1) as for Indigenous people across Australia as a whole.

Health indicators and surveys report on Roma's poor health condition and poor access to healthcare (e.g. Babusik, F. 2004; Fónai, M. *et al.* 2008; EC 2014). Based on the only available health related indicator for Roma, there is a broad gap between Roma's and non-Roma's life expectancy of about ten years less for Roma (Babusik, F. 2004; EC 2014). This is far more than the regional gap in life expectancy (6.5 years) seen between the best (Central) and the worst (Northeast) regions. The literature highlights the strong impacts of low education levels, low incomes, high unemployment rate and high share of Roma population on low life expectancies (Klinger, A. 2003; Uzzoli, A. 2016).

The health status for Australian Indigenous people, especially those in remote areas, is significantly worse than for others. Life expectancy estimates are a prime example with

[9] Only 4.6 per cent of the Roma population is aged 60 years or over (Hungary's average: 23.5%).

[10] For instance, surveys indicate much higher infant mortality compared to the national population average (EC 2014).

estimates suggesting a twelve-year gap for males and an eleven-year gap for females *(Table 4).* Indigenous life expectancies outside of Australia's major cities are estimated at 67.3 years for males and 72.3 years for females (ABS 2013b). Detailed data for remote areas are not compiled due to issues with the registration of Indigenous deaths in some States. Nevertheless, data demonstrate Indigenous Australians die at younger ages and higher rates than non-Indigenous Australians, with 65 per cent of Indigenous deaths occurring prior to age 65 compared to only 19 per cent for non-Indigenous deaths (AIHW 2014). The main causes of life expectancy gaps between Indigenous and non-Indigenous Australians are chronic diseases including circulatory disease (24% of the gap), endocrine, metabolic and nutritional disorders (21%), cancer (12%), and respiratory diseases (12%) (AIHW 2014).

Since poor health status is interrelated to low education levels, it is not surprising that the Roma population has low educational attainment. More than 80 per cent attended only primary school, while an incredibly low 1.2 per cent has a higher school qualification. These figures are reaching far behind the national and the remote average. Comparing the total population of remote and non-remote areas shows a significant gap with much better values for the non-remote population *(Table 5)* with a higher Roma proportion correlating with worse educational indices in both areas.

In remote Australia there is also a strong positive correlation ($r^2 = .82$) between the proportion who are Indigenous in settlements and the proportion of Indigenous who did not attend school *(Figure 5).* For example, a much higher percentage of adults did not go to school in settlement with more than 95 per cent indigenous residents.

Conversely, an inverse relationship is observed between the proportion of residents who are Indigenous in settlements in remote

Table 4. Life expectancy estimates for Indigenous and other Australians, 2010–2013

Level, cities	Indigenous		Other Australians		Indigenous life	
	Males	Females	Males	Females	Males	Females
National level	67.4	72.3	79.8	83.2	12.4	10.9
Outside of major cities	67.3	72.3	80.7	84.7	13.4	12.4
Major cities	68.0	73.1	81.7	85.0	13.7	11.9

Sources: ABS 2012a and ABS 2013b.

Table 5. Population aged 7 years or older by the highest education completed in Hungary, 2011

Proportion of Romas in settlements, %	Share of population aged 7 years or older completed			
	at most primary school, %		higher education, %	
	Remote	Non-remote	Remote	Non-remote
0–1	55.9	35.7	4.2	15.1
1–5	55.5	33.5	5.1	18.6
5–10	57.8	47.3	4.6	8.2
10–20	57.7	50.4	5.0	7.8
20–30	63.4	56.6	4.1	5.9
30–40	69.1	65.3	3.5	4.0
40 and over	77.2	77.8	2.0	1.9
Total	*59.6*	*36.0*	*4.6*	*16.3*
Roma average	*80.6*		*1.2*	

Source: Authors' calculation based on the 2011 Census data.

areas and the proportion that have a post-school qualification equivalent to a Bachelors level or higher *(Figure 6).*

The 2011 census data for Hungary also show the disadvantageous position of the Roma in the labour market. The employment rate among Roma is 25.1 per cent, while the national average is double at 57.9 per cent. The remote area's average is in between the two values (42.5%). These, however, should be treated cautiously since in remote areas, and especially small villages, economic activity is partly realized in the grey and black economy. Thus, statistical data regarding employment and income reflects worse situation than the reality (Feischmidt, M. 2012).[11] The official data on unemployment show the same pattern *(Table 6).*

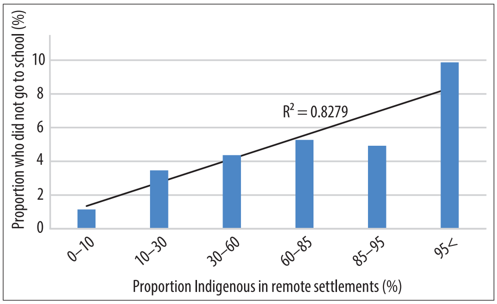


Fig. 5. Did not attend school by proportion Indigenous in remote settlements, 2011. *Source*: Custom data extracted by the authors from ABS Table Builder, 2011 Census.

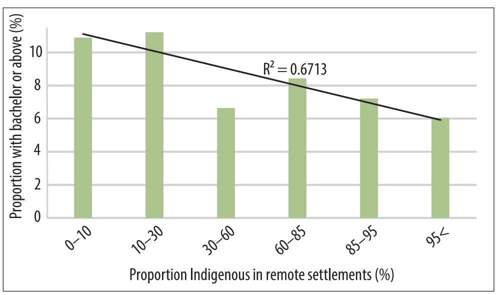


Fig. 6. Bachelor degree level or higher post-school qualification by proportion Indigenous in remote settlements, 2011. *Source*: Custom data extracted by the authors from ABS Table Builder, 2011 Census.

The unemployment rate for the Roma is almost four times higher than the national average. This difference would be much higher without public work, which is counted in statistics as normal employment. Public work dominates the labour supply in remote areas and especially in those municipalities with high proportion of Roma, but still many remote living Roma families subsist without employed family member. The joint presence of high unemployment and low activity among the Roma results in high number of inactive and dependent Roma population.

Australian Indigenous unemployment rates are higher in remote areas and higher for settlements where a greater proportion of residents are Indigenous *(Figure 7).* Conversely, Indigenous participation rates (those either working or actively seeking work) are higher at remote settlements with a lower proportion of Indigenous residents in the population.

At communities with higher proportions of Indigenous residents, employed people are more likely to work in the government sector *(Table 7)* with a third of employed Indigenous residents work in the government sector compared to a fifth in non-remote Australia. For non-Indigenous residents the proportion employed in the government sector is the same in remote and non-remote areas, signifying Indigenous employment is significantly concentrated in the government sector in remote Australia.

Due to their weak position in the labour market, Roma's income is below average and poverty is widespread. Per capita income in remote areas is around half of the national average, and income of remote villages with Roma

[11] However, according to the 2003 national survey, Roma employment and activity rate is characterized by strong regional, urban–rural and gender differences: about 65 per cent of the working-age Roma men in Budapest had regular working opportunity (which is considered to be high even compared with the non-Roma population), while the respective data of working-age Roma women in East Hungary reached only 6 per cent (Kemény, I. and Janky, B. 2005).

Table 6. Employment indicators of remote areas of Hungary, 2011

Proportion of Romas in settlements, %	Employment rate		Unemployment rate		Number of public workers per 100 employed	
	Remote	Non-remote	Remote	Non-remote	Remote	Non-remote
0–1	47.1	60.1	19.6	10.5	22	3
1–5	45.3	59.9	20.7	11.9	24	3
5–10	43.3	51.3	22.6	17.1	26	12
10–20	42.2	49.3	24.2	17.5	29	15
20–30	38.7	46.3	26.7	21.1	37	22
30–40	33.9	39.8	31.1	26.2	52	47
40 and over	25.9	29.3	45.6	33.9	97	85
Total	*41.5*	*58.9*	*24.5*	*12.0*	*31*	*4*
Roma average	*25.1*		*44.3*		–	–

Source: Authors' calculation based on the 2011 Census data.

majority is even less, about 27 per cent *(Table 8)*. Despite the huge differences between remote and non-remote areas as a whole, non-remote localities with Roma majority have almost the same income level as remote ones (27.4 % and 26.6% of the national average respectively).

Low income and deep poverty necessarily manifests in low living standards. Data from the 2011 census show that the remote housing density is significantly higher than other areas, while the quality of flats and the availability of internet subscriptions are far below the non-remote and non-Roma average *(Table 8)*. Overcrowding is common for Roma households because of the relatively high number of children and the small, bad quality of flats. According to the statistics, a low per capita number of internet subscriptions is also inversely correlated to the high Roma share within the local population.

In similarity to Roma people in Hungary, overcrowding is more common in towns where the proportion of Indigenous Australian's in the resident population is higher.

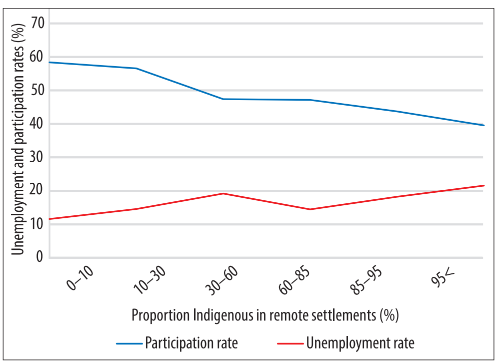


Fig. 7. Unemployment and participation rates in remote settlements, 2011. *Source*: Author's calculations using data extracted from ABS Table Builder, 2011 Census.

Table 7. Indicators of the proportion of employed persons who work in the government sector, 2011.*

Proportion Indigenous in remote communities, %	Number of communities	Average per cent government employed*
0–10	71	34
10–30	57	28
30–60	40	32
60–85	35	27
85–95	112	31
95 and over	89	35
Total remote, Indigenous	*404*	*32*
Total remote, Non-Indigenous	*404*	*16*
Non-remote, Indigenous	*710*	*21*
Non-remote, Non-Indigenous	*710*	*16*

*Government sector includes the Australian State and territory and local governments. *Source*: Custom data extracted by the authors from ABS Table Builder, 2011 Census.

Table 8. Income and some indicators of living circumstances in Hungary, 2011

Proportion of Romas in settlements, %	Relative income per capita (Hungary = 100.0)		Share of dwellings with six or more residents		Number of internet subscriptions per 1,000 persons	
	Remote	Non-remote	Remote	Non-remote	Remote	Non-remote
0–1	58.2	105.5	3.0	2.0	251	359
1–5	55.6	108.4	3.1	1.7	245	369
5–10	53.7	74.1	4.0	3.0	239	279
10–20	51.9	71.1	5.1	4.3	238	281
20–30	46.2	59.5	6.6	6.0	227	256
30–40	39.5	42.8	9.0	7.3	266	219
40 and over	26.6	27.4	12.0	14.1	187	235
Total	*50.4*	*103.4*	*5.1*	*1.9*	*238*	*356*

Source: Authors' calculation based on the 2011 Census data.

There is a strong statistical relationship between the proportion Indigenous in remote towns and the proportion of private dwellings with six or more residents *(Figure 8)*. In remote areas, there are (on average) more persons per bedroom in private dwellings. In Indigenous households in remote Northern Territory, for example, there are an average of 1.5 persons per bedroom and 3.5 persons per household compared to 1.2 persons per bedroom and 2.5 persons per household for non-Indigenous households (ABS 2012b).

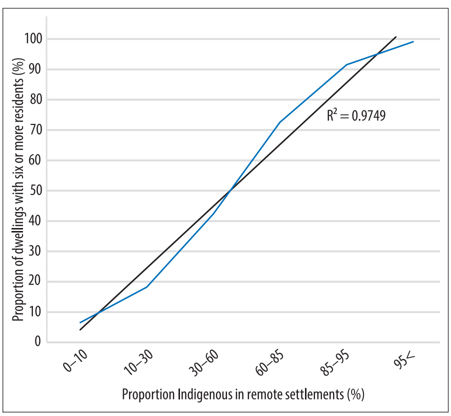


Fig. 8. Dwellings with six or more residents in remote settlements, 2011. *Source*: Author's calculations using data extracted from ABS Table Builder, 2011 Census.

Meanwhile, internet connection rates in remote settlements are inversely related to the proportion of the population of dwellings which are classified as Indigenous dwellings *(Figure 9)*.

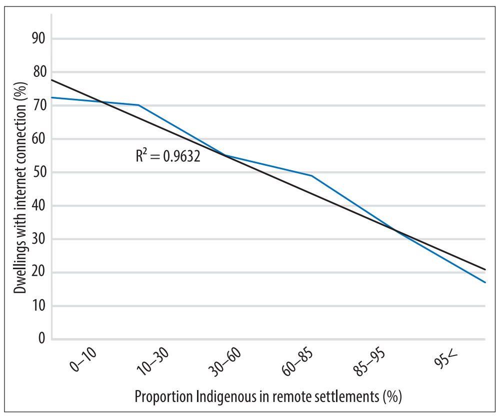


Fig. 9. Proportion of remote dwellings with internet connections, 2011. *Source*: Author's calculations using data extracted from ABS Table Builder, 2011 Census.

Discussion and conclusions

In this study we have compared and contrasted a range of demographic, socio-economic and other indicators to highlight the similar circumstances faced by the visible minorities of Hungarian Roma and Australian Indigenous peoples. The research here emphasises that, although there are substantial conceptual and methodological issues in directly comparing visible minorities with non-migrant backgrounds, people in both populations face similar issues in terms of their social and economic wellbeing, suggesting that they are in a disadvantaged position and are not benefiting to the extent of wider society. Based on statistical data, the research revealed essential similarities in remote geographical position intertwined with poor socio-economic circumstances of the two groups.

It is important to emphasize that both groups are overrepresented in remote areas which are peripheral and underdeveloped areas of the two countries. The data shows substantial 'gaps' in the selected indicators, namely fertility, health, education, income, labour market, household internet and car ownership. Both Roma and Indigenous people are characterized by unfavourable indicators in these areas compared to the majority of society. Furthermore, the research found gaps not only between the visible minorities and the others but between remote living and non-remote people as well. Overall, therefore, the impoverished position of Roma and Indigenous people can be conceptualised along three dimensions: spatial remoteness, socioeconomic remoteness and ethnic differentiation.

What is special in our case is the spatial factor. In developed countries, most of the visible minorities have a migrant background; tending to settle in urban regions, as most developed places providing propitious life-circumstances, when resettling. By contrast, visible minorities with a non-migrant background are concentrated in regions offering a narrower range of possibilities for wellbeing due to historical processes which have resulted in lower socioeconomic status in these areas. This situation is sometimes exacerbated by unfavourable settlement patterns and ethnic residential segregation.

In Australia gaps between both Indigenous and other Australians, as well as between remote-living and urban-living Australians have become the focus for successive iterations of national and State or Territory government policies for rectifying the situation. While key health indicators, such as infant mortality rates, for remote living Indigenous people are improving (Australian Government 2015), it is difficult to argue that decades of high investment have paid dividends in terms of 'closing the gaps'. Some of this, like the gap in life expectancies between Indigenous Australians and others, is because conditions for others continue to improve, and so despite improvements for Indigenous people, the gaps remain.

In Hungary, the analysis has confirmed the general gap between Roma and non-Roma people by comparing national census data. This gap is also traceable within remote areas where generally, a higher Roma population share means worse indicators at the settlement level. Based on the few available data and the general gap between the remote and non-remote areas, and considering the limits of the indirect method, we also argue that remote living Roma face somewhat worse life-circumstances than their co-ethnics in non-remote regions. Similar to the Australian case, despite the governmental policies (mostly employment and education policies) addressing 'closing the gaps' between Roma and non-Roma following the regime change in 1989, Roma life circumstances have barely improved and, thus, the gaps remained or continued to grow (Molnár, E. and Dupcsik, C. 2008; Fleck, G. and Messing, V. 2010; Kertesi, G. and Kézdi, G. 2012).

The reasons for the gaps are mostly derived from visible minorities' inherited social and spatial disadvantage. During the formation of modern societies, non-migrant visible minorities were pushed to the geographical peripheries, excluded from the traditional society (or if integrated, only to the bottom strata) and secluded from the resources. Social and spatial marginalization was facilitated by their 'visibility', i.e. the racial differentiation. Up to the 1970s in Australia and until 1989 in Hungary, the contemporary power made efforts to resolve Indigenous/Roma issue by forced assimilation. In recent decades, policies of multiculturalism are favouring visible minorities, however with little effect, therefore both Indigenous Australians and Hungarian Roma still suffer from low social-political-economic integration, low human capital and low accessibility to resources. Ethnic discrimination and remote geographical position also contributes to unequal social relations and exclusion from the centralized decision-making process.

A lack of human capital and financial resources also hampers mass migration of Roma and Indigenous to non-remote areas, which might be the easiest way to 'break out' of poverty. Nevertheless, numerous examples show that individuals with capacity for social mobility can successfully improve their socioeconomic status. However, these "success stories" more likely result in assimilation, especially if the individuals' anthropologic character allows getting out from Indigenous/Roma ethnic category. Overall, as a consequence of the changing ethnic self-identification of wealthy members of visible minorities, only poor, marginalized people likely living in remote areas will be associated with non-migrant visible minorities.

Our study is an attempt to conceptualise international comparisons of visible minorities focusing on remote living Hungarian Roma and Australian Indigenous. We found that, independent from the geographical location, the scale and the social context, visible minorities face similar problems and gaps, and patterns of social and spatial exclusion are similar across the developed nations. Policy makers will benefit from understanding marginalization and disadvantage of minority groups through the lenses applied in this study to formulate policies for improving these circumstances across international boundaries.

***Acknowledgement*:** Patrik Tátrai's research was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

REFERENCES

ABS 2007. Discrete Indigenous Communities & Australian Geographical Classification Remoteness Structure. Canberra, Australian Bureau of Statistics. http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/499711EC612FF76ECA2574520010E1FE/$File/communitymap.pdf. Accessed 20.09.2017

ABS 2012a. 3302055003DO002_20102012 Life Tables for Aboriginal and Torres Strait Islander Australians, 2010–2012. www.abs.gov.au. Accessed 23.03.2015.

ABS 2012b. *2002.0 – Aboriginal and Torres Strait Islander Peoples (Indigenous) Profile*. Canberra, Australian Bureau of Statistics.

ABS 2013a. *2077.0 – Census of Population and Housing: Understanding the Increase in Aboriginal and Torres Strait Islander Counts, 2006–2011*. www.abs.gov.au Accessed. 16.04.2016.

ABS 2013b. *3302055003DO002_20102012 Life Tables for Aboriginal and Torres Strait Islander Australians, 2010–2012*. www.abs.gov.au. Accessed 23.03.2015.

ABS 2015. *3101.0 – Australian Demographic Statistics, Jun 2015*. http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0. Accessed 13.03.2016.

ABS 2016. *2011 Census QuickStats*. http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/0?opendocument&navpos=220. Accessed 26.08.2016.

Abu-Saad, I. and Creamer, C. 2012. Socio-Political Upheaval and Current Conditions of the Naqab Bedouin Arabs. In: *Indigenous (In)Justice*. Eds.: Amara, A., Abu-Saad, I. and Yiftachel, O., Cambridge, Harvard University Press, 18–66.

AIHW (Australian Institute of Health and Welfare) 2014. *Mortality and life expectancy of Indigenous Australians: 2008 to 2012*. Canberra, Australian Institute of Health and Welfare.

Australian Government 2015. *Closing the Gap: Prime Minister's Report 2015*. Canberra, Commonwealth of Australia.

Australian Population and Migration Research Centre 2014. *ARIA (Accessibility/Remoteness Index of Australia)*. http://www.adelaide.edu.au/apmrc/research/projects/category/about_aria.html. Accessed 03.10.2014.

Babusik, F. 2004. Állapot-, mód- és okhatározók. A romák egészségügyi állapota és az egészségügyi szolgáltatásokhoz való hozzáférése I. (The health status of the Roma and their access to health care I). *Beszélő*, 9. (10): 84–93.

Bock, B., Kovacs, K. and Shucksmith, M. 2014. Changing social characteristics, patterns of inequality and exclusion. From rural development to rural territorial cohesion. In *Territorial cohesion in rural Europe: the relational turn in rural development*. Eds.: Copus, A.K. and de Lima, P., New York, Routledge, 193–205.

Csepeli, G. and Simon, D. 2004. Construction of Roma Identity in Eastern and Central Europe: Perception and Self-identification. *Journal of Ethnic and Migration Studies* 30. (1): 129–150.

Durst, J. 2010. "What Makes Us Gypsies, Who Knows…?!": Ethnicity and Reproduction. In *Multidisciplinary Approaches to Romany Studies.* Eds.: Stewart, M. and Rövid, M., Budapest, CEU Press, 13–34.

EC 2014. *Roma Health Report. Health status of the Roma population. Data collection in the Member States of the European Union*. European Commission. http://ec.europa.eu/health/social_determinants/docs/2014_roma_health_report_en.pdf. Accessed 18.04.2016.

Faluvégi, A. and Tipold, F. 2012. A társadalmi, gazdasági és infrastrukturális szempontból elmaradott, illetve az országos átlagot jelentősen meghaladó munkanélküliséggel sújtott települések (Socially, economically and infrastructurally disadvantaged settlements, and those with high unemployment). *Területi Statisztika* 15. (3): 278–290.

Feischmidt, M. 2012. Constraints and Accommodation. Economic and Symbolic strategies of Romani people living in Hungarian villages. In *Identities, Ideologies and Representations in Post-transition Hungary.* Eds.: Heller, M. and Kriza, B., Budapest, ELTE Eötvös Kiadó, 259–290.

Fleck, G. and Messing, V. 2010. Transformations of Roma employment policies. In *The Hungarian Labour Market 2010: Review and Analysis.* Eds.: Lovász, A. and Telegdy, Á., Budapest, Insitute of Economics, HAS & National Employment Foundation, 83–98.

Fónai, M., Fábián, G., Filepné Nagy, É. and Pénzes, M. 2008. Poverty, health and ethnicity: The empirical experiences of researches in Northeast-Hungary. *Review of Sociology of the Hungarian Sociological Association* 14. (2): 63–91.

Galabuzi, G. 2006. *Canada's economic apartheid: The social exclusion of racialized groups in the new century*. Toronto, Canadian Scholars' Press.

Gregory, R. and Daly, A. 1997. Welfare and Economic Progress of Indigenous Men of Australia and the U.S.: 1980–1990. *Economic Record* 73. 101–119.

Hablicsek, L. 2008. The Development and the Spatial Characteristics of the Roma Population in Hungary Experimental Population Projections till 2021. *Demográfia* 51. (5): 85–123.

Havas, G., Kemény, I. and Kertesi, G. 2000. A relatív cigány a klasszifikációs küzdőtéren (The relative Roma in the classification struggle). In *Cigánynak születni. Tanulmányok, dokumentumok.* Eds.: Horváth, Á., Landau, E. and Szalai, J., Budapest, Aktív Társadalom Alapítvány & Új Mandátum Kiadó, 193–201.

Hoddie, M. 2006. *Ethnic Realignments. A Comparative Study of Government Influences on Identity*. Lenham, Lexington Books.

Hou, F. and Picot, G. 2004. Profile of ethnic origin and visible minorities for Toronto, Vancouver, and Montreal. *Canadian Social Trends* 11. 9–14.

Janky, B. 2006. The Social Position and Fertility of Roma Women. In *Changing Roles.* Eds.: Nagy, I., Pongrácz, T. and Tóth, I., Budapest, TÁRKI, 136–150.

Kemény, I. and Janky, B. 2005. Roma Population of Hungary 1971–2003. In *Roma of Hungary.* Ed.: Kemény, I., Highland Lakes, Atlantic Research and Publication, 70–225.

Kertesi, G. and Kézdi, G. 2012. *Ethnic segregation between Hungarian schools: Long-run trends and geographic distribution*. Budapest, Institute of Economics, RCERS, HAS & Department of Human Resources, Corvinus University of Budapest.

KIM 2011. *Nemzeti társadalmi felzárkózási stratégia – mélyszegénység, gyermekszegénység, romák – (2011–2020)* (National Social Inclusion Strategy – extreme poverty, child poverty, Romas – [2011–2020]). Budapest, Ministry of Public Administration and Justice, Hungary http://romagov.kormany.hu/download/8/e3/20000/Strat%C3%A9gia.pdf

Klinger, A. 2003. Mortality differences between the subs regions of Hungary. *Demográfia* 46. (5): 21–53.

Kocsis, K. and Kovács, Z. 1991. A magyarországi cigány népesség társadalomföldrajza (The social geography of the Gypsy population in Hungary). In *Cigánylét.* Eds.: Utasi, Á. and Mészáros, Á., Budapest, MTA Politikai Tudományok Intézete, 78–105.

Ladányi, J. and Szelényi, I. 2001. The Social Construction of Roma Ethnicity in Bulgaria, Romania and Hungary during Market Transition. *Review of Sociology of the Hungarian Sociological Association* 7. (2): 79–89.

Ladányi, J. and Szelényi, I. 2006. *Patterns of Exclusion: Constructing Gypsy Ethnicity and the Making of an Underclass in Transitional Societies of Europe*. New York, Columbia University Press.

Ladányi, J. and Virág, T. 2009. A szociális és etnikai alapú lakóhelyi szegregáció változó formái Magyarországon a piacgazdaság átmeneti időszakában (Forms of social and ethnic segregation in Hungary during the market transition period). *Kritika* 38. (7–8): 2–8.

Lang, T. 2015. Socio-economic and political responses to regional polarisation and socio-spatial peripheralisation in Central and Eastern Europe: a research agenda. *Hungarian Geographical Bulletin* 64. (3): 171–185.

Lee, K.W. 2011. A comparison of the health status of European Roma and Australian Aborigines. *Ethnicity and Inequalities in Health and Social Care* 4. (4): 166–185.

Lőcsei, H. and Szalkai, G. 2008. Helyzeti és fejlettségi centrum-periféria relációk a hazai kistérségekben (Role of location and development in the centre-periphery relations in the Hungarian subregions). *Területi Statisztika* 11. (3): 305–314.

Milcher, S. 2006. Poverty and the Determinants of Welfare for Roma and Other Vulnerable Groups in Southeastern Europe. *Comparative Economic Studies* 48. (1): 20–35.

Molnár, E. and Dupcsik, C. 2008. *Country Report on Education: Hungary.* Budapest, Center for Policy Studies, CEU.

Nagy, E. 2015. Discussing inequalities from the periphery. *Hungarian Geographical Bulletin* 64. (3): 167–170.

Pásztor, I.Z. and Pénzes, J. 2012. Employment crisis and income peripherization in Northeastern Hungary with special attention to the Roma population. In *Roma Population on the Peripheries of the Visegrad Countries.* Eds.: Pénzes, J. and Radics, Z., Debrecen, Didakt, 52–65.

Pásztor, I.Z., Pénzes, J., Tátrai, P. and Pálóczi, Á. 2016. The number and spatial distribution of the Roma population in Hungary – in the light of different approaches. *Folia geographica, Acta facultatis studiorum humanitatis et naturae Universitatis Prešoviensis* 58. (2): 5–21.

Pedersen, A. and Walker, I. 1997. Prejudice against Australian Aborigines: old-fashioned and modern forms. *European Journal of Social Psychology* 27. (5): 561–587.

Pénzes, J. 2013. The dimensions of peripheral areas and their restructuring in Central Europe. *Hungarian Geographical Bulletin* 62. (4): 373–386.

Pénzes, J., Tátrai, P. and Pásztor, I.Z. 2018. A roma népesség területi megoszlásának változása Magyarországon az elmúlt évtizedekben (Changes in the spatial distribution of the Roma population in Hungary during the last decades). *Területi Statisztika* 58. (1): 3–26.

Rowse, T. 2006. Towards a history of Indigenous statistics in Australia. In *Assessing the Evidence on Indigenous Socioeconomic Outcomes: A Focus on the 2002 NATSISS.* Ed.: Hunter, B.H., Canberra, Centre for Aboriginal Economic Policy Research, The Australian National University, 1–10.

Tátrai, P. 2015. Transformations of the ethnic structure in Hungary after the turn of the millennium. *Human Geographies* 9. (1): 79–96.

Tátrai, P., Pálóczi, Á., Pásztor, I.Z. and Pénzes, J. 2017. Etnikai besorolási gyakorlatok: a cigányság külső kategorizálását befolyásoló tényezők (Contributions to the background of external categorization of Roma). *Socio.hu Társadalomtudományi Szemle* 7. (2): 44–64.

Taylor, A. and Bell, B. 2013. *The Northern Territory's declining share of Australia's Indigenous population: A call for a research agenda*. Darwin, Charles Darwin University.

Taylor, A., Larson, S., Stoeckl, N. and Carson, D. 2011. The haves and have nots in Australia's Tropical north – new perspectives on a persisting problem. *Geographic Research* 49. (1): 13–22.

Uzzoli, A. and Szilágyi, D. 2009. Life expectancy and its regional inequalities in Hungary. *Geographica Pannonica* 13. (4): 127–136.

Virág, T. 2006. The regional ghetto. *Review of Sociology of the Hungarian Sociological Association*, 12. (1): 51–70.

Wang, J-H. 2015. Happiness and Social Exclusion of Indigenous Peoples in Taiwan – A Social Sustainability Perspective. *PLoS ONE* 10. (2): e0118305.

White, P.A. 2008. The Hot Seat: The Black Scholar's Perception of the "Chilly Climate". In *Whose University is It, Anyway?: Power and Privilege on Gendered Terrain.* Eds.: Acker, S., Wagner, A. and Mayuzumi, K., Toronto, Sumach Press, 79–89.

DOI: 10.15201/hungeobull.67.1.5 Hungarian Geographical Bulletin **67** 2018 (1) 61–74.

Using Google Maps road traffic estimations to unfold spatial and temporal inequalities of urban road congestion: A pilot study from Budapest

Péter BAJI[1]

Abstract

In recent urban geography literature, smart cites became a fashionable subject. The smart city paradigm is strongly connected to researches based on big data. The main objective of this paper is to strengthen the idea of usefulness of big data in examining and developing the urban transportation system as part of smart cities. In this pilot research, Google Maps traffic estimation data were used to evaluate the special vehicular traffic flows in District 3, in Budapest. On 45 defined road sections, travel time estimation data were collected with the aim to calculate the extent of wasted time in traffic jams. According to our results this source of 'big data' is a feasible way of conducting 'smart' research on a city road system. The most relevant advantage of this database is that it is continually generated on a high spatial and temporal resolution. The conclusion of this pilot research is that spatial and temporal inequalities are evincible from this database, unrecognized processes can be easily analysed, which can help urban planners to rethink their strategies on urban transport system. The most important findings showed that, on workdays, there is a second wave of peak traffic on many roads, and, within our chosen district, there are congestion hot spot places. It is important to note that Google Maps data have limits, but by understanding them this method is a useful way for geographers to examine urban traffic congestion patterns with a high spatial resolution.

Keywords: smart city, urban transport, big data, Google Maps, travel costs, wasted time, urban traffic

Introduction

Over the last decade, smart cities became a fashionable subject of urban development both in the international academic literature and public discourse. There are three main global urban issues wherein the smart city concept can provide solutions for urban development. The first is urban crowd or congestion: cities should handle their growing population and the challenges that this process generates (Chuan Tao, Y. *et al.* 2015). The second issue is providing sustainable urban environment in cities for a higher quality of life for their citizens (Abella-Garcia, A. *et al.* 2015). The third issue is creating social inclusion and decreasing inequalities in urban life conditions (Batty, M. *et al.* 2012). Big ICT companies like IBM, Cisco or Telekom provide IT solutions for cities who put their investments in 'smart city' development projects in order to promote their 'smart', 'sustainable' and 'green' nature. At the same time social researchers are more critical about these oversimplified computational solutions to social problems (Anttiroiko, A.V. 2013, 2014; Townsend, A.M. 2013; Kitchin, R. 2014).

The main objective of this paper is to strengthen the idea of usefulness of big data in examining and developing the urban transportation system. In 2011, Google Maps made its real-time traffic congestion data available in Hungary, and today they also have available traffic forecasts on cer-

[1] Institute for Sociology, Centre for Social Sciences, Hungarian Academy of Sciences, H-1097 Budapest, Tóth Kálmán u. 4. E-mail: baji.peter@tk.mta.hu

tain roads where significant congestions can be measured. These data can provide lots of new insights for urban geographers especially in cities like Budapest, where vehicular traffic jams generate huge problems.

For the sake of this pilot research the 3rd district of Budapest was chosen as case-study area due to several reasons. Firstly, this district lies in a geographically transitional position between the 'wealthier' north-western part of the suburban zone and the downtown area of Budapest; thus, vehicular traffic generated both by commuters and inner-city car users can be analysed at the same time. For instance, in recent times, the volume of commuters from agglomeration settlements to Budapest has increased (Keserű, I. 2013), and this extra traffic can be observed on the roads of the case-study district. Moreover, this area has mixed residential land use pattern, with the largest pre-fab housing estate in Budapest, garden suburbs, and high-density downtown-type urban housing. These differences can serve as explanatory factors for the road traffic patterns. Secondly, this area has a complex, but well analysable, road system that fits the organic historical neighbourhood types of the district; thus, it is suitable for a pilot study.

Research background

Smart transport and mobility as a smart city 'domain'

Since cities are complex systems containing lots of physical, social and environmental layers, smart city research also addresses different aspects (or so-called 'domains') of smart cities. According to Mattoni, B. *et al.* (2015), there are hard and soft domains in smart city development. Hard domains are related to the physical infrastructures of the city, like energy grids, water management system, buildings, or transport. In the development of these domains, the relevance of big data generated by sensors and their software is often emphasized (Neirotti, P. *et al.* 2014). Among them smart urban transport is probably the most promising research field for geographers, because the optimization of an urban transport system directly improves the life of local residents and the environment of the city.

In the international literature, lots of studies emphasize the potential development possibilities of smart mobility or intelligent transport systems (Giffinger, R. *et al.* 2007; Attiroiko, A.V. *et al.* 2014; Steenbruggen, J. *et al.* 2015; Bálint, D. and Trócsányi, A. 2016). During the development process of telecommunication in the 1990's, a demand arose among developers to keep track of urban traffic flows even in real-time (Marvin, S.J. 1994), and today, through smart sensors and contracted GPS user transporters, these flows became analysable (these results can be seen in a simplest way on Google Maps). These data are increasingly feasible for unfolding and detecting traffic jam zones within the city; furthermore, these real-time data provide opportunities for quick intervention for urban planners and a great potential for urban researchers to detect the results of these interventions. Thus, cities became "urban laboratories", where planners and researchers can conduct experiments (Batty, M. *et al.* 2012).

This study is strongly connected to the old dilemma of interchangeability of the travelling and telecommunication (Graham, S. 1997); the main point of this issue is how society can decrease travel time, travel costs, and lower the level of pollution through cheaper telecommunication opportunities that connect people while eliminating the need to travel (e.g. home office days, Skype meetings). The importance of this issue was highlighted by a recent study based on the Hungarian time-budget survey (1986/1987–2009/2010), which revealed the consistency of the average daily transport time-use per capita (60–65 minutes) in the last four decades, and showed that in this period the motorcycle/car time-use ratio roughly doubled in the total transport time use among Hungarian commuters (Fleischer, T. and Tir, M. 2016).

Environmental, economic and social effects of urban congestion

It is also important to note that urban transport systems generate 40 per cent of carbon-dioxide emissions in modern cities, but there are good examples where this pollution has been decreased through smart IT solutions and cross-city cooperation (Navarro, C. *et al.* 2015). In the last decades, a lot of studies have highlighted the increasing amount of air pollution caused by urban sprawl and road traffic congestion in different urban areas around the world (Chin, A. 1996; Camagni, R. *et al.* 2002; Quingyu, L. *et al.* 2007). Although, different vehicle types generate different amounts of pollutants, the emission ratio is higher in traffic jams, thus, congestion hot spots became pollution hot spots, too.

The economic and social effects of road traffic congestion can be measured by the length of vehicles' travel delay. On the one hand, researchers argue that measuring congestion with the help of travel delay times can show the amount of unproductive, wasted time for society (Cohen, H. and Southworth, F. 1999; Schrank, D. *et al.* 2010). On the other hand, it is not clear how the real value of time and an accurate benchmark of road congestion can be defined (Rouwendal, J. and Nijkamp, P. 2004; Sweet, M. 2011). Although, the economic costs of congestion are more measurable (e. g. by the amount of wasted work time), several studies highlight that these kinds of travel delays not always generate significant losses in economic productivity (Stopher, P.R. 2004) because individuals change their travel behaviour through modal, temporal and spatial corrections (Downs, A. 1992).

Big data applications for a better understanding of the city

Based on the international smart city literature, it is safe to claim that the use of big data is unavoidable, because such data enable real-time analysis of city life and provide huge amounts of information for planners in order to make more sustainable and efficient cities (Kitchin, R. 2014). Kitchin, R. (2013, 2014) emphasizes that using big data for urban research can complement well-known 'small data' research like censuses and other small-sample based qualitative surveys. Because of the high accessing velocity (created at close to real time) and the high spatial and temporal resolution of this data type, it can provide static snapshots and overviews of the dynamic unfolding of the daily life pattern of cities.

Many researchers emphasize, furthermore, that data generated worldwide about society and business sectors are growing dynamically; moreover, today, more data is being generated every two days than in all of history (Manyika, J. *et al.* 2011; Smolan, R. and Erwitt, J. 2012; Zikopoulos, P.C. *et al.* 2012; Rial, N. 2013). Although growth of available data can be seen impressive for 'data hungry' researchers, it is important to note that there are several difficulties when we try to use these data sets. For instance, in most cases, big data come from a huge unstructured file with different types of data (numbers, pictures, strings), therefore, making reliable connections among these data can be a slow and complex work (Al Nuaimi, E. *et al.* 2015).

According to Kitchin, R. (2014), the sources of big data can be divided into three categories: directed, automated, and volunteered. Directed data comes from the traditional forms of surveillance conducted by states (e.g. passport control, fingerprints, public surveillance cameras). Automated data are produced by automatized data capture systems like smart phones that record their usage history and cell phones' call data. The third type of data source is volunteered data, which is generated by the conscious decisions of users who make observations, and create posts and uploads on social media sites, for example (Lengyel, B. and Jakobi, Á. 2016). While the first and third categories generate several concerns about defending personal privacy (Niaros, V. 2016), the second source can provide aggregated data without ethical problems. Research results presented in this paper are clearly linked with the second big data source.

Methods and database

Transport sciences have a long history of measuring traffic flows with different methods and approaches (Wardrop, J.G. and Charlesworth, G. 1954; Leduc, G. 2008). Transportation engineers generate traffic data with the help of static and dynamic measurement methods. The typical way of measuring cross-sectional static traffic is by using loop detectors to calculate the number of vehicles passing through a given point of a road. For instance, the national cross-sectional study in Hungary uses raw data from this type of instrument (Magyar Közút Nonprofit Zrt. 2017). Although the advantage of this method is its accuracy, its main limit is the spatially fixed nature of the measuring instruments, therefore, the length and geographical positon of measured road sections are consistent. Thus, these data can be used for transportation planning on a larger geographical scale, but the local spatial pattern of transport habits in urban society cannot be detected this way. The other method for unfolding traffic flow patterns is dynamic measurement. Formerly, this method used a car moving with traffic and registering its own traits of trajectory. In recent times, FCD (Floating Car Data) measurement has been emerging: where vehicles operated by fleet management systems send their GPS data while they are in traffic. This real-time data is supplemented by private car owners' GPS positions, using navigation applications on their drivers' smart phones. Google Maps traffic data is typically generated this way; hence, in comparison with the aforementioned cross-sectional survey, the advantage of these data is in their temporal and spatial resolution. Moreover, annual Hungarian cross-sectional surveys are limited to main roads, and they cannot detect the traffic patterns in smaller urban roads within a day.

This pilot study tried to test the usefulness of big data about traffic generated by Google Maps. In the first step, the measured roads of the whole district were subdivided into roughly one-km-long sections. These sections were adjusted according to the morphology of the district's urban road system, and I made sure to fit them to the real organic neighbourhoods. The total number of road sections is 45. Secondly, I defined a week when traffic estimation data were collected. This time period was from 13 to 19 November 2017. Choosing a complete week helped me to observe the road traffic patterns on weekend days as well as workdays. The selected time period is a normal week without any national holiday; and in November the number of tourists is generally low. Thus, the estimated traffic data closely approaches the real average traffic in this time period.

The third step was the process of data collection with the help of Google Maps (www.maps.google.hu). From this website, two data types where collected: the basic travel time (shorter) and the travel time with the estimated traffic volume (longer). The time intervals of collected data within the days were 20 minutes long, because the website allowed this temporal level. The first point of time was 06:00 in the morning and the last was 22:00 at night on every measured day. After the raw data were collected, I built a database on further indicators, like average speed of traffic, total number of vehicles, and volume of time wasted per kilometre and car on certain road sections. To estimate the number of vehicles, the so-called Greenshields-formula was used (Greenshields, B.D. 1935), which assumes that there is a linear connection between the velocity and the density of road traffic. Even though this formula was developed for estimating highway traffic, which is simpler than urban road systems with their intersections and traffic lights, it is still applicable to the general estimation of urban traffic patterns as well (Erhart, Sz. 2007), and thus it is suitable for the main goal of this pilot research.

$$V = V_{\max}\left(1 - \frac{K}{K_d}\right), \quad (1)$$

where V = velocity, V_{max} = maximum velocity, K = actual traffic density, K_d = traffic density in the case of maximum traffic congestion;

$$Q = V \cdot K, \quad (2)$$

where Q = number of vehicles in a certain time period on the defined road.

Using these indicators, I was able to compare the main temporal and spatial traffic patterns of the districts. Finally, the whole database was analysed with statistical methods and thematic maps were produced.

According to Google's official statements, these data are calculated using different sources: government departments of transportation, and private data providers (gadgets.ndtv.com). The latter include individuals who use smart phones for navigation (e.g. Waze or Google Maps). Although Google has enough collected historical data even in Budapest to make rather accurate real-time and future traffic estimations, the accuracy of data always depends on the actual number of 'data providers' within the chosen area. However, the data on these numbers are not public. Even though Google Maps traffic estimations have been used for many years in different countries, little scientific analysis has been conducted about the accuracy of their application; but there is some evidence about the fairly good accuracy of web-based traffic estimations like those done with Google Maps (Morgul, E. *et al.* 2014).

Results of the pilot research

The big picture: basic pattern of daily road traffic

According to the results, there are three different daily congestion flow types within a week, if we analyse the cumulated data in the whole district. The first type is the typical workday from Monday to Thursday. On these days we can differentiate three main congestion time periods *(Figure 1).*

In the direction of the city centre roads become congested in two waves. In the morning, this wave lasts from 6.00 to 11.20, with the peak between 7.40 and 8.00. Though the volume of traffic decreases around midday, it does not fade away. The second wave starts in the afternoon from 14.20 and ends at night 20.20. This wave peaks at 17.40. Comparing the two traffic waves in the direction of the city centre, we can see that the morning one is larger in volume. But observing the second wave points to a frequently unrecognized phenomenon which, in terms of urban development, is truly significant. The phenomenon is the second traffic wave itself, generated by people who are on their way home and who leave their home for the second time, travelling by car in the direction of the city centre to go shopping or do other leisure activities. The third congestion period is also in the afternoon between 15.00 and 19.40, but in the direction of the outskirts *(Figure 1).* This congestion wave shows the normal vehicular traffic generated by people who leave their workplace to go home.

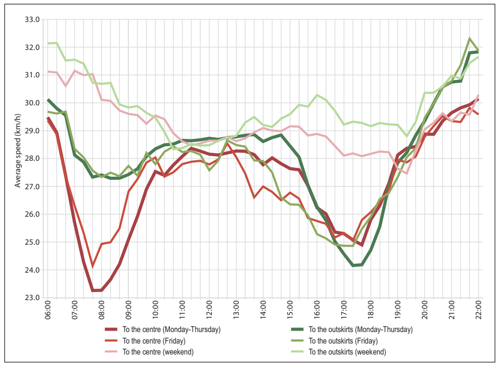


Fig. 1. Estimated average traffic speed on measured roads of District 3 in Budapest over a day. Time of estimation: 13.11.2017–19.11.2017. *Source*: https://maps.google.com

The second somewhat transient day type, is Friday. On this day, the morning traffic towards the city centre is somewhat lower and shifts slightly later (by 20 minutes). However, the main feature that distinguishes it from other workdays is the earlier start of the afternoon congestion waves in both directions. This wave in the direction of the centre starts from 13.00 and also ends in the evening at 20.20. The main peak of this wave comes 20 minutes earlier than on other workdays. Friday traffic to the outskirts shows a similar pattern; it starts also at 13.00 but ends earlier, at 19.40 in the evening, with an earlier peak between 16.40 and 17.20. Thus, we can say that afternoon traffic on Friday has the same volume but has a longer duration than on other workdays. This result indicates that working people probably leave their workplaces earlier on Fridays, and this largely affects the characteristic of urban traffic congestion in our analysed district.

The third separate traffic type is, of course, weekend days. The most important observation about these days is that the volume of traffic over a day is much lower than on the other days of the week *(Figure 1)*. Besides this, we can note that traffic flow patterns are quite similar in both directions. On the weekend days, there are two smaller traffic waves. The first is from 10.20 to 13.40 (mainly to the outskirts), which can refer to the people who leave their home by car to have lunch somewhere. The second, slightly increasing traffic wave is in the afternoon between 16.20 and 20.00 (mainly to the centre). It represents those car users who go to do some leisure activities in the afternoon.

The volume of social time wasted

Although the costs of traffic jams for citizens are a hot topic among urban researchers, there is no consensus about the real volume of its negative economic impacts (Sweet, M. 2011, 2013). Even so, the volume of wasted time through traffic jams in society can be calculated from collected raw data. If we know the ideal and real travel times and the estimated number of vehicles on particular road sections, the total wasted time in congestion can be determined within the whole district *(Table 1)*.

If we analyse the traffic differences among different days, we can recognize that, while congestion peaks in the direction of the city centre are on Wednesdays, the peak to the outskirts is on Fridays. Thus, the traffic generated by workers travelling by car peaks not on Monday, the first workday, as one would expect, but in the middle of the week. This is generally true for both directions, but on roads

*Table 1. The daily estimated volume of urban congestion and wasted time**

Volume of congestion	Days of the week							Weekly amount
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
	to the centre							
Total number of congested vehicles on all roads in District III.	139,669	144,177	149,592	149,128	143,242	84,650	81,644	*892,101*
Sum of daily wasted time on all roads in District III, hours.	3,562	3,672	3,787	3,614	3,099	1,389	1,350	*20,473*
	to the outskirts							
Total number of congested vehicles on all roads in District III.	162,182	169,283	174,787	173,920	174,827	131,465	116,428	*1,102,894*
Sum of daily wasted time on all roads in District III, hours.	3,248	3,537	3,649	3,612	3,713	2,263	1,981	*22,002*

*Time of estimation 13.11.2017–19.11.2017. *Source:* Own calculations based on Google Maps data.

which lead out of the city, this peak remains on Thursday and Friday as well; moreover, the volume of vehicles and wasted time grows slightly. In contrast to workdays, on weekend days, the volume of daily traffic and wasted time is roughly half of the average workday traffic. But there is a larger difference between the two measured directions at weekends. In the direction to the suburban areas, the volume of traffic is higher (by a third) than towards the city centre. It can be related to weekend, holiday and leisure traffic, which starts already on Friday. So, if we see the weekly amount of vehicular traffic, the total number of vehicles in congestion is roughly 200,000 cars higher in the direction of the outskirts or the agglomeration. The origin of this phenomenon is the inclination of citizens to leave their home for leisure activities on weekends.

According to our findings, the magnitude of citizens' wasted time in traffic congestion is so large that it should be a relevant topic for urban planners in the investigated district. If we assume that all cars in congestion have only one passenger (this is the minimum estimation), then, on an ordinary workday, car users waste the total of nearly 300 days within this district alone *(Figure 2).*

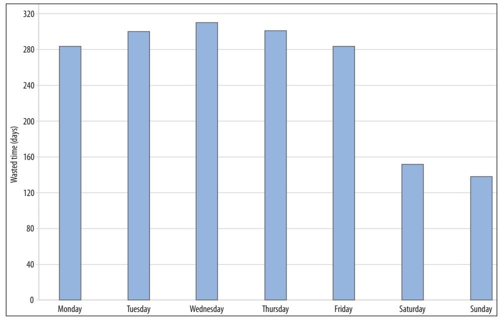


Fig. 2. Sum of daily wasted time in traffic congestion in Budapest's District III, on all roads and in all directions (2017). Time of estimation: 13.11.2017–19.11.2017. *Source*: Own calculations based on Google Maps data

This amount of time is slightly more than a year's worth of full-time work for a citizen, which means that, on a rough estimate, every year, District 3 of Budapest wastes around 250 people's yearly work time because of road traffic congestions. These data should inspire urban planners to explore the features and causes of congestion more intensely, because Budapest in general, and the 3rd district in particular, need to tackle this social and environmental problem.

Congestion hot spots on a deep spatial level

In the following, four aspects of road traffic patterns are investigated on a fine spatial resolution. The first two answer questions such as how the road size and geographical position relate to the intensity of congestions, or where the traffic hot spots are, and why they are there. The third aspect shows the differences between the two measured directions on a deep spatial level. Finally, the last question is whether we can define different road types according to their daily traffic flow.

To unfold the relations between some parameters of road sections and the volume of traffic, Pearson's correlation was calculated *(Table 2).* The main result of the analysis is that the size of certain roads impacts principally the volume of congestions and social time wasted, but these correlation coefficients are at best medium-strength. The results show that this interdependence is mainly true for workdays, and, in the case of the outskirts' direction, also Fridays and weekend days because of weekend traffic, as mentioned above. There is a weak negative correlation between the distance of road sections from the city centre and the daily amount of congested time wasted. This means that the more centrally located road sections have somewhat higher chance of congestion within a day, mainly on workdays *(Table 2).*

The last explanatory variable was the geographical position of the road section. This variable was generated with the help of a 2 km size grid, which was used to define the deeper geographical position of road sections *(Figure 3).* Although there is a weak positive correlation on workdays and mainly in the

Table 2. Pearson's correlation coefficients of road parameters and volume of time wasted*

Explanatory variables	Independent variables			
	workdays	Friday	Saturday	Sunday
Daily amount of time wasting per km, to the centre, min				
Size of road section,total length of lanes, m	*0.466*	0.276	– 0.203	– 0.242
Nearest distance from city centre of road section, m	– 0.232	– 0.206	– 0.031	– 0.019
Geographical position of the road section, 1 km grids	0.153	0.151	0.043	0.057
Geographical position of the road section, 2 km grids	0.167	0.160	0.035	0.051
Daily amount of time wasting per km, to the outskirts, min				
Size of road section,total length of lanes, m	*0.540*	*0.478*	*0.361*	*0.316*
Nearest distance from city centre of road section, m	– 0.105	– 0.006	– 0.011	– 0.077
Geographical position of the road section, 2 km grids	0.031	– 0.055	– 0.020	0.055
Daily amount of time wasting per km, both directions, min				
Size of road section,total length of lanes, m	*0.599*	*0.469*	0.149	0.094
Nearest distance from city centre of road section, m	– 0.215	– 0.135	– 0.024	– 0.064
Geographical position of the road section, 2 km grids	0.132	0.068	0.004	0.066

*Highest positive values in italics. *Source:* Own calculations.

direction of the city centre, the geographical position of these road sections is the weakest explanation for the congestion patterns of our measured district.

Thus, we can say that the congestion volume is primarily connected with the main roads of the district, and because these roads go through the whole area, the other geographical features of road sections are less relevant. It is obvious, that these main roads deserve more attention by urban planners and developers to detect the causes of vehicular traffic jams and decrease them. Another relevant consequence also comes from this observation; namely, the factor of commuting traffic from the agglomeration settlements to Budapest. The two main roads (Numbers 10 and 11) collect all transit traffic from the neighbouring settlements of District 3 and channel it towards the other neighbouring districts of Budapest. Thus, research on the effects of commuter traffic from neighbouring settlements deserve also special attention.

With the help of a database, the daily congestion hot spots are detectable; in other words, we can reveal which road sections have the largest amount of daily congestion and delay time. To measure the inequalities between particular roads, the amount of daily wasted time was used *(Figure 4).* This indicator shows the permeability of certain roads, and according to the results, there are some roads that are more traffic sensitive than others. In the direction of the city centre three congestion hot spots can be defined. The first is in the southern part of the district, near the downtown area. The main road of a sub-district called Újlak and its quay road integrate the total traffic to the city centre; thus, this is the main congestion hot spot within the district. Connected to this part of the district, there is another important road (Szépvölgyi and Kolostor streets) which channel the complete traffic from the southern highland neighbourhoods to the city centre *(Figure 4).*

The second, smaller congestion hot spot is the periphery of the Pók Street housing estate, where traffic attempts to avoid the congestion of Main Road 11, however, this itself generates traffic congestion in both directions. The third congestion hot spot is in the northern part of the district, and is affected by the large pre-fab housing estate of Békásmegyer. It is important to see that, although the sum of

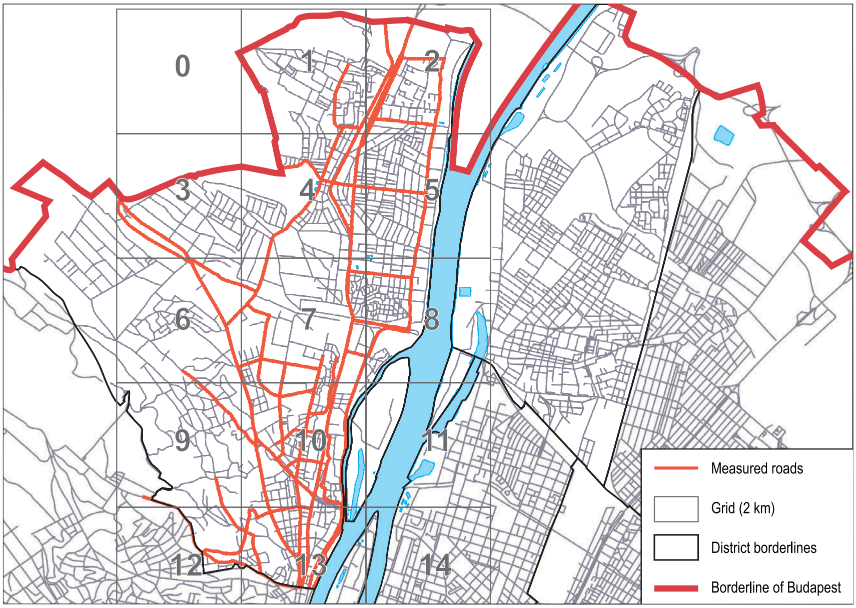


Fig. 3. The 2 km size grid used to define the geographical positions of road sections (edited by the author)

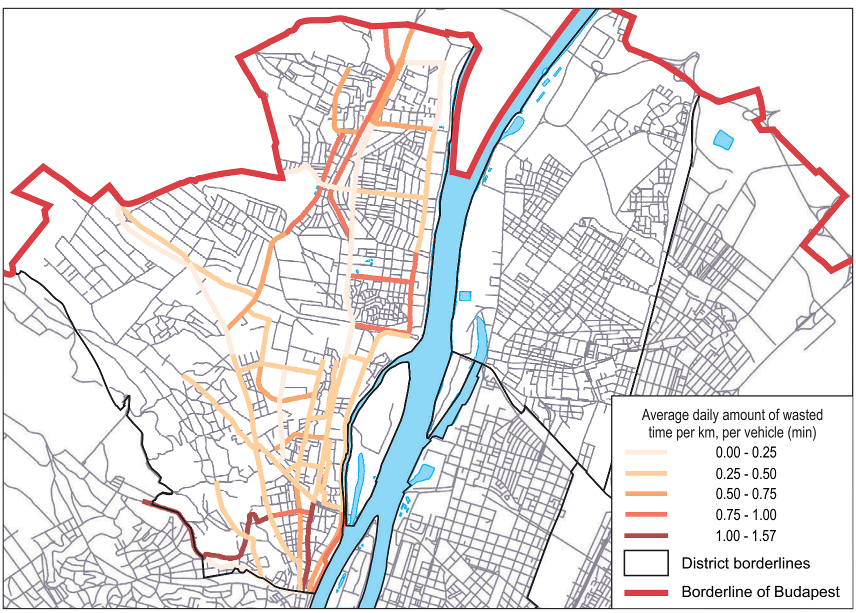


Fig. 4. The average amount of daily wasted time in traffic congestion on different road sections (between Monday and Thursday, towards the city centre). Time of estimation: 13.11.2017–16.11.2017. *Source*: Own calculations based on Google Maps data

time wasted is larger on main roads, in this area, the smaller roads are more sensitive to high traffic levels. In addition, the geographical position of the suburban railway can be an explanatory factor, because the railway line lies between Road 11 and congested smaller roads; thus, to reach the main road, drivers must go across the railway. Because of the heavy railway traffic at congestion times, these crossing points frequently slow down vehicular traffic with light barriers. Not counting a couple of smaller road sections, traffic in the direction of the outskirts shows similar patterns to traffic in the direction of the city centre *(Figure 5)*. The three congestion hot spots (mentioned above) are the same within the analysed district.

As the last part of the pilot research one question remained. Can we define road types based on their daily traffic flow? To answer this question, two statistical values were calculated from the daily velocity fluctuation data between 6:00 and 22:00 on all road sections. The first is their standard deviation and the second is their range. Standard deviation can show the volume of daily traffic speed fluctuation on certain roads and range defines the difference between the minimum and maximum values of data series. From these indicators, I calculated a new indicator, which displays the ratio of the standard deviation to the range of the data sets. If this ratio is low, the traffic flow on a certain road is smooth; and if it is higher, the traffic fluctuation within a day is larger. According to this indicator, three road types were separated. For the first type, the indicator was 0. This means that on type 1 roads the average measured traffic speed is the same within the days. For the second type, the value of the indicator is less than 25 per cent, which shows a medium size traffic fluctuation on a certain road. Type 3 roads have a large daily traffic fluctuation, where the values are between 25 and 50 per cent.

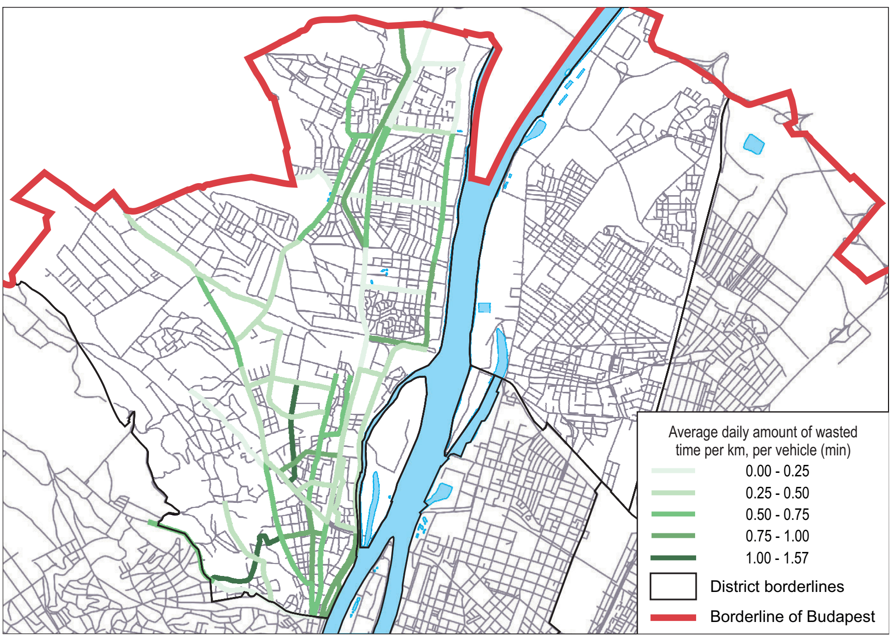


Fig. 5. The average amount of daily wasted time in traffic congestion on different road sections (between Monday and Thursday, to the outskirts) Time of estimation: 13.11.2017–16.11.2017. *Source*: Own calculations based on Google Maps data

The analysis of daily flow types focused only on workdays from Monday to Thursday. In general, we can see that road sections that have no traffic fluctuation are the least frequent in both directions. There can be significant traffic on these roads, but their flow is predictable and they have no peaks. These road sections are in the middle of the district and a few of them are in congestion hot spots. In the second type, there are more road sections, and they all have one little congestion peak, which duration is short. In the direction of the centre, this is the morning traffic peak, whereas the formerly mentioned second wave in the afternoon is difficult to perceive. In the direction of the outskirts, road sections also have a small and short instance of congestion, which shows that afternoon traffic, when citizens leave their workplaces, affects these roads very much. Their geographical positions are also interesting, because in this 'medium' type, there are many main road sections and roads that are close to the district or city boundaries. The most peak sensitive type is the third category of roads, and it contains more than half of the investigated roads *(Figure 6.* and *7).*

On these roads, there are two congestion peaks in both directions, but, the morning peak is necessarily stronger in the direction of the city centre, and the afternoon peak is stronger in the direction of the outskirts. These peaks are generally longer and larger than in type 2. Geographically, in the direction of the city centre most of them are smaller roads that are connected to main roads with high traffic, and because their traffic cannot avoid these roads, they have heavier congestion at peak periods *(Figure 6).* In the other direction, the situation is not the same. Whereas the aforementioned smaller road sections are also congested in the direction of the outskirts, the entire Main Road Number 10 has heavy congestion *(Figure 7).* The explanation behind these phenomena may be that the northern part of the district (with Road 11) has a larger population density than the western one; thus, while a huge part of traffic from Road 11 probably goes off to these dense neighbourhoods, the larger part of Road 10's traffic goes directly to the settlements of Budapest's agglomeration.

From these results, we can see that there are important differences between road sections by their daily traffic flow. These differences depend on the size and the geographical position of the road section, but the features and morphology of the road system are also important factors. However, equally important finding is that the daily commuting and travelling habits of residents are at least as important factor for comprehending the main road congestion problems, their costs, and their solutions. Traffic peaks are originally generated by society through their driving habits, and these space usage patterns can be changed. This deep spatial analysis can help urban developers to handle urban congestion problems at their basic roots.

Conclusions

From the analysis of Google Maps data, it can first be concluded that this source of 'big data' is a feasible way of conducting 'smart' scientific research and making smarter development decisions on a city road system. The most relevant advantage of this database is that it is continually generated on a deep spatial and temporal level. Moreover, plenty of cities are measured by Google in the same way; thus, these data are comparable on a wider (even international) level. In Hungary, the forms of 'traditional' annual traffic surveys cannot analyse the patterns of daily traffic flows on a deep spatial level, and local municipalities have also limited capacity to make their own traffic measurements. Hence, using Google Maps data we can extend our knowledge based on traditional census data regarding commuting (e. g. Pálóczi, G. 2016; Varga, L. *et al.* 2016).

The second conclusion of this pilot research is that spatial and temporal inequalities are evincible from this database, and heretofore unrecognized processes can be analysed in a deep way, which can help urban planners to smartly rethink their conceptions about

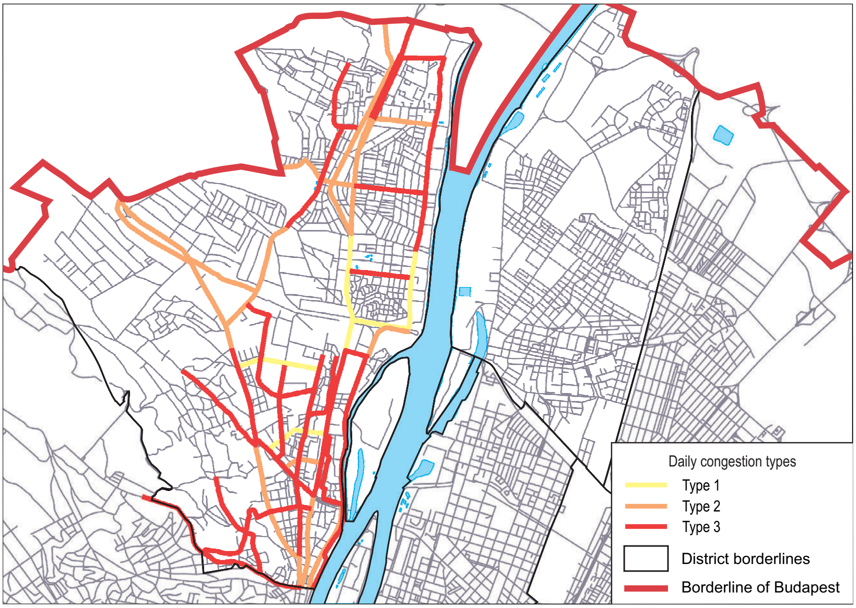


Fig. 6. Types of traffic fluctuation on road sections (between Monday and Thursday, towards the city centre). Time of estimation: 13.11.2017–16.11.2017. *Source*: Own calculations based on Google Maps data

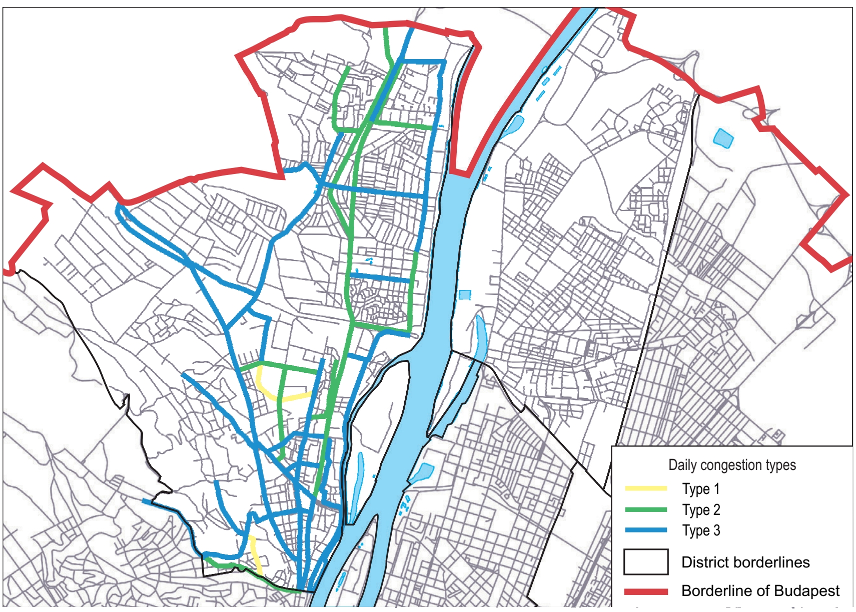


Fig. 7. Types of traffic fluctuation on road sections (between Monday and Thursday, to the outskirts). Time of estimation: 13.11.2017–16.11.2017. *Source*: Own calculations based on Google Maps data

the transport system. The research proved empirically that, on workdays, there is a second wave of peak traffic on many roads, and, within our case-study area, there are congestion hot spot times and places. This information can be very useful for residents in planning their travels, and aiming to avoid time-wasting traffic jams.

As the third conclusion, it is important to highlight that Google Maps data have their limits. Firstly, we have to be sensitive with choosing time periods and temporal resolution because some data loss is inevitable. For instance, in this research, the 20-minute periods are useful to estimate traffic and wasted time because the travel time delays cannot be more than 10–12 minutes on roughly one-km-long road sections. But this is also the weakness of the estimation, because between the two measured time points, some of the traffic data go to waste. Therefore, this research method is highly sensitive in terms of the temporal and spatial resolutions. If the road sections are too long, congested travel times also get higher, but there are limits to the minimum size of road sections and limits to the distance between temporal measured points as well, because the maximum amount of congested travel time on a certain road cannot be higher than the time between measured time points.

The pilot research presented in this paper opens a new perspective for methodology, because it is a useful example of using often-contested 'big data'. These methodological experiences could provide more input for further research where the database used could be assembled from different Google applications. In the future, it would be important to extend and refine this research in the remaining districts of Budapest or its agglomeration, or even compare the result with the vehicular traffic patterns of other cities.

REFERENCES

Abella-García, A., Ortiz-de-Urbina-Criado, M. and De-Pablos-Heredero, C. 2015. The ecosystem of services around smart cities: An exploratory analysis. *Procedia Computer Science* 64. 1075–1080.

Al Nuaimi, E., Neyadi, H.A., Mohamed, N. and Al-Jaroodi, J. 2015. Applications of big data to smart cities. *Journal of Internet Services and Applications* 6. (1): 1–15.

Anttiroiko, A.V. 2013. U-cities reshaping our future: reflections on ubiquitous infrastructure as an enabler of smart urban development. *AI & SOCIETY Journal of Knowledge, Culture and Communication* 28. (4): 491–507.

Anttiroiko, A.V., Valkama, P. and Bailey, S.J. 2014. Smart cities in the new service economy: building platforms for smart services. *AI & SOCIETY Journal of Knowledge, Culture and Communication* 29. (3): 323–334.

Bálint, D. and Trócsányi, A. 2016. New ways of mobility: the birth of ridesharing. A case study form Hungary. *Hungarian Geographical Bulletin* 65. (4): 391–405.

Batty, M., Axhausen, K.W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G. and Portugali, Y. 2012. Smart cities of the future. *The European Physical Journal Special Topics* 214. 481–518.

Camagni, R., Gibelli, M.C. and Rigamonti, P. 2002. Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion. *Ecological Economics* 40. (2): 199–216.

Chin, A.T.H. 1996. Containing air pollution and traffic congestion: Transport policy and the environment in Singapore. *Atmospheric Environment* 30. (5): 787–801.

Chuan Tao, Y., Zhang, X., Hui, C., JingYuan, W., Daven, C. and Bertrand, D. 2015. A literature survey on smart cities. *Science China Information Sciences* 58. (10): 1–18.

Cohen, H. and Southworth, F. 1999. On the measurement and valuation of travel time variability due to incidents on freeways. *Journal of Transportation and Statistics* 2. (2): 123–131.

Downs, A. 1992. *Stuck in Traffic.* Washington, Brookings Institution.

Erhart, Sz. 2007. A budapesti közlekedési dugók okai és következményei (The causes and consequences of traffic jams in Budapest). *Közgazdasági Szemle* 54. (5): 435–458.

Fleischer, T. and Tir, M. 2016. The transport in our time-budget. *Regional Statistics* 6. (2): 54–94.

Giffinger, R., Fertner, C., Kramar, H., Meijers, E. and Pichler-Milanovic, N. 2007. *Smart cities: Ranking of European medium-sized cities.* Vienna, Vienna University of Technology.

Graham, S. 1997. Telecommunications and the future of cities: de-buking the myths. *Cities* 14. (1): 21–29.

Greenshields, B.D. 1935. A Study of Traffic Capacity. *Highway Research Board Proceedings* 14. 448–477.

Keserű, I. 2013. Commuting patterns of secondary school students in the functional urban region of

Budaepst. *Hungarian Geographical Bulletin* 62. (2): 197–219.

Kitchin, R. 2013. Big data and human geography: Opportunities, challenges and risks. *Dialogues in Human Geography* 3. (3): 262–267.

Kitchin, R. 2014. The real-time city? Big data and smart urbanism. *GeoJournal* 79. (1): 1–14.

Leduc, G. 2008. *Road Traffic Data: Collection Methods and Applications.* Working Papers on Energy, Transport and Climate Change N. 1, European Commission – Joint Research Centre, Institute for Prospective Technological Studies, 53 p.

Lengyel, B. and Jakobi, Á. 2016. Online social networks, location, and the dual effect of distance from the centre. *Tijdschrift Voor Economische en Sociale Geografie* 107. (3): 298–315.

Magyar Közút Nonprofit Zrt. 2017. *Az országos közutak 2016. évre vonatkozó keresztmetszeti forgalma* (Cross-section traffic of public roads in Hungary for 2016). Budapest, One Planet Mérnökiroda Kft.

Manyika, J., Chiu, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C. and Byers, A.H. 2011. *Big data: The next frontier for innovation, competition, and productivity.* McKinsey Global Institute.

Marvin, S.J. 1994. Green signals. The environmental role of telecommunications in cities. *Cities* 11. (5). 325–331.

Mattoni, B., Gugliermetti, F. and Bisegna, F. 2015. A multilevel method to assess and design the renovation and integration of Smart Cities. *Sustainable Cities and Society* 15. 105–119.

Morgul, E., Yang, H., Kurkcu, A., Ozbay, K., Bartin, B., Kamga, C. and Salloum, R. 2014. Virtual sensors: Web-based real-time data collection methodology for transportation operation performance analysis. *Transportation Research Record: Journal of the Transportation Research Board* 2442. (12): 106–116.

Navarro, C., Roca-Riu, M., Furió, S. and Estrada, M. 2015. Designing new models for energy efficiency in urban freight transport for smart cities and its application to the Spanish case. *Transportation Research Procedia* 12. 314–324.

Neirotti, P., De Marco, A., Cagliano, A.C., Mangano, G. and Scorrano, F. 2014. Current trends in Smart City initiatives: Some stylised facts. *Cities* 38. 25–36.

Niaros, V. 2016. Introduction a Taxonomy of the "Smart City": Towards a Commons-Oriented Approach? *tripleC: Communication, Capitalism & Critique* 14. (1): 51–61.

Pálóczi, G. 2016. Researching commuting to work using the methods of complex network analysis. *Regional Statistics* 6. (1): 3–22.

Qingyu, L., Zhicai, J., Baofeng, S. and Hongfei, J. 2007. Method Research on Measuring the External Costs of Urban Traffic Congestion. *Journal of Transportation Systems Engineering and Information Technology* 7. (5): 9–12.

Rial, N. 2013. *The power of big data in Europe.* New Europe, May 24th. https://www.neweurope.eu/article/power-big-data-europe/ Downloaded: 28.02.2017.

Rouwendal, J. and Nijkamp, P. 2004. Living in two worlds: A review of home-to-work decisions. *Growth and Change* 35. (3): 287–303.

Schrank, D., Lomax, T., Turner, S., Geng, L., Li, Y. and Koncz, N. 2010. *TTI's 2010 Urban Mobility Report.* Texas Transportation Institute, A&M University, College Station TX.

Smolan, R. and Erwitt, J. 2012. *The Human Face of Big Data.* New York, Sterling.

Steenbruggen, J., Tranos, E. and Nijkamp, P. 2015. Data from mobile phone operators: A tool for smarter cities? *Telecommunications Policy* 39. (3–4): 335–346.

Stopher, P.R. 2004. Reducing road congestion: A reality check. *Transport Policy* 11. (2): 117–131.

Sweet, M. 2011. Does Traffic Congestion Slow the Economy? *Journal of Planning Literature* 26. (4): 391–404.

Sweet, M. 2013. Traffic Congestion's Economic Impacts: Evidence from US Metropolitan Regions. *Urban Studies* 51. (10): 2088–2110.

Townsend, A.M. 2013. *Smart Cities. Big data, civic hackers, and the quest for a new utopia.* New York, W.W. Norton & Company.

Varga, L., Tóth, G. and Néda, Z. 2016. An improved radiation model and its applicability for understanding commuting patterns in Hungary. *Regional Statistics* 6. (2): 27–38.

Wardrop, J.G. and Charlesworth, G. 1954. A method of estimating speed and flow of traffic from moving vehicle. *Proceeding of the Institution of Civil Engineers* 3. (1): 158–171.

Zikopoulos, P.C., Eaton, C., de Roos, D., Deutsch, T. and Lapis, G. 2012. *Understanding big data.* New York, McGraw Hill.

http://gadgets.ndtv.com/apps/features/how-google-maps-gets-its-remarkably-accurate-real-time-traffic-data-1665385

http://trrjournalonline.trb.org/doi/pdf/10.3141/2442-12

Flea markets in the space – Typology and spatial characteristics of second-hand retail in Budapest

Ibolya VÁRNAI[1]

Abstract

Nowadays the term "used items" has a rather rich connotation, thus their retail trade has also diversified, has broken into several segments. This study first defines the aspects according to which the different types of second-hand retail trade can be classified, then – on the basis of this – it describes the types and sub-types of the sector. Based on Hungarian and foreign literature, considering the profile of second-hand retailers we can distinguish fairs (antique fair, car boot sale, and garage sale), markets (flea market, burse) and shops (second-hand clothes shop, vintage shop, flea shops, charity shops, antique shop and shops with additional functions). The study based on primary research also classifies the different retail units on the basis of their location, product range, opening hours and their operators. Then with GIS methods the spatial distribution of used item retailers in Budapest is represented on a map, finally the data is analysed. In 2016 the majority of second-hand retail units was antique shops and second-hand clothes shops, but the market was enriched with flea shops, thrift stores and flea markets as well. The study points out that due to their functions in the market, the different types show spatial characteristics, the different shops are concentrated in different parts of the capital.

Keywords: second-hand retailing, flea market, shop typology, spatial structure, Budapest

Introduction

Our consumer society faces a rather diverse typology of second-hand retail nowadays, which puts second-hand retailing into a different perspective. Parallel with the development of consumer culture and retail trade, the market of second-hand items has greatly diversified (Stobart, J. and Van Damme, I. 2010), and broken into special segments. Not only the economic, social, and cultural driving factors of consumer behaviour are getting more and more complicated, but the motivations of the actors of the supply-side are expanding with new aspects.

Trading with second-hand goods has been expanding in Hungary too. Along with the appearance of new forms of trade, new consumer trends appear, which further diversify Hungarian market competition, however, so far relatively little attention has been placed on the analysis of their spatial aspects. Additionally, second-hand retail may contribute to the transformation of consumption spaces (Nagy, E. *et al.* 2016) and support the retail trade diversity of public spaces in urban areas (Boros, L. *et al.* 2016).

In our everyday shopping experiences, we run into second-hand items on flea markets, in antique shops, thrift stores and flea shops, as well as on antique fairs and garage sales. Retailing in second-hand clothes and used cars have developed their own market, and due to the development of e-commerce, online market places for used items and auction sites have also become popular. However, until now there is no study which examines and thoroughly analyses the characteristics of the elements of this market segments.

When defining the market of used items, one has to very careful, since it is rather difficult to draw the exact line between retailing in

[1] Enyedi György Doctoral School of Regional Sciences, Faculty of Economics and Social Sciences, Szent István University, H-2100 Gödöllő, Páter Károly u. 1. E-mail: varnai.ibolya@gmail.com

second-hand goods and other forms of retail trade. Moreover, on the market of used items not exclusively "used" goods are traded, so it is more accurate to talk about re-selling (Van Cayseele, P. 1993). For the definition international standards for classifications of economic activities can provide a reference point. ISIC Rev.4 applied by the United Nations Statistics Division and NACE Rev.2 used in the EU member countries – on which the Hungarian NACE '08 system is built – lists in-store retailing in used items (mainly books, clothing items, antiques) and the activities of auction houses under the heading „not elsewhere classified" retail activities (https://unstats.un.org, http://ec.europa.eu, http://www.teaorszamok.hu). The branch does not include retailing in used cars and their parts, online auctions, mail order and pawning activities. At the same time, the author also finds it important to make distinction between retailing in second-hand items and used cars because of the different market mechanisms. Plus, we have to make distinction between retail of second-hand goods – in the traditional sense – and selling in auction houses. The latter ones mainly sell artwork and antiques in auctions for adding or storing value, so their activities are more like the activities of art galleries, than of garage sales or flea markets. Thus, the author more agrees with the classification of the North American Industry Classification System (NAICS), which distinguishes the activities of auction houses and retailing in used items.

The aim of this study is to introduce the supply side on the market of used items in Hungary through the example of Budapest. The author sets up a typology which can be used for classifying activities on the market of used items, and also covers the full spectrum of retail activities in second-hand goods. This systematic classification would be required, because in Hungary buying and selling used goods, and the experiences connected to this affect several layers of the society.

Another aim of the study is to examine spatial dimensions of second-hand retail units in the capital from a point of view of regional science, highlighting spatial distribution of the actors of this special market segment. The author seeks answer to the question whether a concentration or separation in space can be observed in the distribution of these retailers, and if there is a connection between spatial distribution and the functions of the different types.

Theoretical overview – outline of previous international research

In the research history of second-hand retailing, the development features of second-hand clothes retail have been in focus. This sector has been investigated mainly from culture- and socio-historical points (Lemire, B. 1997; Frick, C. 2005; Palmer, A. and Clark, H. 2005; Fontaine, L. 2008). However, Gregson, N. and Crewe, L. (2003) dealt with the spatial dimensions of second-hand clothes retail. While Williams, C. and Paddock, C. (2003), as well as Guiot, D. and Roux, D. (2010) have remarkable findings in researching the sector's market. DeLong, M. *et al.* (2005) focused on a special segment in second-hand clothes retail, on vending vintage and retro fashion items.

More holistic studies on the whole of the market for second-hand goods are mainly related to the names of economists. In previous decades, several macroeconomic researches focused on the issues of substitutability between new and used items and the effects of changes in product life cycle on the market (Swan, P.L. 1972; Liebowitz, S.J. 1982). Scitovsky, T. (1994) in his work discussed how second-hand retail influences the macrobalance of the market, while Shulman, J.D. and Coughlan, A.T. (2007) placed the emphasis on the conditions of profitability. Another studies focused on transactional costs on the market for second-hand goods and on the role of price discrimination (Anderson, S.P. and Ginsburgh, V.A. 1994; Thomas, V.M. 2003), and on revealing bidding mechanisms and pricing factors (Stroeker, N.E. and Antonides, G. 1997). Williams, C.C. (2002, 2003) discussed the factors of the operation of second-hand retail market and buyers' needs and motivation from a demand-side approach. Gabbott, M. (1991) analysed consumers' risk-taking behaviour, Huang, S. *et al.* (2001) segmented consumers on the basis of their willingness to pay.

Besides the earliest researches on U.S: swap markets (Sherman, E. *et al.* 1985), socio-cultural (Sherry, J. 1990a) and eco-sociological researches (Chantelat, P. and Vignal, B. 2005) are worth mentioning. The characteristics of traditional US garage sales and community fairs were examined by Soiffer, S. and Herrmann, G. (1987), Herrmann, G. (2011) and Crawford, M. (2014). Researches in car boot sales are connected to Mulholland, M. and Cockfield, R. (1993), Stone, J. *et al.* (1996), Crewe, L. and Gregson, N. (1998).

The first scientific researches of charity shops of Wester-European origin started in the 1990s (Horne, S. and Broadbridge, A. 1995; Horne, S. 1998), and several outstanding studies have been published on the clientele of charity shops, on customer behaviour and motivation (Chattoe, E. 2000; Bardhi, F. and Arnould, E.J. 2005; Mitchell, M. and Montgomery, R. 2010).

Nowadays two new directions of research on second-hand retail have emerged. With placing environment-conscious lifestyle and re-use of gods into focus, novel aspects of second-hand goods market will gain more attention (Gregson, N. *et al.* 2013; Fortuna, L.M. and Diyamandoglu, V. 2017). As a result of the spread of e-commerce, researchers also focused on exploring online marketplaces and auction sites (Peters, M. and Severinov, S. 2006; Hummel, P. 2015).

Definition of second-hand retail trade

The market of used goods can be considered an alternative/informal distribution channel for consumer durables, see C.C. Williams' work (2002), whose emergence and operation is based on the substitutability of products (Swan, P.L. 1972; Anderson, S.P. and Ginsburgh, V.A. 1994), and on different consumer value judgement (Shulman, J.D. and Coughlan, A.T. 2007).

Selling and buying used goods is a diverse activity, and is constantly changing in the context of space-and-time. Its prime characteristic is *self-organization* (Sherry, J. 1990b, Leyshon, A. *et al.* 2003; Williams, C.C. 2003). It includes legitimately (or in some cases illegally) organized garage sales, antique fairs and flea markets, as well as individual and chain stores selling second-hand clothes, thrift stores and flea shops, and electronic auctions and auctions as well.

Items sold and bought during the transaction can be new or used ones, and cover the full range of goods, but their basic common feature is that they used to be the property of at least one owner, so they end up on the market as second-hand items.

Hungarian aspects of the research topic

In Hungary, in the previous decades, researches in second-hand culture mainly focused on social and sociological aspects (Valuch, T. 2004; Zachariás, K. 2007; Berta P. 2012).

The history of the most well-known Hungarian flea market, the "Ecseri" in Budapest was researched by Bruckner, É. (2007). The range of goods supplied on the Ecseri market, the market in Bakancs Street, and the flea market in Petőfi Csarnok covers the whole spectrum of used goods, including unique pieces of collections and rarities. A special form of used goods retail, typical for East Central Europe, is *junk and jumble picking*, popular with antique retailers. As Kovács, E. *et al.* (2008) state, at times of house clearance and junk removals pickers select items which are of considerable value and sell them at different fairs and in markets. Opposed to waste pickers, junk pickers are specialized in collecting different tools, objects, materials and often work cross-border.

Differentiation in retailing in used items can be observed in Hungary too. Although car boot sales are not very common in Hungary, thrift stores, flea shops, vintage stores, community and garage sales have already appeared. Today – in the age of electronic auctions – prevail of auction websites sets the trends in second-hand retail. The most well-known international online markets (Amazon, Craigslist, Ebay, FreeCycle és a Yahoo!) (Hickman, B. 2010; Fortuna, L.M. and Diyamandoglu, V. 2017) are gaining popularity in Hungary too, and the number of users of Hungarian auctions sites is also increasing (Vas-Egri, M. and Danó, Gy. 2013). The most popular ones are Apród, Jófogás, TeszVesz, and Vatera.

Applied research methods

The methods for establishing the typology are based on the relevant literature and on the results of inductive research. International and Hungarian literature mostly fall short on the holistic approach. Generally, researchers specialize in a segment and research only that one thoroughly. Consequently, a model which synthetizes the different segments of second-hand retail needs to be developed.

To establish a primary database Google search engine was used. The research – besides the retailers with an own homepage and a webshop – was extended to information in online directories, databases, advertising portals and on Facebook. Data collection included data on stores operating in the field of second-hand retail in the capital and events and facilities connected to them. (Due to the above mentioned reasons, data collection did not include auction houses and used car dealers.) Data collection took place between September 2015 and January 2016. In this period a total of 178 retailers were listed, their data were collected in an Excel spreadsheet. The database[2] contains the name and address of the retail units, their product range and other relevant pieces of information.

Data were collected in Budapest, because the relatively new forms second-hand retailers (flea shops, thrift stores, vintage shops, etc.) appeared in Budapest first. To reveal these processes, data collection was supplemented with personal observation (visits to shops and markets). During the field work the main characteristics of second-hand retailers were further discovered and primary data were refined.

In Phase One of the research, criteria for the typology were set. From the results based on the primary analysis of the database, it turned out that second-hand retail units in Hungary can be classified according to their *profile* (1), *location* (2), *product range* (3), *opening hours* (4), *purpose of the business activity* (5), and *owner/operator* (6).

The next stage in the research process was to examine spatial aspects of second-hand retail in Budapest. To this end, the change in the number of second-hand retail units between 1998 and 2014 was analysed and represented on a graph (annual data for districts derived from TeIR – National Regional Development and Spatial Planning Information System (hereinafter referred to as SPIS) – and were combined according to areas). Besides this, changes in the examined period were analysed according to districts and the results were marked on a map. We were looking for the answers to two important questions: whether the different types of second-hand retail units are spatially separated and to what extent the different types of these units are concentrated inside the capital. Results were represented on the map with GeoMarket 4.5 and Mapinfo 10.5 GIS software.

Since the research focused mainly on used goods retail in geographical space, spatial dimension of transactions on auctions sites and online auctions were not analysed. Locations of one-time events (antique fairs, garage sales, car boot sales) and bourses are not marked on the map either, since marking the constantly changing location of these occasional markets would only provide a snapshot, thus they would distort the process of the exploration of permanent spatial

[2] Only data of major second-hand clothes shop chains were entered into the database, because some of these shops exist only for a short period (many of them are private enterprises where the owner would be unemployed otherwise.)

processes. The location choices of antique fairs and garage sales in different periods of time should be discussed in a separate study.

Aspects for classification of retail of used goods and their types

As the analysis of the database including data about 178 second-hand retailers, which was compiled during the research process, and the results of on-the-spot observations proved, the different forms of second-hand retail in Hungary fall into the above described 6 categories (*Table 1*).

Types based on profiles

Regarding the profile of second-hand retail units, *fairs, markets and shops* can be distinguished. Fairs are events providing unique occasions for buying and selling, while markets function as a regular location for exchanging goods. There are similarities and differences between the types based on their frequency and gravity zone. *shops and chain shops* operate indoors, in a permanent brick-and-mortar shop. These chains include a set of shops with the same profile; however, their sub-types greatly differ from each other.

a) Fairs: defining events of the sector are *antique fairs*, which are usually attended by a great number of sellers. *Garage sales, community sales* and *car boot sales* belong to the group of occasional events, which usually involve local groups, thus locality plays a remarkable role. The location of garage sales are usually the home of the seller (Soiffer, S. and Herrmann, G. 1987), while carboot sales are held in a public area (parking lot, schoolyard, etc.) (Stone, J. *et al.* 1996).

b) Markets: among markets, *flea markets* are outstanding locations where supply meets demand in a multi-actor arena, and they are relatively constant, regularly available channels for sales activities (Sherry, J. 1990b). Just like antique fairs, these events may have an extended gravity zone, often with international relations. Swop markets (flea markets) are the oldest and most common informal places for retail and black market (Sherman, E. *et al.* 1985). They provide place for different transactions, and illegal barters, but, at the same time, they serve as traditional locations for interactions (Belk, R. *et al.* 1988; Petrescu, M. and Bhatli, D. 2013). According to the experiences of the author, *bourses* are organised with varying frequency; their main characteristics are defined by their supply concentrating on a certain theme.

c) Shops and chain shops: retailing in second-hand clothes have evolved their special, informal channels (Palmer, A. and Clark, H. 2005); so *second-hand clothes shops* also have special selections, different price structures and different locations. Increasing demand for second-hand clothes can be depicted in the fact that after the economic downturn in 2008, several second-hand clothes boutiques appeared in the streets of shopping malls (Makó, A. 2013). Motivations for buying used clothes vary between economic, ethical ecological aspects but uniqueness, nostalgia, and quest for stimuli or experiences also count (Guiot, D. and Roux, D. 2010). The vintage style and shopping in *vintage shop* is a tool for self-expression for young people (DeLong, M. *et al.* 2005). For the followers of this style the historical value is important (Cervellon, M-C. *et al.* 2012), thus the selection of shops also comprises of high quality, exclusive pieces of clothes (Palmer, A. and Clark, H. 2005).

Flea shops are the location for private individuals to exchange goods with each other (C2C marketplaces). People wishing to sell bring in their items, and pay a certain amount of money – shelf money or rental fee. When the product is sold, they will receive its countervalue. In Hungary prices are usually set by the seller, while the shop in advance stipulates the share they get from the transaction. C*harity shops* sell goods donated to them as voluntary offering (Parsons, E. 2004). Their activities are similar to the activities of swop markets, but the profit generated from the activity mainly serves charity purposes (Horne, S. and Madrell, A. 2002; Bardhi,

Table 1. Possible aspects of typology of second hand retail trade

Aspect	Type	Sub-type
Profile	fair	antique fair garage sale, community fair car boot sale
	market	flea market bourse
	shop, chain shop	second-hand clothes shop flea shop thrift shop antique shop additional second-hand retail function
Location	in real geographical	traditional self-service
	electronic markets multichannel	– –
Product range	general used items	wide range of general used items specialized on one kind of product
	second-hand clothes	wide range of clothing items baby and children clothes vintage, retro
Opening hours	fixed (according to working hours)	–
	periodical	periodically open according to fair calendar seasonal
	by appointment occasional	– –
Purpose of business activity	profit-oriented not-for-profit	– –
Operator	private person	private person private entrepreneur
	partnership, cooperation	legal entity (limited liability company, ltd., cooperation) without a legal entity (partnerships)
	not an open market player	state organization owned by the local government

Note: Data from the research database.

F. 2003; Mitchell, M. and Montgomery, R. 2010). In the supply of *antique shops,* we can find used furniture, inherited items, artefacts and paintings with stable value at the same time. Due to this versatility, this sub-type represents transition between second-hand retail and art trade. According to the experiences of the author, recently a new type of shop has evolved, shops *with additional retail functions* are a new phenomenon, where besides the dominant function of the shop, used items are also sold, but only as a supplementary activity.

Types based on location

Trading with used items can take place offline, or on online markets. According to the location, the following 3 types can be distinguished:

a) trading in real geographical space includes any retail activity which is bound to physical space. Among its sub-types the first one is *traditional retail* process, when in every step there is a contact between the seller and the buyer; while in case of a *self-service buying processes,* generally there is no contact between the two parties, the buyer makes decisions independently, on his own. Great examples for traditional retail processes are flea markets and antique fairs, where a lot might depend on the personal contact and trust (Chantelat, P. and Vignal, B. 2005) between the vendor and the potential buyer. At the same time in self-service flea shops and second-hand clothes shops the joy and pleasure of shopping lies in the lengthy looking and picking and in the quest for the perfect "haul" (Guiot, D. and Roux, D. 2010).

b) Exchanging, buying and selling used items can also take place in *electronic marketplaces*. A large number of businesses operate only online, people can simultaneously buy or sell in webshops and online auctions sites, without any personal contact, due to the opportunities provided by technological innovation (smartphone apps for shopping, PayPal mobile payment).

c) Multi-channel retail is becoming more and more popular in the market of second-hand items. Then business activities take place in traditional and online channels at the same time, and this may refer to fairs, markets and shops as well. This, obviously, increases competitiveness.

Types based on product range

Based on their product range, used items retail can be divided into two types: *general used items retail*, and *second-hand clothes retail*, which is restricted to selling clothing items and textiles.

a) In this type, the first sub-type is retailing in *a wide-range of second-hand items*. Those antique fairs and flea markets are characterized by this selection of goods where more expensive relics and dirt-cheap items can be found next to each other. The main feature of the second sub-type – *the specialist* – is limited to a single type of product; the product range does not include any other kind (flea markets for electronic goods or second-hand books, fairs for bicycle parts or old-timer cars, antique shops specialized in old vinyl records or clocks, etc.).

b) Retail units selling a wide range of used clothing items, other accessories and textiles have been serving their clients for a long time. Although second-hand clothes shops with their large selection represent the most popular sub-type, the individual shops apply rather different price strategies, depending on the quality of the goods (individual prices, "hanger", "baled", or "falling prices" strategies). An important sub-type of second-hand clothes retail trade specializes in *maternity, baby and children's clothes* and in "pawning" baby clothes. Apart from clothing items, these shops also sell shoes, toys and other textiles. A newly emerging sub-type of used goods retail units is the group of "luxury thrift shops", which is the Hungarian equivalent of *vintage and retro shops*. The special selection they offer makes them unique compared to the other second-hand clothes shops. These shops usually deal with high quality, individually priced pieces and accessories.

Types based on opening hours

Retailers of used goods fall into 4 categories based on their opening hours and schedules. There are retailers with *permanent or fixed opening hours*, some are *periodically open*, others are *open by appointment*, and finally, other retail units operate *occasionally*.

a) Shops with fixed opening hours usually adjust to the schedule of the 5-day working week. To this type belong most shops, chain shops and some flea markets.

b) Shops, fairs and markets which are periodically open fall into 3 sub-categories: *periodically* open ones (for example, flea markets with opening hours limited to certain days of the week), events organized as scheduled in the half year or annual fair calendars (for example antique fairs, bourses when organizers advertise the date and venue in advance), and *seasonal* fairs and markets (their organization is mostly bound to the changes of seasons and weather conditions, so this mainly refers to open air flea markets).

c) Opening *by appointment* is applied when it is not profitable to keep the shop open for a longer period or to employ a full-time shop assistant (e.g. thrift shops, specialist antique shops).

d) Occasional retail activities like community fairs and garage sales and non-recurring bourses held occasionally should also come into a separate category.

Types based on the purpose of their business activity

Based on the primary purpose of their business activity, second-hand retailers can fall into two categories: *profit-oriented* and *not-for-profit* (charity).

a) Profit-oriented second-hand retailers aim to create profits. Their activities are motivated by different things. Specialist antique retailers spend remarkable time on finding rare pieces their clients (collectors) crave for, vintage and retro clothes retailers choose sought-for and fashionable items and accessories with refined taste. Both groups have one thing in common: to satisfy customer demand, to make their clients happy. The organizers of garage sales and owners of flea shops, however, have different drivers in selling used items (e.g. environmental consciousness, recycling used goods, raising money without investing some, etc.).

b) All second-hand retailers can be considered *not-for-profit* who wish to spend their profit deriving from their business activity on a charity purpose, undertaking environmental or social responsibility. In Hungary mainly thrift shops belong to this category, but garage sales and community fairs can also be organized for charity purposes.

Types based on the person of operator/owner

Second-hand retail units based on who operates them can fall into the following categories: units operated by *private persons*, *partnerships*, or by *not the players of the open market*.

a) Private persons (or groups of them) can pursue second-hand retail activities as *private individuals* if they do not pursue any registered business activity (e.g. organizers of one occasion garage sales, community fairs), or as *private entrepreneurs*, who have the necessary contractor ID number. The majority of the examined retail units belong to this type (e.g. antique shops, flea shops, vintage and retro shops and some thrift shops).

b) Partnerships and cooperatives *with separate legal entity* are usually the owners of second-hand clothes shop chains (Angex Kft, Háda Kft, Humana Kft), or the operators of thrift shops chains (Cseriti Szociális Szövetkezet, Közösségi Szociális Szövetkezet). Partnerships *without separate legal entity* include antique shops and second-hand clothes shops too, since to establish them requires smaller capital.

c) Partnerships run by *government organizations* mainly pursue activities connected to social responsibility (Red Cross thrift shops), while businesses owned by local governments (e.g. companies managing urban areas) mostly operate antique fairs and flea markets.

Spatial distribution of the different types of second-hand retail in Budapest

Before describing and analysing the main features of the spatial distribution of second-hand retail trade in Budapest, we should provide an overview of the changes in size and direction which took part in the last few years (between 1998 and 2014). Analysing the data form National Regional Development and Spatial Planning Information System (SPIS) database[3] we can point out that while in 1998 only 760 second-hand retail units operated in Budapest, this number more than doubled in 16 years, and by 2014 it exceeded 1460.

[3] SPIS data referring to used goods retail trade include the number of auctions and art galleries, which significantly increases the number of shops in case of districts and groups of districts (CBD and central districts in Pest) which traditionally provide location for art trade.

The increase in the number of shops in the sector can be explained by two main reasons.

Firstly, demand for value-increasing artefacts and antiquities increased among the representatives of a narrow, but wealthy layer of the society, triggering art-traders to open more shops. Additionally, the same tendency can be observed in the case of "retro" goods, which are increasingly sought after by foreign tourists. Secondly, impoverishing groups in the different layers of the society living in the capital and its agglomeration zone also create growing demand for low-price goods (second-hand clothes, low-price furniture, household items, electronic appliances, etc.) and satisfying their demand can also urge sellers to open new units.

The twofold increase in the number of shops dealing with used goods in the capital shows remarkable differences in the CBD and in some groups of districts (district V and its 4 neighbouring central districts, 5 districts in the transition zone, 7 suburban districts and another 6 districts in Buda)[4]. These differences reflect the difference in the pace the number of second-hand retail chains increase (*Figure 1*).

As the graph shows, in the Central Business District (CBD) in Budapest almost 70 shops with this profile existed already back in 1998, which number approached 150 by the year 2014 (an increase of 2.25 times). The other 4 districts in the central area can also be characterized by a dynamic increase, where – in contrast with the figure lower than 130 in 1998 – the number of shops well exceeded 400 by 2014 (an increase of 3.25 times). As a result, since the millennium the extension of send-hand trade units mostly concentrated to the central districts. Around the millennium, the number of empty stores in the city centre significantly increased because of high rental fees and continuous restructuration of shops (Sikos, T.T. 2000), which enabled the appearance of second-hand retail units and antique shops, and also their increase in numbers in these districts.

The 5 districts in the transition zone have been an important venue for second-hand retail trade for a long time. This is underlined by the fact that back in 1998 63 per cent of the capital's "classical" second-hand retail shops were registered in district XIX, home for "Ecseri" flea market. (This rate still reached 43% in 2014.) Although in the transition zone the number of shops in this sector only increased by 26 per cent between 1998 and 2014, which can be explained with the relatively high benchmark value (in 1998 about 300 shops), we can still find the largest number of second-hand retail shops here.

During the examined period, the changes in the number of shops in this sector the 6 districts in Buda scored below average (1.48 times), while the 7 outskirt districts showed average (1.88 times) increase, and this is in accordance with the above described general tendency. Examining the rate of change in the number of second-hand shops in the capital between 1998 and 2014 on the level of districts, we can say that the winners of this process are districts VII, VIII and IX, i.e. the central districts, where the increase rate slightly exceeded 200 per cent. In these districts the increase in demand for used items was significantly higher than in the other districts in the capital, which triggered second-hand goods retailers to open new shops primarily in these districts after the millennium. Among the suburban districts only district XXIII can boast with a similar increase rate (*Figure 2*). A similar process took place in Poland during the post-socialist transition period, and as a result, the number of outdoor markets and street vendors grew significantly in Warsaw (Witkowski, T.H. 1993).

In districts belonging to the first category we can detect a smaller, but still significant increase (between 100% and 180%): the 6 districts covering the north-western part of the capital (3–3 districts in Buda and Pest) and additional 3 ones in South-Pest. Analysing the spatial characteristics in this area, we can discover that the primary direction of the ex-

[4] Central districts are: district VI, VII, VIII and IX; districts of the transition zone: X, XIII, XIV, XIX and XX; suburban districts: IV, XV, XVI, XVII, XVIII, XXI and XXIII; districts in Buda: I, II, III, XI, XII and XXII.

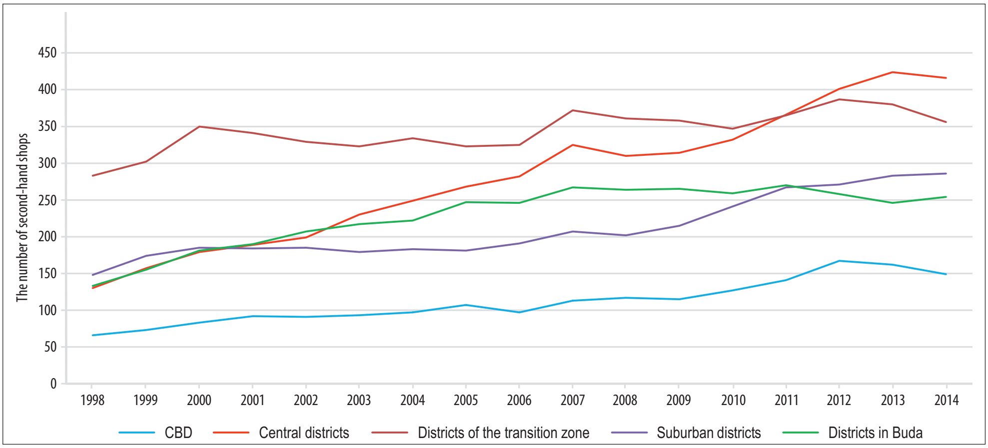


Fig. 1. Changes in the number of second-hand shops in Budapest between 1998 and 2014 according to district-groups. *Source:* Data from the SPIS database, 2016.

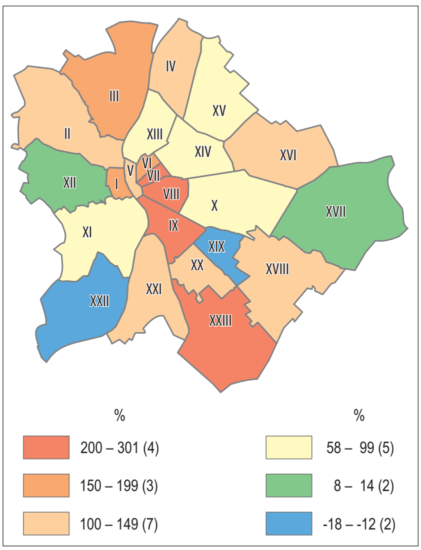


Fig. 2. Rate of change in the number of second-hand goods shops in the districts of Budapest between 1998 and 2014. *Source:* Data from SPIS database, 2016.

pansion process in this sector in Budapest is northwest and the secondary is the south. Among the suburban districts in district XVI – including Sashalom and Mátyásföld – was there a change bigger than 100 per cent in the number of shops. But the districts surrounding this administrative unit all show smaller increase in this respect.

The 3 districts in the transition zone and their neighbouring district (district XV) produced a modest (below 100%) increase. However, even this group of districts in the capital can be regarded as a location for vivid second-hand retail trade. Only district XI in Buda belongs to this category.

Increase in the number of second-hand retail shops was insignificant only in 4 districts (2 districts in Buda and 2 in Pest), or even there was a decrease. This can be explained by the fact that inhabitants here have above average living standards, so only few of them shop in these stores (districts XI, XII and XVII), and market conditions for opening second-hand retail shops are more favourable in the neighbouring districts, see district XIX for example.

Examining the internal structure of the individual districts, there are remarkable differences in the distribution rate of shops based on their profiles (*Figure 3*).

As *Figure 3* clearly shows, the proportion of *antique shops* is outstanding (above 80%) in tourist areas, mainly in CBD and in district I and XII, but their rate is above 50 per cent

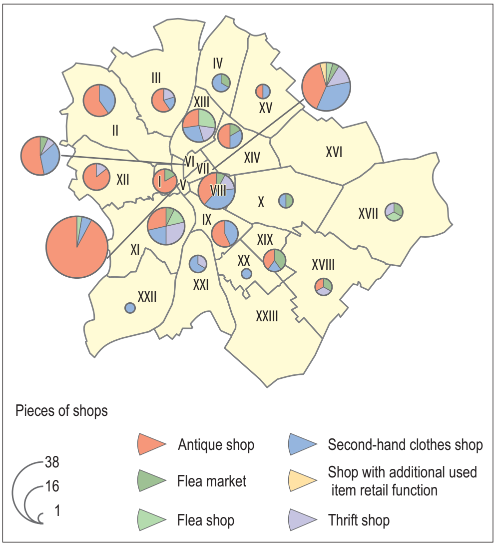


Fig. 3. Distribution rate of shops in the districts of Budapest based on their profile. *Source:* Data from the research database.

among the shops in the second-hand retail sector in Buda in district II and III, and in Pest in district VI, IX and XIV. This figure in the central districts in Pest (VII, VIII and XIII) and in district XI in Buda is between 25 and 50 per cent.

The rate of *second-hand clothes shops* is the highest (50–100%) in those districts where only few (1–3) second-hand retail shops can be found (district XXII in Buda, district X in Pest and in suburban districts), which is the natural result of the low nominal values. Their rate in the central districts in Pest does not reach 50 per cent. (In 2 districts in Buda and in 4 districts in Pest this type of shops does not exist.)

17 *thrift shops* are scattered in 10 districts in the capital, so their rate in the individual districts exceeds 25 per cent only in district XI and in 3 of the suburban districts (XVII, XVIII and XXI). The case of *flea markets* is rather similar, they only have a significant rate in district X (50%) and in district IV, XVII, XVIII and XIX (33–40%). Belk, R. *et al.* (1988) in their work also refer to the fact that flea markets usually can be connected to the outskirts. The 8 *flea shops* represent remarkable rate in the selection of second-hand retail units only in districts XIII and XVIII (27% and 33%).

Examining the *profile* of the 178 second-hand retail units, we can see that in 2014 53.3 per cent of them were *antique shops*, and 25.3 per cent of them were *second-hand clothes shops*. Thus, these two types of second-hand retail units together represent 4/5 of the whole network (*Table 2*).

Spatial distribution of antique shops is rather uneven. As the author has previously mentioned, the supply of antique dealers extends to valuable artworks and antiquities, so it is not surprising that there are a lot of these shops in the Vth district, which is also the centre of Hungarian art trade. There are a significantly large number of them in district V, so 36.8 per cent of the total number of shops in the capital is concentrated here. Sherry, J. (1990a) also points out that antique shops are mainly located in the downtown areas. Their share in used items retail reaches 92 per cent. Their number in the other central districts is under 10. In the Buda districts (except district XXII), where the purchasing power is rather high, the number of these shops vary between 3 and 6, so Buda's share from the total number of antique shops is more than 15 per cent. The majority of these shops are situated along the boulevards or near them, in the side streets. Among the districts in the transition zone only in district XIII and XIV, which districts are mainly inhabited by highly educated people, can we find 3 of them in each, and in district XIX there are 2. Out of the 7 suburban districts only district XV and XVIII operate one shop. In more than one third of the districts in the capital this type of retail unit does not exist at all.

The distribution of *second-hand clothes shops* in the districts is much more even. 17 districts in the capital give home to some of the total of 45 shops, which means that only 6 districts (26%) do not have a shop of this kind. The densification zone of second-hand clothes shops covers districts VI, VII, VIII and IX, where almost half of these shops

Table 2. Spatial distribution of used item retail units of different profiles in the districts of Budapest

District	Antique shop	Second-hand clothes shop	Thrift shop	Flea market	Flea shop	Shop with additional used item retail function	Total
I	5	–	–	1	–	–	6
II	6	4	–	–	–	–	10
III	3	1	1	–	–	–	5
IV	–	2	–	1	–	–	3
V	35	2	–	–	1	–	38
VI	8	5	1	1	–	–	15
VII	9	8	3	1	1	1	23
VIII	5	5	2	1	–	–	13
IX	4	3	–	–	–	–	7
X	–	1	–	1	–	–	2
XI	4	3	4	1	2	–	14
XII	6	–	1	–	–	–	7
XIII	3	3	2	–	3	–	11
XIV	3	2	–	1	–	–	6
XV	1	1	–	–	–	–	2
XVI	–	–	–	–	–	–	–
XVII	–	–	1	1	1	–	3
XVIII	1	–	1	1	–	–	3
XIX	2	1	–	2	–	–	5
XX	–	1	–	–	–	–	1
XXI	–	2	1	–	–	–	3
XXII	–	1	–	–	–	–	1
XXIII	–	–	–	–	–	–	–
Together	*95*	*45*	*17*	*12*	*8*	*1*	*178*

Note: Data from the research database.

(46.7%) are concentrated. One third of the shops deal with vintage or retro goods, 2/3 of them belong to one of the market leader second-hand clothes shop retail chains. Shops with different profiles are rather clearly separated from each other in space. Most of the vintage boutiques are located inside the ring of the Great Boulevard, in areas next to the CBD, these "luxury" thrift shops are probably able to keep pace with the high rental fees. As we move away from this area, with distance these boutiques are replaced with leading second-hand clothes chain shops.

Second-hand retail in district IV, X, XV and XI is formed mainly by used clothes shops, and in district XX and XXII the only form of second-hand retail is clothes shops.

As we can see, in the southern and south-eastern outer districts of Pest, and in the northern and north-western parts of Buda none of the chains are represented. Háda Kft opened 10 out of their 19 shops in shopping malls. Humana shops – similar to Háda's strategy – await customers in the central districts in favourable locations, in malls and shopping precincts. Their boutique in district V specializes in vintage clothes and accessories. The 4 Angex shops operating in the capital are not centred in the city centre. Humana only deals with individually priced clothes; Háda sells clothes on hangers and by kilo as well, while Angex's strategy is to combine piece prices and falling prices. Pricing policy of the 2 latter chains is supposed to be addressed to a wider layer of society.

The share of *thrift shops* in the total number of shops in second-hand retail sector is only 10 per cent. There is no significant spatial concentration here, these shops are mainly situated in the side streets in central districts (VII, VIII and XIII) or operate near the boulevards and busy main streets, embedded in busier commercial areas (Gregson, N. and Crewe, L. 2003). Thrift shops in Buda (4 shops) are concentrated in district XI. Some outer ones (district XVII, XVIII and XXI) also have one. Two chains of thrift shops must be mentioned here: *Cseriti Szociális Szövetkezet* (Charity Social Cooperation) maintains 5 charity points on the Pest side, and *Közösségi Szociális Szövetkezet* (Community Social Cooperation) operates two E-Cherry shops in Buda.

Flea markets are rather scattered on the capital's map. This is not surprising, since in Prague in the 1990s a similar tendency could be observed: these shops and markets were excluded to outer parts of the city (Temelová, J. and Novák, J. 2011). They operate almost in half of the districts (11 districts). Usually there is one of them in each, except district XIX, where 2 flea markets can be found. Some of them are organized indoors, in downtown courtyards, but the most are held in suburban public places, near roads leading out of the city since they require a large place. Similarly, in Košice (Slovakia) the popular flea market of the city is located in the outskirt (Fertaľová, J. 2006). Regarding their opening hours, it can be said that 2/3 of them operate occasionally, another 2 flea markets (16.6%) are seasonal.

The share of flea shops in second-hand retail in Budapest is rather modest. The existing eight flea shops account only for 4.5 per cent of the total. Flea shops are sometimes – incorrectly – called garage sales or flea markets, although their characteristics match those of a flea shop. They operate only in 5 districts and almost 2/3 of them are located in district XIII (3 shops) and in district XI (2 shops).

There is only one shop with *additional second-hand retail function* in district VII, in the cellar of a street food restaurant. The bazaar is located in the bar, where retro and rare items – originally part of the decoration – can also be bought.

Conclusions

In conclusion we can state that the emergence and spatial expansion of the different types of second-hand retail units is stimulated by customer needs constantly changing in space and time. The difference in their target groups and business strategies can clearly be seen in the spatial distribution of the different types, in the areas where their shops and markets are concentrated. Following the U.S. and Western European trends, second-hand retail trade in Budapest has been going through a remarkable diversification process in the last few decades. This process can be characterized by the followings:

- The number of second-hand retail units in Budapest almost doubled between 1998 and 2014, and this process was the most dynamic in the central districts of the capital.
- Antique shops and second-hand clothes shops represent more than 4/5 of the total in second-hand retail in Budapest. Elegant antique shops and more expensive vintage stores are concentrated in the inner Buda and Pest districts, the locations of second-hand clothes shop chains are in districts further from the centre.
- Thrift shops, flea markets and flea shops mainly make the palette more colourful, but at the same time, they play an important role in satisfying the needs of customer groups of different socio-economic situations.
- Increasing concentration of second-hand retail trade can be observed in districts next to the downtown area, and here can be found the most diverse selection of shops considering their profiles. These busy areas are popular locations for flea shops and charity shops too.
- Opposed to this, the second-hand retail trade network in the suburban districts is modest both in size and profile, they provide favourable location mainly for flea markets.

In the future, a remarkable research direction can be the comparison of spatial characteristics of second-hand goods retail and other retail segments, the exploration of similarities and differences between them. According to the author, in the future it would be worth exploring the different customer groups shopping in different types of used item retail units and exploring the motivations and behaviour of the consumers in the domestic culture of used goods.

REFERENCES

Anderson, S.P. and Ginsburgh, V.A. 1994. Price discrimination via second-hand markets. *European Economic Review* 38. 23–4.

Bardhi, F. 2003. Thrill of the HUNT: Thrift shopping for pleasure. *Advances in Consumer Research* 30. 375–376.

Bardhi, F. and Arnould, E.J. 2005. Thrift shopping: Combining utilitarian thrift and hedonic treat benefits. *Journal of Consumer Behaviour* 4. (4): 223–233.

Belk, R.W., Sherry, J.F. and Wallendorf, M. 1988. A Naturalistic Inquiry into Buyer and Seller Behaviour at a Swap Meet. *Journal of Consumer Research* 14. 449–470.

Berta, P. ed. 2012. *Használtcikk-kultúrák. Ideológiák, gyakorlatok és értelmezések* (Cultures of second-hand items. Ideologies, practices and explanations). Budapest, MTA BTK Néprajztudományi Intézet.

Boros, L., Fabula, Sz., Horváth, D. and Kovács, Z. 2016. Urban diversity and the production of public space in Budapest. *Hungarian Geographical Bulletin* 65. 3. 209–224.

Bruckner, É. 2007. *A zsibárus boszorkány. Az Ecseri piac krónikája a Teleki tértől a Nagykőrösi útig* (The witch of the flea market. A chronicle of the Ecseri Market from the Teleki Square to the Nagykőrösi Street). Budapest, Athenaeum Kiadó.

Cervellon, M.-C., Carey, L. and Harms, T. 2012. *Back from the Past: specific antecedents to consumer's purchase of vintage fashion vs. second-hand or recycled fashion.* 11th International Marketing Trends Conference 2012. http://www.marketing-trends-congress.com/archives/2012/Materials/Papers/Consumer%20Behaviour/CervellonHarmsCarey.pdf

Chantelat, P. and Vignal, B. 2005. „Intermediation" in used good markets: Transactions, confidence, and social interaction. *Sociologie du travail* 47. 71–88.

Chattoe, E. 2000. Charity shops as second-hand markets. *International Journal of Non-profit and Voluntary Sector Marketing* 5. (2): 153–160.

Crawford, M. 2014. The Garage Sale as Informal Economy and Transformative Urbanism. In *The Informal American City. From Taco Trucks to Day Labor*. Eds.: Mukhija, V. and Loukaitou-Sideris, A. Cambridge, MA, The MIT Press, 21–38.

Crewe, L. and Gregson, N. 1998. Tales of the unexpected: exploring car boot sales as marginal spaces of contemporary consumption. *Transactions of the Institute of British Geographers* 23. 39–53.

Delong, M., Heinemann, B. and Reiley, K. 2005. Hooked on Vintage! *Fashion Theory* 9. (1): 23–42.

Fertaľová, J. 2006. Evaluation of attendance in selected hypermarkets and shopping stores in the tows of Prešov and Košice. *Geographica* 39. 19–29.

Fontaine, L. ed. 2008. *Alternative Exchanges. Second-Hand Circulations from the Sixteenth Century to the Present, 1–12.* New York, Berghahn Books.

Fortuna, L.M. and Diyamandoglu, V. 2017. Disposal and acquisition trends in second-hand products. *Journal of Cleaner Production* 142. 2454–2462.

Frick, C.C. 2005. The Florentine 'Rigattieri': Second hand clothing dealers and the circulation of goods in the Renaissance. In *Old clothes, new looks: Second hand fashion.* Eds.: Palmer, A. and Clark, H., New York, Berg, 13–28.

Gabbott, M. 1991. The Role of Product Cues in Assessing Risk in Second-hand Markets. *European Journal of Marketing* 25. (9): 38–50.

Gregson, N. and Crewe, L. 2003. *Second-hand cultures*. New York, Berg.

Gregson, N., Crang, M., Laws, J., Fleetwood, T. and Holmes, H. 2013. Moving up the waste hierarchy: Car boot sales, reuse exchange and the challenges of consumer culture to waste prevention. *Resources, Conservation and Recycling* 77. 97–107.

Guiot, D. and Roux, D. 2010. A second-hand shoppers' motivation scale: Antecedents, consequences, and implications for retailers. *Journal of Retailing* 86. (4): 355–371.

Herrmann, G.M. 2011. New lives from used goods: Garage sales as rites of passage. *Ethnology: An International Journal of Cultural and Social Anthropology* 50. (3): 189–205.

Hickman, B. 2010. On the pricing rule in electronic auctions. *International Journal of Industrial Organization* 28. 423–433.

Horne, S. 1998. Charity shops in the UK. *International Journal of Retail & Distribution Management* 26. (4): 155–161.

Horne, S. and Broadbridge, A. 1995. Charity shops: a classification by merchandise mix. *International Journal of Retail & Distribution Management* 23. (7): 17–23.

Horne, S. and Madrell, A. 2002. *Charity Shops. Retailing, Consumption and Society*. London, Routledge.

Huang, S., Yang, Y. and Anderson, K. 2001. *Theory of finitely durable goods monopoly with used-goods market and transaction costs.* Available at: University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/3525

Hummel, P. 2015. Simultaneous use of auctions and posted prices. *European Economic Review* 78. 269–284.

Kovács, E., Bacsi, Zs., Bokor, I. and Lőke, Zs. 2008. *Lomizók és lomok az Európai Unió perifériáján – a* *szegénység fogyasztói társadalma* (Junk and jumble pickers in the periphery of the European Union – the consumer society of poverty). Annual report, OTKA-49335K. 21. http://real.mtak.hu/1955/1/49335_ZJ1.pdf

Lemire, B. 1997. *Dress, Culture and Commerce. The English Clothing Trade before the Factory, 1660–1800.* London, Macmillan Press Ltd.

Leyshon, A., Lee, R. and Williams, C. 2003. *Alternative Economics Spaces.* London, SAGE Publications.

Liebowitz, S.J. 1982. Durability, Market Structure, and New-Used Goods Models. *The American Economic Review* 72. (4): 816–824.

Makó, A. 2013. A „buborék" vége, válság vagy korszakváltás (The end of „the bubble", crisis or the end of an era). In *A válság hatása a kiskereskedelemre*. Ed.: Sikos, T.T., Gödöllő, Szent István Egyetemi Kiadó, 21–32.

Mitchell, M. and Montgomery, R. 2010. Examination of Thrift Store Shoppers. *Marketing Management Journal* 20. (2): 94–107.

Mulholland, M. and Cockfield, R. 1993. Trading to Boot: The Legal Implications of Car Boot Sales. *Business Law Review* 14. (9): 223–227.

Nagy, E., Nagy, G. and Dudás, G. 2016. The uneven transformation of consumption spaces and the rise of new marginalities in Hungary. *Regional Statistics* 6. 2. 149–172.

Palmer, A. and Clark, H. eds. 2005. *Old clothes, new looks: Second hand fashion*. New York, Berg.

Parsons, E. 2004. Charity shop management in the UK: becoming more professional? *Journal of Retailing and Consumer Services* 11. (5): 259–268.

Peters, M. and Severinov, S. 2006. Internet auctions with many traders. *Journal of Economic Theory* 130. 220–245.

Petrescu, M. and Bhatli, D. 2013. Consumer Behaviour in Flea Markets and Marketing to the Bottom of the Pyramid. *Journal of Management Research* 13. (1): 55–63.

Scitovsky, T. 1994. Towards a Theory of Second-hand Markets. *KYKLOS International Review of Social Sciences* 47. (1): 33–52.

Sherman, E., McCrohan, K. and Smith, J.D. 1985. Informal Retailing: An Analysis of Products, Attitudes, and Expectations. *Advances in Consumer Research* 12. 204–208.

Sherry, J.F. 1990a. A Sociocultural Analysis of a Midwestern American Flea Market. *Journal of Consumer Research* 17. 13–30.

Sherry, J.F. 1990b. Dealers and Dealing in a Periodic Market: Informal Retailing in Ethnographic Perspective. *Journal of Retailing* 66 (2): 174–200.

Shulman, J.D. and Coughlan, A.T. 2007. Used goods, not used bads: Profitable secondary market. *Quantitative Marketing and Economics* 5. 191–210.

Sikos, T.T. 2000. *Marketingföldrajz* (Marketing geography). Budapest, VÁTI Dokumentációs Osztály, Komáromi Nyomda és Kiadó Kft.

Soiffer, S. and Herrmann, G.M. 1987. Visions of power: ideology and practice in the American garage sale. *The Sociologial Review* 35. (1): 48–83.

Stobart, J. and Van Damme, I. eds. 2010. *European Consumption Cultures and Practices, 1700–1900*. London, Palgrave Macmillan.

Stone, J., Horne, S. and Hibbert, S. 1996. Car boot sales: a study of shopping motives in an alternative retail format. *International Journal of Retail & Distribution Management* 24. (11): 4–15.

Stroeker, N.E. and Antonides, G. 1997. The process of reaching an agreement in second-hand markets for consumer durables. *Journal of Economics Psychology* 18. 341–367.

Swan, P.L. 1972. Optimum Durability, Second-Hand Markets, and Planned Obsolescence. *The Journal of Political Economy* 80. (3): 575–585.

Temelová, J. and Novák, J. 2011. Daily street life in the inner city of Prague under transformation: the visual experience of socio-spatial differentiation and temporal rhythms. *Visual Studies* 26. (3): 213–228.

Thomas, V.M. 2003. Demand and Dematerialization Impacts of Second-Hand Market. Reuse or More Use. *Journal of Industrial Ecology* 7. (2): 65–78.

Valuch, T. 2004. *A lódentől a miniszoknyáig. A XX. század második felének magyarországi öltözködéstörténete* (From the loden to the mini skirt. Clothing history of the 2nd half of the 20th century in Hungary). Budapest, Corvina Kiadó – 1956-os Intézet.

Van Cayseele, P. 1993. Lemons, Peaches and Creampuffs: Economics of a Second-Hand Market. *Tijdschrift voor Economie en Management* 38. (1): 73–85.

Vas-Egri, M. and Danó, Gy. 2013. Hazai e-vásárlási szokások fő jellemzői és dinamikája (Main characteristics and dynamics of Hungarian online shopping habits). In *A válság hatása a kiskereskedelemre*. Ed.: Sikos, T.T., Gödöllő, Szent István Egyetemi Kiadó, 101–129.

Williams, C.C. 2002. Why Do People Use Alternative Retail Channels? Some Case-study Evidence from Two English Cities. *Urban Studies* 39. (10): 1897–1910.

Williams, C.C. 2003. Explaining Informal and Second-Hand Goods Acquisition. *International Journal of Sociology and Social Policy* 23. (12): 95–110.

Williams, C.C. and Paddock, C. 2003. The meanings of informal and second-hand retail channels: Some evidence from Leicester. *The International Review of Retail, Distribution and Consumer Research* 13. (3): 317–336.

Witkowski, T.H. 1993. The Polish Consumer in Transition: Shopping Warsaw's Street Vendors and Open Air Markets. *Advances in Consumer Research* 20. 13–17.

Zachariás, K. 2007. Használt holmik piaca (Market of used items). *Kultúra és Közösség* 11. (2–3): 147–154.

Other sources

European Commission 2008. NACE Rev.2. Statistical classification of economic activites in the European Community. 363. p. http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

Executive Office of the President Office of Management and Budget 2017. North American Industry Classification System (NAICS), 961. p. https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf

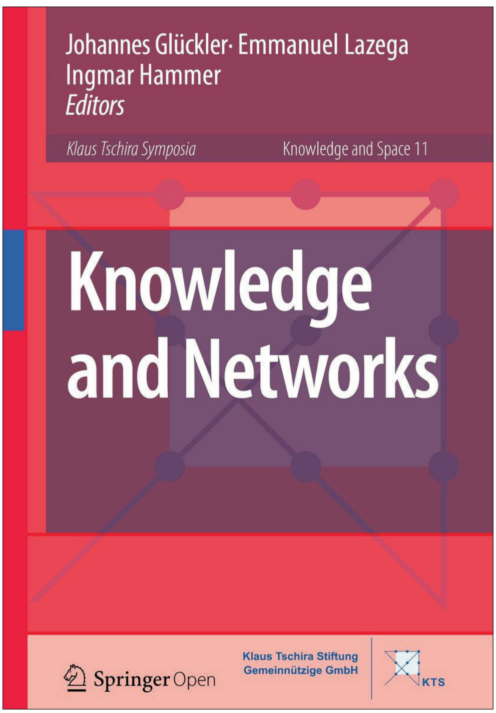
TEÁOR '08 nómenklatúra http://www.teaorszamok.hu/4779/Haszn%C3%A1ltcikk%20bolti%20kiskereskedelme/

United Nations Statistics Division: International Standard Industrial Classification of All Economic Activities (ISIC Rev.4) https://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=4774

BOOK REVIEW SECTION

Glückler, J., Lazega, E. and Hammer, I. (eds.): Knowledge and Networks. Cham, Springer, 2017. 386 p.

Why geo-located social networks matter in how knowledge is created and diffuses in space? According to a central tenet in social sciences, network position of individuals explains much of information access (Ibarra, H. 1993), control of flows (Newman, M.E.J. 2005), and thus the outcomes of new knowledge creation (Burt, R.S. 2004). It is also widely recognised that social ties and personal acquaintance reduce transaction costs and enhance the efficiency of mutual learning (Borgatti, S. P. *et al.* 2009). However, we still need to better understand how social ties form and evolve in space (Juhász, S. and Lengyel, B. 2017) and how they contribute to socio-economic and technological development (Lengyel, B. and Eriksson, R. 2017). With the large ICT-related datasets now available, we can investigate the structure and dynamics of social interactions at an unprecedented scale (Lazer, D. *et al.* 2009). Yet, most empirical works on large-scale social networks neglect the very geography inscribed in all socio-economic relations (Fernandez, R.M. *et al.* 2004), thus falling short of grasping the economic, social, political, and institutional diversity of regions.



The recent book edited by Johannes Glückler, Emmanuel Lazega and Ingmar Hammer targets this very important research niche by bringing together a wide variety of scholars from economics, geography, management and sociology. It is the 11th volume of the Knowledge and Space book series, financed by the Klaus Tschira Foundation, and has been edited from the papers presented at the "Topographies and Topologies of Knowledge" symposium in Villa Bosch, Heidelberg (12–15 June, 2013). This series has grown to be an essential collection of the efforts in understanding the complex nature of knowledge and its relation to places and spaces.

In their introductory chapter, the editors stress the necessity to strengthen the conversation between the parallel literatures of social network theory and the geography of knowledge. I completely agree with this central aim of the book and the implicit call for a new interdisciplinary social science research agenda. Place and space provide fundamental contexts and also barriers of social relations, and in turn, social networks analysis provides very good tools to investigate the creation and diffusion of complex knowledge in space. Glückler and his colleagues provide an overview of the core geography literature focusing on social networks and then summarise the geographical aspects of the sociology literature. After this, the authors set out their theoretical framework of the inter-disciplinary conversation about the interrelatedness of space and connections. They distinguish the roles of space in conditioning network formation from the spatial effects that moderate the network outcomes. In a similar fashion, the authors argue that connectivity influences spatial effects such as neighbourhood diffusion and mediate knowledge sharing if peers are not in physical proximity. Finally, they call for a multilevel geographical approach focusing on the interactions between agents. Indeed, the complex interdependencies of individuals and organisations need to be considered and therefore we have to analyse horizontal interactions between individuals and between organisations, and we also need to understand how the relations between the individual and organisational layers of networks influence the geographies of knowledge.

The book structure is organised into three sections: "Knowledge about Networks", "Network Evolution and Social Outcomes" and "Network Geographies of Learning". Each block consists of five chapters.

In the first section, the chapters stress the importance of the multilevel approach of spatial social networks analysis from a theoretical point of view. In the opening chapter, Nancy Ettlinger questions the classic direction of causality between the structure of social networks and economic outcomes, and argues that economic processes shape the evolution of social relations. This chapter is a critical synthesis of economic geography, sociology and business literatures; and the way Ettlinger conceptualises economic and social relations makes it an important read for those interested in polarisation and inequalities. The following chapter looks at intercultural competence and learning in the context of globalising labour division and focuses on employees who are sent by the employer firms on foreign assignments. Erika Spiess develops an interesting framework in which the personal connections of the previous life of these employees foster inter-cultural learning when combined with the new ties created abroad. In the fourth chapter, Pengfei Li examines the role of family networks in developing regions and claims that the role of family connections in learning weakens when the economies take off. Li argues in a very interesting manner that other types of social connections – such as friendship and professional connections – gain importance during fast development, but the transition is not automatic and the collapse of strong family networks might lead to fragmented societies. In the next chapter, Laurent Beauguitte analyses speeches and votes in the United Nations General Assembly and observes that nations collaborate more and more on international and global issues and also finds an emerging importance of regional groups of countries. In the final chapter, Sarah Hall discusses how social networks of graduate and postgraduate students influence the education strategies students make.

The second section includes exciting empirical papers that examine the relations between the dynamics of social network formation and network outcomes of individuals and regions. In the seventh chapter, Emmanuel Lazega analyses an advice network among lay judges and investigates how the mobility of judges and the social networks created thereof shape collective learning. The author gives us a short introduction into how the structure of networks and agency endogenously form each other, then provides a very interesting spinning-top model to describe the cyclical centralisation and decentralisation process in multilevel networks. Drawing on a cool case, Charles Kirschbaum investigates how collaboration over the 40-year evolution in jazz can describe individual musicians' career and how the style of collaboration in music changed and became more and more competitive over generations. In the ninth chapter, Laura Prota, Maria Prosperina Vitale and Maria Rosaria D'Esposito analyse collaboration networks in a high-tech industrial district in Italy. By looking at how the core-periphery structure of the collaboration network changed over time, they contribute to the literature on cluster evolution. In the following chapter, Jörg Sydow and Friedemann Koll ask the policy-related question whether regional technological capabilities can be designed by fostering the relations between local agents. The final chapter of the section is authored by Martin Kilduff, Ajay Mehra, Dennis Gioia and Stephen Borgatti. The authors analyse in an excellent way the emergence of informal leadership in terms of individual behaviour in a high-tech firm and the effect of consequently gained structurally advantageous network positions. The findings suggest that those employees who adopt quickly to temporary social groups and change attitudes accordingly are more likely to be recognised by colleagues as informal leader, and the network position gained is more advantageous for them as for others whose attitudes are more consistent.

The content of the third section specifically focuses on the role of networks in new knowledge creation and knowledge sharing. Satyam Mukherjee, Brian Uzzi, Ben Jones, and Michael Stringer investigate the origins of the impact of scientific publications measured by the number of citations. This chapter is a well reflected paper, in which the authors find that the highest impact papers combine previous work in a conventional way but also introduce some unusual combinations. The authors compare the dynamics of scientific impact in the fields of economics, geography and physics in this chapter and also demonstrate that publications authored by teams have higher impact than solo-authored papers. In the following chapter, Johannes Glückler and Ingmar Hammer provide interesting insights into the outcomes of knowledge diffusion by confronting two forms of local inter-firm learning: friendly imitation fostered by social connections between firms and unfriendly forms of rival learning incentivised by co-location of firms. Their case study on a German IT organised network demonstrates that the tension caused by unfriendly rivalry is lowered by social connectedness and sanctions, which points toward better knowledge sharing opportunities in local economies. Stefano Breschi and Camilla Lenzi analyse large geo-located co-inventor networks in order to understand how network bridges between local innovation systems induce the dynamics of innovation in cities. Their findings suggest that direct external relations bring fresh new knowledge into the local community of inventors and help the renewal of the knowledge base in the region. Collecting survey data from questionnaire with civil servants, Christopher Ansell, Martin Lundin, and Per Ola Öberg analyse the network of learning across Swedish municipalities. The authors illustrate that most of the learning processes occurs between neighbouring municipalities and that the social networks of civil servants are shaped by administrative borders of counties. In the final chapter, Uwe Cantner, Susanne Hinzmann, and Tina Wolf look at social relations, knowledge transfer and cognitive proximities as the drivers of innovative collaboration dynamics. The authors report that collaboration ties are not likely to be repeated, which stresses the importance of finding new partners. Their findings suggest that firms prefer to repeat cooperation with those firms that has similar knowledge base to their own.

Being active in the field this volume focuses on, I have very positive feelings about this book. All the chapters are open access and I highly recommend the read for everyone interested in spatial social networks. In general, I think that social networks provide very effective tools to better understand a variety of topics from spatial economic and social processes. This volume brings together a very nice selection of research questions and prompt answers in a way that the reader is motivated to develop new questions and answers. I think this is a great asset of the book.

Networks are everywhere and the beauty of the theory and methods of social networks is in its interdisciplinary character. The book "Knowledge and Networks" is an important building block in strengthening cross-disciplinary conversation between social scientists and geographers. I definitely think we have to follow this path and even think we have to extend the conversation to other communities. The emerging field of computational social science already integrates natural scientists interested in social networks and spatial phenomena with social scientists (Lazer, D. *et al.* 2009). Although the translation of research questions is challenging, because scholars in the natural science tradition of network science are looking for universal patterns instead of looking closely at the contexts of economic and social phenomena (Hidalgo, C.A. 2016), I believe that widening the dialogue is beneficial for both streams of network research. For example, I am very much looking forward to the computational social science translation of key social science cornerstones, such as the multi-level approach including agency and organisation, which is one of my major lessons from the recent book.

Professor Peter Meusburger, the father of the Knowledge and Space symposia series at Heidelberg University, passed away with tragic suddenness on 18th December 2017. Although he did not directly participate in editing the book or authoring its chapters, and I did not know him personally, I would like to express my gratitude for this remarkable book series he started. Professor Meusburger devoted a significant share of his research on the spatial transformation during post-socialism and helped the integration of Central and Eastern European scholars in the international community. Interested in spatial social networks, I believe that the path the recent "Knowledge and Networks" volume follows will further integrate researchers from Central and Eastern Europe in the international discussion, which Professor Meusburger must have wished for us. May he rest in peace.

Balázs Lengyel[1]

REFERENCES

Borgatti, S.P., Mehra, A., Brass, D.J. and Labiance, G. 2009. Network analysis in the social sciences. *Science* 323. (5916): 892–895.

Burt, R.S. 2004. Structural holes and good ideas. *American Journal of Sociology* 110. (2): 348–399.

Fernandez, R.M. and Su, C. 2004. Space in the study of labor markets. *Annual Review of Sociology* 30. (1): 545–569.

Hidalgo, C.A. 2016. Disconnected, fragmented, or united? A trans-disciplinary review of network science. *Applied Network Science* 1. (6): DOI 10.1007/s41109-016-0010-3

Ibarra, H. 1993. Network centrality, power, and innovation involvement: Determinants of technical and administrative roles. *Academy of Management Journal* 36. (3): 471–501.

Juhász, S. and Lengyel, B. 2017. Creation and persistence of ties in cluster knowledge networks. *Journal of Economic Geography* https://doi.org/10.1093/jeg/lbx039

Lazer, D., Pentland, A., Adamic, L., Aral, S., Barabasi, A.L., Brewer, D., Christakis, N., Contractor, N., Fowler, J., Gutmann, M., Jebara, T., King, G., Macy, M., Roy, D. and Van Alstyne, M. 2009. Life in the network. *Science* 323. (5915): 721–723.

Lengyel, B. and Eriksson, R. 2017. Co-worker networks, labour mobility and productivity growth in regions. *Journal of Economic Geography* 17. (3): 635–660.

Newman, M.E.J. 2005. A measure of betweenness centrality based on random walks. *Social Networks* 27. (1): 39–54.

[1] Agglomeration and Social Networks Lendület Research Group, Centre for Economic and Regional Studies, Hungarian Academy of Sciences, Budapest, Hungary. E-mail: lengyel.balazs@krtk.mta.hu

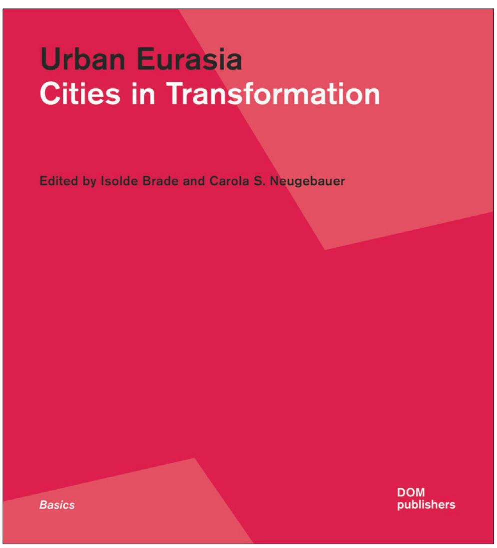
Brade, I. and Neugebauer, C.S. (eds.): Urban Eurasia – Cities in Transformation. Berlin, DOM publishers, 2017. 288 p.

The book invites us to a journey across the cities of the former Soviet Union, from Kaliningrad to Vladivostok, from Baku to Almaty, and intends to show us how urban space and society have changed and are still changing during the time of transition.

The album-like publication is the 58th volume in the "Basics" series of DOM publishers, a series featuring a wide range of topics in architecture and urban development. This format addresses a broad audience with short texts, informative diagrams, and plenty of photographs.

The volume heavily draws on the scientific results of "ira.urban", a 4-year-long international research project conducted by the Leibniz Institute for Regional Geography, Leipzig. The "ira.urban" or "Urban reconfiguration in post-Soviet space" project aimed to investigate how cities in the former Soviet Union answer the challenges of economic and social changes generated by the emergence of new nation states and globalisation. The research project was supported by an international scientific network, the participants of which also contributed to the current volume.

The latent question whether urban development in cities east of the former Iron Curtain after the socialist, or Soviet, regime is still influenced by past practices, heritage and settings, or whether the new trends of globalisation, individualisation and, for example, neoliberalisation are more significant factors, has long been of concern to urban researchers. Numerous



publications have been released analysing the political, economic, and social changes, and in some cases their consequences in the urban spaces of Central and Eastern European post-socialist cities (cf. edited collections of Andrusz, G. *et al.* 1996; Enyedi, G. 1998; Hamilton, I. *et al.* 2005; Tsenkova, S. and Nedović-Budić, Z. 2006; Stanilov, K. 2007). But the other, much larger part of the former Eastern Bloc, namely the ex-Soviet states and their cities, were hardly studied by urban researchers, at least till the 2010s. Since then, the work of urban anthropologists in particular has come to the forefront in post-Soviet urban society and urban space research (cf. Alexander, C. *et al.* 2007; Gdaniec, C. 2010; Darieva, T. *et al.* 2011; Schröder, P. 2017). This body of research examines primarily the appropriation and use of public urban spaces by different social groups, mainly in the form of case studies.

The benefit of the current collection is that it takes a comparative approach: it tries to make comparisons in time, including pre-socialist and socialist times as well as the period during and after transition, and also to compare cities in the post-Soviet space, besides giving insights into several urban topics such as housing, infrastructure, economy, planning, and the social perception and appropriation of urban space. The major questions are, among others, who the winners and losers of the transition are, who can be identified as key actors, and to what extent are forces driven (still) by the state?

The first chapter outlines the context by taking a macro-scale view of the urban network. It presents the characteristics of the Soviet urban system and the challenges that emerged after the dissolution of the USSR, such as the growing competition among cities. Firstly, Frost investigates spatial changes in the post-Soviet city system, claiming that the urban network is being transformed from a relatively balanced structure (as an outcome of spatial equalisation) to a polarised system. Urban shrinkage heavily affects both medium- and small-size towns, and especially monocities (mono-functional cities). Meanwhile, capital cities, large urban centres and their satellite towns, and cities close to specific natural resources like gas or oil, keep growing in significance. The process of polarisation is confirmed by Zubarevich as well, adding that it is not accompanied by significant changes in the urban hierarchy or in inter-urban ties: "a classical centre-periphery model is a privilege in this space" (p. 39). Although polycentricity will grow within the post-Soviet region, and the role of Moscow as primary centre is gradually eroded, there are no other cities that can be considered as strong alternative poles. The contribution by Sgibnev and Tuvikene raises issues regarding the maintenance of urban infrastructure, with a special focus on public transport, as well as the social consequences of the termination of subsidised provisions, e.g. in housing. "The end of infrastructure provision sounded the disintegration of society" (p. 55) and sometimes may have enhanced the nostalgia for the Soviet Union. That is also why the two authors suggest to "draw attention to social and cultural aspects of infrastructure, their role for identity formation and power relations" (p. 60).

The second chapter deals with urban housing and how planning, construction, and maintenance have changed during the transformation in the three main types of residential areas: in the inner-city, on large housing estates, and in suburban areas. Golubchikov, Badyina and Makhrova report on inner-city reconstructions, ranging from less violent forms such as *kommunalki* (shared homes) resettlement and renovation to newly-built gentrification, often at the site of destroyed urban heritage, or at the expense of public and green spaces. Due to weak regulation or the improper application of rules, construction developments, e.g. high-rise housing, could also result in highly eclectic urban landscapes. Nonetheless, these phenomena are similarly known in post-socialist countries (Hirt, S. 2012). The study by Neugebauer provides a good overview of the ideological background, urban design concepts, socio-political dimensions and the social appreciation of Soviet mass housing, while making comparisons with their Western European counterparts. Neugebauer also scrutinises the legal and informal changes in housing practices. A revival of mass housing on the urban fringes of growing cities, either as private investment or as national housing programmes is also noticeable. Golubchikov and Makhrova describe housing processes in exurban areas: previous urban-sprawl in Soviet and early post-Soviet times by *dachas* (second home for non-permanent use), and more recently, often at the site of these dacha areas, by *kottedzhi* (cottages, villas), or even by gated, elite settlements. At the same time, city edges are also characterised by newly-built mass housing, giving home to less well-off families, and even the informal settlements of migrants are present. As a result, "the periphery has also emerged as a territory where social inequality is spatially most visible" (p. 178).

The third chapter addresses urban economic transformation, primarily the change in the institutional environment (transition to market economy) and the structural shift due to the growing importance of the service sector and consumer goods industry, and their impact on urban structure. Kuznetsov, Chetverikova and Baronina give evidence in their study that deindustrialisation is not an overarching tendency in the post-Soviet space, and there are some successful examples of industrial modernisation in metallurgy and car production. These developments are financed either from state investments or from private capital, which often means foreign, especially Asian, direct investments. Some of the monotowns were effectively turned into *naukograds,* science cities – again, with the help of state subsidy. However, in (mono)cities where unsuccessful industries are present (e.g. agricultural machinery, civil electronics), social problems are not analysed. Axenov discusses the retail evolution in the post-Soviet urban space, first the flood of kiosks and ground floor capitalism (see also Tosics, I. 2006), and later on the more regulated, but at the same time also more exclusionary and exclusive shopping centres. These commercial space developments are responses to the insufficient supply during the Soviet era and to the high demand in post-Soviet times. Moreover, petty vending as source of (additional) income was and still is a response to the impoverishment of the population. Turgel and Vlasova give examples in their contribution to tertiarisation in the cityscape, based on experiences from Yekaterinburg and its region. The restructuring of the economy affected both inner city areas and the urban edge. The function of buildings has changed, former industrial headquarters have been turned into banks, offices, or commercial buildings. Retail suburbanisation took place especially through international retail chains.

In the final, fourth chapter, cities are studied as "material stage to display and means to negotiate societal diversity and conflicts" (p. 234). Its essays deal with micro-scale urbanity; social and cultural aspects are considered. The study by Rekhviashvili and Neugebauer focuses on the use of urban public space. On the one hand, citizens use urban public space as a stage for (pro or contra) protests, and they use it in their everyday life, in the routines and practices they have partly inherited from pre-Soviet or Soviet times. On the other hand, the state utilises urban public space to foster nation building, which might also be a form of how political power is still being projected on urban space. Materialised forms of nation building and memory policy are the main topics of the contribution by Kinossian. In former Soviet member states built Soviet legacies, architecture, and monumental art have been handled in various ways in the post-Soviet period. In some places they have been destroyed or removed (e.g. in Ukraine, Azerbaijan), while elsewhere they remained untouched. They are either intentionally kept in the absence of other unifying symbols (Russia), or are simply neglected (for the Central and Eastern European context see Czepczyński, M. 2008). In addition, built heritage from pre-Soviet times in historic cities is in danger of economic transformation and marketisation.

The cultural landscape "has become a battlefield of preservation values and interests of profit extraction" (p. 262). This phenomenon, profit maximisation, is also explained by Appenzeller in the section "Urban planning and governance". He argues for "engaging citizens more actively and reducing the hierarchical system that is vulnerable to corruption and all too easily hijacked by the political or economic ambition of individuals" (p. 273). Western European planning tools, however, can only be adapted to post-Soviet countries to a lesser extent. Low civil activity, especially towards urban issues, and the weak institutionalisation of civil society are discussed by Mezentsev, Neugebauer and Mezentseva as well. These shortcomings and a "disbelief in any effectiveness of public activism" (p. 276) (similarly to Hirt's notion of 'privatism', Hirt, S. 2012) are claimed to be the heritage of Soviet times. Nonetheless, proactive and counteractive activities are present in post-Soviet cities too. Counteractive activities are aimed mainly at the protection of built heritage, memorials, public and green spaces, and at opposition to demolition and new construction.

Based on these studies, it is striking how the role of state is constantly changing in urban planning and development, and, consequently, in terms of its influence on living and residential forms as well. During the Soviet-era, as urbanisation had key relevance, planning extended even to the organisation of everyday life, for instance in the '*Socgoroda*', which were laboratories "for socialism's ideal interaction between working, living, and recreating" (p. 219). At the dawn of the post-Soviet era, the "almost lawless environment" (p. 183) could not prevent the "violation with existing plans, norms and heritage" (p. 87). Later on, the state regained its role in both regulation and investment, supporting, among other things, social housing, the modernisation of heavy industry, and the conversion of some monotowns into science cities.

It should be noted that although the book was not intended to give a comprehensive overview, the cases of Russian (large) cities are well stressed (especially in Chapter 4) through the examples selected by the authors. Instances from other ex-Soviet states are less numerous and are generally limited to capital cities. However, the images and short texts provide a broader view. Notwithstanding, extending research to small and medium-size cities would still be desirable in post-Socialist urban science (Borén, T. and Gentile, M. 2007).

The current volume, as a medium for raising awareness, is informative and manages to give an insight into the diversity of post-Soviet cities. From a scientific point of view, especially valuable are some of the highlighted aspects, which could be further used in research: the abandonment of the *transitological* focus and the consideration of social and cultural aspects. These are mentioned in the book in connection with studying infrastructure (p. 60) and housing (p. 72), but they are applicable in more general terms as well. All in all, the volume fulfils its purpose and indeed offers an intriguing starting point for further exploration.

Orsolya Eszenyi[1]

REFERENCES

Alexander, C., Buchli, V. and Humphrey, C. eds. 2007. *Urban Life in Post-Soviet Asia*. London–New York, University College London Press.

Andrusz, G., Harloe, M. and Szelényi, I. eds. 1996. *Cities after Socialism: Urban and Regional Change and Conflict in Post-Socialist Societies*. Oxford, Blackwell.

Borén, T. and Gentile, M. 2007. Metropolitan processes in post-communist states: an introduction. *Geografiska Annaler: Series B, Human Geography* 89. (2): 95–110.

Czepczyński, M. 2008. *Cultural Landscapes of Post-Socialist Cities: Representation of Powers and Needs*. Aldershot, Ashgate.

Darieva, T., Kaschuba, W. and Krebs, M. eds. 2011. *Urban Spaces after Socialism: Ethnographies of Public Places in Eurasian Cities.* Frankfurt, Campus Verlag.

Enyedi, G. ed. 1998. *Social Change and Urban Restructuring in Central Europe*. Budapest, Akadémiai Kiadó.

Gdaniec, C. ed. 2010. *Cultural Diversity in Russian Cities: The Urban Landscape in the Post-Soviet Era*. Oxford, Berghahn Books.

Hamilton, F.E.I., Dimitrovska, A.K. and Picheler-Milanović, N. eds. 2005. *Transformation of Cities in Central and Eastern Europe: Toward Globalization*. Tokyo, United Nations University Press.

Hirt, S. 2012. *Iron Curtains. Gates, Suburbs and Privatization of Space in the Post-Socialist City*. Chichester, Wiley-Blackwell.

Schröder, P. ed. 2017. *Urban Spaces and Lifestyles in Central Asia and Beyond*. Abingdon–New York, Routledge.

Stanilov, K. ed. 2007. *The Post-Socialist City. Urban Form and Space Transformations in Central and Eastern Europe after Socialism*. Dordrecht, Springer.

Tosics, I. 2006. Spatial restructuring in post-socialist Budapest. In *The Urban Mosaic of Post-Socialist Europe. Space, Institutions and Policy*. Ed.: Tsenkova, S. and Nedović-Budić, Z. Heidelberg, Physica Verlag, 131–150.

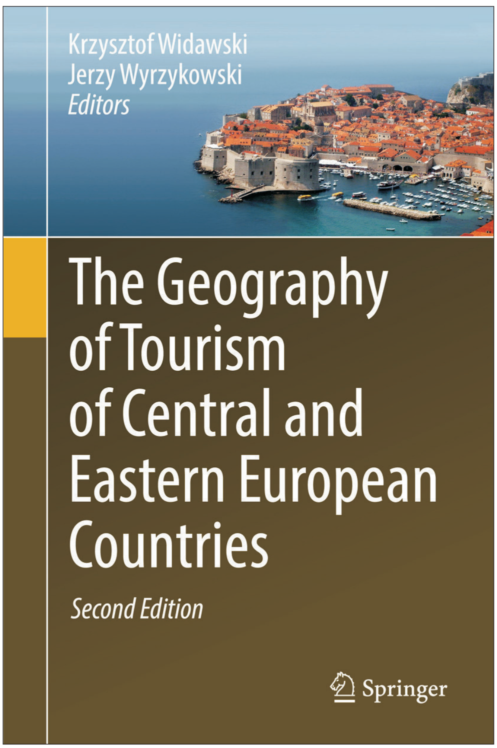
Tsenkova, S. and Nedović-Budić, Z. eds. 2006. *The Urban Mosaic of Post-Socialist Europe. Space, Institutions and Policy*. Heidelberg, Physica Verlag.

[1] Doctorate School of Earth Sciences, Eötvös Loránd University (ELTE), Budapest, Hungary. E-mail: eszenyi.orsolya@gmail.com.

Widawski, K. and Wyrzykowski, J. (eds.): The Geography of Tourism of Central and Eastern European Countries. Second edition. Cham, Springer, 2017. 551 p.

Stephen Williams underlined the importance of the geography of tourism in 1998 with the following initial sentences in his book "Tourism Geography": "Thirty years ago, the inclusion of a book on tourism within a series of introductory texts covering differing aspects of human geography would have been an unlikely event. Today, the exclusion of tourism from the geography curriculum seems equally improbable." (Williams, S. 1998. p. 1). Williams (1998) also emphasised that tourism is an essentially geographical phenomenon since it deals with subjects like the spatial distribution of tourism, tourism impacts, tourism planning and spatial modelling of tourism development. Hence, since the dawn of the 2000s we can state that the role of geography in tourism studies is widely accepted and inevitable.

Academic works on tourism geography date back to 1976, when Harry Robinson published his book "A geography of tourism". Considering the geography of tourism as general topic, the most essential piece of literature coming to my mind is the book of C. Michael Hall and Stephen J. Page entitled "The Geography of Tourism and Recreation: Environment, Place and Space" (the first edition was published in 1999 and the fourth in 2014). In my view the second most important volume is "Tourism Geography" by Stephen Williams in 1998, which I already referred to in the last section. Concerning the discussion of the theoretical background of the geography of tourism we can also refer to recently published volumes such as the book of Velvet Nelson (2017) ("An Introduction to the Geography of Tourism") or the revised edition of Stephen Williams's seminal work ("Tourism Geography: A New Synthesis") (Williams, S. 2009).



There is also another sort of books highly relevant here, dealing with the geography of tourism from the regional perspective. I find important to highlight the works of Lew, C.M., Hall, C.M. and Timothy, D. (2008) "World Geography of Travel and Tourism: A Regional Approach" and Lew, A.A., Hall, C.M. and Timothy, D.J. (2011) "World Regional Geography: Human Mobilities, Tourism Destinations, Sustainable Environments". In general, these books deal with the regional perspectives of tourism geography on the global scale.

As far as I could revise international literature I was unable to find relevant volumes from prominent publishers which exclusively deal with the tourism geography of Central and Eastern Europe. So, from this perspective, I believe that the presently reviewed volume is a niche publication.

The reviewed book primarily originates from the initiative of the Department of Regional Geography and Tourism at Wrocław University. From 1990 to 2010 this institute regularly organised scientific meetings for experts and professionals of tourism, in their words, "in order to exchange research experience in the scope of the development on international tourism in Central and Eastern Europe" (p. vii). This initiative led by Jerzy Wyrzykowski resulted in 11 scientific publications in the book series "Conditions for the foreign tourism development in Central and Eastern Europe" (p. vii) (the title was written incorrectly in the reviewed volume, using 'the' before the word 'Central'). Issues of the series were released between 1992 and 2010, and finally, in 2012, the Department of Regional Geography and Tourism published a volume entitled "Geography of Tourism of Central and Eastern European Countries". (The title of this volume was also mistyped in the reviewed book, as "Europe" instead of "European", p. vii.)

The original 2012 volume was followed by an updated edition in 2017, now including a chapter about Belarus as well. The second edition is the object of my current book review. As the editors underline, the major scope of the volume has been limited to the post-socialist countries of the region. They justify this focus by that tourism industry in this region has experienced similar environment, development and progress in the past 60–70 years. According to the short description of the book at springer.com the volume "presents a comprehensive overview of the tourism market development in Central and Eastern European countries" (http://www.springer.com/us/book/9783319422039).

The volume is divided into two introductory chapters ("Introduction"; "The Output of International Scientific Conferences Entitled 'The Conditions of Foreign Tourism Development in Central and Eastern Europe' Organised by the Department of Regional Geography and Tourism at the University of Wrocław"), 13 chapters and an Erratum to the geography of tourism in Slovakia.

"Introduction" is followed by "The Output of International Scientific Conferences Entitled 'The Conditions of Foreign Tourism Development in Central and Eastern Europe' Organised by the Department of Regional Geography and Tourism at the University of Wroclaw" from page ix to page xv. This chapter provides a detailed description of the above mentioned international conferences, their scientific organisers, locations as well as the participants and their affiliation. The primary aim of this chapter is to present the goals and objectives of the volumes which were published upon the scientific conferences. While reading this chapter, my major concern was the use of English, since I strongly think that no language revision was provided for this part of the book. The text is informative and its meaning is clear, but it obviously was not reviewed by a professional or native speaker.

Chapter 1 was written by two Polish authors from the University of Business in Wrocław, Janusz Marak and Jerzy Wyrzykowski. They discuss "The Position of Countries of Central and Eastern Europe on the International Tourism Market". This chapter gives an overall analysis of 20 former socialist countries between 2005 and 2013/2014. After the introduction, the first subchapter deals with "Tourist potential". Although one might think the demand side will be analysed here only, we receive information on the supply side as well. Since it deals with tourism in a complex approach maybe a title like "Overall tourism potential" would fit better here. The next subchapter describes "The Current Extent of International Tourism". My main concerns here are that the authors refer twice to Wikipedia as data source (I would strongly advise not to refer to Wikipedia in a scientific publication), and that the data could have been more recent, since we usually find 2014 data in a 2017 publication. In the following parts of the chapter, too, there is almost no data from after 2013. The chapter finishes by analysing the "Current Role of Central and Eastern European Countries as the Source of International Tourist Traffic" and the "Balance of Receipts and Expenditure in International Tourism in Central and Eastern Europe".

Chapter 2 by Ivan Pirozhnik (a Belarusian scientist from the Belarusian State University in Minsk) deals with the "Geography of Tourism of the Republic of Belarus". The introduction gives a thorough and precise literature overview of the studies on history of tourism in Belarus. Thereafter, subchapters have the following sequence: "Natural Resource Potential and Trends in Tourism Development"; "Cultural and Historical Potential"; "Touristic Infrastructure and Level of Regional Development"; "Tourist Flows and Types of Tourism"; "Dynamics of Visitors and Organized International Tourist Flows"; "Tourist Flows in Accommodation Facilities and the Regional Intensity of the Tourist Development"; "The Main Forms and Types of Tourism; Tourist Regions of Belarus".

The following chapters about the analysed countries basically follow the same sequence. However, the titles and topics of the subchapters are not the same for every country, which I find a bit confusing.

The chapter is written from a professional point of view and in a very detailed, accurate and comprehensive way. It is also illustrated with numerous photos and figures, which are excellent in both quality and content. My only concern with the text is related to language quality at some points and that the latest statistical data are from 2014.

Chapter 3 from Robert Wiluś (University of Łódź) discusses the "Geography of Tourism in Bulgaria". This chapter is also carefully written, detailed, and very precise, and is illustrated with photos and precisely edited figures. The latest data are from 2015, which is excellent, since usually we can find 2-year-old data in general and national tourism statistics. Language quality, from my point of view, is very good.

In Chapter 4, Armina Kapusta and Robert Wiluś (University of Łódź) investigate the "Geography of Tourism in Croatia". This chapter is well focused and elaborated and provides at many points the most recent data possible (2015), although a lot of 2014 data can also be found in the second part. Language quality from my point of view is excellent.

Chapter 5 was written by Jiří Vystoupil and Martin Šauer (Masaryk University, Brno) about the "Geography of Tourism in the Czech Republic". The outstanding and acknowledged authors provide a much detailed, punctual and relevant analysis and describe the tourism geography of the Czech Republic in its complexity. Their chapter employs high quality photos as well as detailed figures and maps. Language quality is excellent. My only concern is that some of the data are from 2013, so they are not up-to-date.

Katalin Formádi, Péter Mayer and Erzsébet Pénzes (University of Pannonia, Veszprém, Hungary) investigate the "Geography of Tourism in Hungary" in Chapter 6. Their paper provides a thorough description of the topic, but I have some concerns about the content. The use of geographical names is improper at some points (for example, the authors use "Little Plain" for Kisalföld and "Northern Mountains" for the North Hungarian Mountains) (pp. 193). I also wonder why such terms like "Hungarian Mountain Range" and "Limestone Mountains" (pp. 193) are in capitals when not used as proper nouns. In my view the overall language quality of the text is not sufficient enough. Some subchapters lack any reference to academic works, they only employ tables and photos. As my greatest concern, the chapter predominantly uses data from 2010, whereas some of the data are from as early as 2007 and 2008, without any reference to more up-to-date statistics. (Examples for that are Table 6.1, 6.2 as well as Figure 6.3, 6.4 and 6.6; for the last one, there is no data source added, either). For statistical data, only the last subchapters have been revised for the second edition, employing 2016 data in the sections "Seasonality" and "Main Forms and Types of Tourism". Some figures have a poor quality, whereas some sentences refer to data from 2010 and then to a figure presenting the case of 2016 (p. 214).

In Chapter 7, Algirdas Stanaitis and Saulius Stanaitis (Vilnius Pedagogical University) analyse "Lithuanian Tourism Geography". This is a relatively well written chapter giving a comprehensive overview of the tourism geography of the country, although I also found some critical areas. Basically all the figures of the chapter are supplied without sources. Tables are often not provided with the year of the data. The chapter deals with 2014 data which again could have been 2015. Subchapters from 7.5.2 to 7.5.11 (characterisation of the most important tourism products of the country) have no sources or references. And finally, subchapter 7.5.2 is entitled 'Rural (Ecological) Tourism – A Promising Branch of Trade'. (I do not understand the subtitle, why 'trade' is used here.)

Chapter 8 investigates the "Geography of Tourism of Poland". The authors, Magdalena Duda-Seifert, Krzysztof Widawski and Jerzy Wyrzykowski (University of Wrocław and the University of Business in Wrocław) give an in-depth introduction to the history of tourism geography as discipline in Poland. They highlight some information by putting them in italics or bold. It is a pity that this editing technique was used only occasionally in other parts of the book. The text is very detailed and covers all the important aspects of the geography of tourism in Poland. As minor weaknesses, Figure 8.1 and 8.2 lack reference to data source, and some tables (Table 8.3 and 8.7) rely on data from 2008 and 2009. I find interesting that Polish academic literature on tourism uses the phrase "qualified tourism" for touristic activities that "require[s] having proper equipment and skills. It is an important and very accessible form of active leisure" (klasterturystyczny.pl). I have found this phrase only in Polish language literature.

Chapter 9 was written by Alexandru Ilieş, Dorina Camelia Ilieş, Corina Tătar and Marin Ilieş (University of Oradea, Romania) about the "Geography of Tourism in Romania". Their paper gives a complex and detailed description about the country. Yet, unfortunately, most of the data are from 2014 or even 2012, which suggests that the chapter had not been revised properly for the 2017 edition. It is a pity that there is no reference to the cultural heritage and the touristic aspects of the minorities in Romania. Sometimes we can read about "ethnographic events" (p. 352), but without any further specific information. Some figures (maps) are stretched horizontally in the text (e.g. Fig. 9.18 and 9.19). Terminology is unclear at some points, presumably for the lack of proofreading. I also miss some academic authors from the Hungarian minority in Romania, who deal with the country's tourism geography (e.g. István Dombay, Alpár Horváth, Zsolt Magyari-Sáska).

Chapter 10 was written by Victoria Pogodina and Anna Matveevskaya (University of Economics and Management, St. Petersburg), who deal with the "Geography of Tourism of the European Part of Russia". My opinion about this chapter is basically the same as about the earlier ones. The description, analysis and content are excellent, since the authors as local scientists have a very solid knowledge about the regional tourism geography of Russia. Still, the authors use some phrases (e.g. "entry and exit tourist flows" (p. 380) and "popular types of tourism" (p. 387)) which are not used in English language academic literature on tourism. Both the text and figures are based on data up to 2010, sometimes 2011, which is not up-to-date.

Peter Čuka (Pedagogical University in Cracow, Poland) is the author of Chapter 11 on the "Geography of Tourism of Slovakia". To this chapter an erratum was added at the end of the book, which clarifies some personal data of the author including his affiliation. In my view, the title of the subchapter "Cultural and Historical Preconditions for Tourism" does not exactly match the content, several important aspects and areas are missing (including historical background, the role of the Hungarian minority, the importance of towns beyond Bratislava and Košice). I have to emphasise, however, that these topics are discussed to some extent in other parts of the chapter. Some information is written in bold which technique is generally not used in the book, and some data are a bit outdated (for instance, the analysis at the beginning of the chapter is based on statistics from 2009).

Chapter 12 was written by Dejan Cigale and Anton Gosar (University of Ljubljana and University of Primorska). This chapter about the "Geography of Tourism of Slovenia" has excellent language, and the description and analysis of the tourism geography of Slovenia are outstanding. Yet, some legends are hard to figure out, and some figures are employed without reference to data source. The title at Table 12.4 consists data up to 2008 but the table uses data until 2014. Unfortunately, Tables 12.2, 12.3 and 12.7 present 2008 data only. In general, the latest data used was from 2014, maybe it could have been 2015.

Chapter 13 was written by Viktoriya Kiptenko, Olga Lyubitseva, Marta Malska, Mykhajlo Rutynskiy, Yuriy Zan'ko and Jurij Zinko (Ivan Franko National University of L'viv, Ukraine) about the "Geography of Tourism of Ukraine". Semantics and grammar as well as the use of academic terminology are excellent, even if some minor mistakes can be found at Fig. 13.1 and Table 13.1 to Table 13.7 (no information about source). The most up-to-date data in the text are from 2014. Unfortunately, there is no information about the national minorities in Ukraine and their impact on tourism.

My overall impression about the book is that it definitely fills a void in the regional tourism geography literature due to its focus on Central and Eastern European countries. Such a comprehensive work, however, should pay more attention to adopting the same structure in every chapter, meeting high standards of academic language, and employing the most recent data possible.

János Csapó[1]

REFERENCES

Hall, C.M. and Page, S.J. 2014. *The Geography of Tourism and Recreation: Environment, Place and Space* 4th edition. Abingdon–New York, Routledge.

http://www.klasterturystyczny.pl/. Klaster Marek Turystyczny Polski Wschodniej. http://www.klasterturystyczny.pl/en/wybrane-uslugi-firm-klastra-turystycznego/qualified-tourism,2.html. Accessed: 09.02.2018.

Lew, A., Hall, C.M. and Timothy, D.J. 2008. *World Geography of Travel and Tourism: A Regional Approach.* Oxford, Elsevier.

Lew, A.A., Hall, C.M. and Timothy, D.J. 2011. *World Regional Geography: Human Mobilities, Tourism Destinations, Sustainable Environments.* 2nd edition. Dubuque, Kendall Hunt.

Nelson, V. 2017. *An Introduction to the Geography of Tourism.* 2nd edition. Lanham, Rowman & Littlefield.

Robinson, H. 1976. *A Geography of Tourism*. Plymouth, MacDonald and Evans.

Williams, S. 1998. *Tourism Geography.* London–New York, Routledge.

Williams, S. 2009. *Tourism Geography: A New Synthesis.* 2nd edition. Abingdon–New York, Routledge.

http://www.springer.com/us/book/9783319422039. Accessed: 09.02.2018.

[1] Institute of Marketing and Tourism, Faculty of Buiness and Economics, University of Pécs, Pécs, Hungary. E-mail: csapo.janos@ktk.pte.hu

CHRONICLE

In memoriam Peter Meusburger (1942–2017)

A few days before the Christmas of 2017 a sad news shocked the international community of geographers. Peter Meusburger, a distinguished senior professor at Heidelberg University in Germany, passed away on the 18th of December at the age of 75 to a tragic illness he had dealt with dignity. With his death the Hungarian community of geographers lost its eminent supporter, the Hungarian Geographical Society its honorary member, Eötvös Loránd University in Budapest its honorary doctor, and our journal its advisory board member.

Peter Meusburger was born on 14th March 1942 in Lustenau, Austria, a small town in the federal state of Vorarlberg, on the border of Switzerland. He started his school-years in his hometown before attending the secondary grammar school in Bregenz. After one year of mandatory military service he went to the University of Innsbruck, where he studied Geography and English. In the first years, the focus of his academic interest was the human geography of his homeland. He investigated the Vorarlberg cross border commuters in his PhD thesis, which he defended in 1968 with distinction. While keeping his commitment to science and working at the university as lecturer, his interest soon turned to the geography of education, which he began to scrutinise on the basis of a comprehensive survey of the Ministry of Education and Culture in Austria. This field of research became the central topic of his habilitation thesis in 1980, and also of his whole scientific work in the coming decades.

In 1982 Peter Meusburger was invited to Heidelberg University, where he received a professorship and was now responsible for managing the Institute of Geography. The new context and tasks soon revealed his outstanding capacity of organising science and creating innovative frameworks for scholarly work. He established the education geography specialty group of the German Society of Geography ("Deutsche Gesellschaft für Geographie, Arbeitskreis Bildungsgeographie") in 1983, and launched the Heidelberg Geographical Society as founding president two years later. Over the next decades he took considerable part of steering the institute, the faculty and also the whole university, the "Ruperto Carola", as vice dean, dean, vice rector (1991–1993) and elected member of the Senate of the university (1999–2006).

Peter Meusburger made truly pioneering work in the renewal of German language geography and the improvement of its international network. His efforts were motivated not only by the experience he gained as guest lecturer and researcher in Oxford (1977), Paris (1979), Tokyo (1981), Beijing (1987) and Budapest (1988), but especially by his stay at Clark University (Worcester, USA) in 1993–1994, which regularly hosted leading scholars of the field for lectures and roundtable talks. In 1997, Peter Meusburger launched the Hettner Lectures, a series of ten events until 2006, for which they invited leading personalities of Anglophone human geography to Heidelberg. In addition to regular lectures, roundtable talks and informal discussions were inherent parts of these events, enabling young scholars and students to exchange ideas with great names of the field. In 2006 he initiated a new project, the "Knowledge and Space Symposia", where outstanding experts making research on knowledge have been brought together from various countries and diverse academic fields in order to promote interdisciplinary academic communication. So far 15 symposia have been held in Heidelberg.

Beyond organising innovative scientific events, Peter Meusburger made a great contribution to scientific work by opening up new domains of academic publishing and elaborating new publication forms. His seminal work on geography of education ("Bildungsgeographie", Spektrum Verlag, 1998) set the framework for a whole discipline, and the volumes of "Hettner Lectures" and "Knowledge and Space" became nodal points in the international landscape of scientific publications on geographies of knowledge. He was the main initiator and coordinator of the "Wissenschaftsatlas of Heidelberg University" (Verlag Bibliotheca Palatina, 2012, with German and Spanish editions in 2011 and 2014), which established a novel and truly geographical genre in the global research of education and knowledge.

The importance of these achievements is clearly reflected by the numerous prizes and awards Peter Meusburger received, including the Presidential Achievement Award of the American Association of Geographers in 2010 and several prizes in Germany and Austria. Several international journals and scientific funds, including the Alexander von Humboldt Foundation and the German Research Foundation (DFG), and the council of the town of Heidelberg regularly relied on his advice and evaluations.

It is of utmost importance from the point of view of Hungarian geography that Peter Meusburger played a distinctive role from the 1980s onwards in fostering academic cooperation between German and Hungarian speaking geographers, which significantly contributed to the internationalisation of Hungarian geography in general. He regularly held lectures at academic events in Hungary, and brought hundreds of students to Hungary on his field trips. He gave the opportunity to a lot of Hungarian scholars to attend scientific visits, research projects and graduate studies in Heidelberg, and to publish internationally. At Heidelberg University he served for more than ten years (1998–2009) as the rector's representative for the partnership with Eötvös Loránd University.

Over these decades he played an eminent role in disseminating geographical knowledge about Hungary in the international scientific domain. He published, both on his own and with German as well as Hungarian colleagues together, a number of works on the human geography of Hungary, including the volume "Transformations in Hungary" (Physica Verlag, 2001), which he co-edited with Heike Jöns. He and his colleagues were the first to describe and explain several trends of Hungary's geography of labour and knowledge based on Hungarian census data from 1980 and 1990. He also was advisory board member of our journal. As an admiration for his outstanding efforts he was elected honorary member of the Hungarian Geographical Society and honorary doctor of Eötvös Loránd University in 2010, and received the Lóczy Lajos Prize, the highest rank award of the society, in 2015.

In addition to his diverse and invaluable academic achievements, it was his humane attitude, open-minded character and legendary helpfulness that became the true hallmark of Peter Meusburger in the eyes of his colleagues and disciples, including the 164 master students and 27 PhD students he supervised, many of whom are prominent geographers now in various countries. Professor Meusburger, as we commonly called him in Hungary, belonged to those few scholars who, instead of "producing" "academic labour force", created human communities and helped individuals in finding their own way as well as viable forms of cooperation with other people. He often mentioned that it is people who are doing science. Many of us will never forget how he asked us to inform him about the exact time of our arrival in Heidelberg, so that he can take us by car from the railway station. The many times he not simply replied amazingly quickly to our e-mails in which we sent a new manuscript or asked him for a supporting letter, but sent back a long list of wonderfully nuanced comments or a remarkably detailed recommendation along with some warm encouragement, as if all this generous support had been just natural. We will also remember the feeling we had so many times, that he paid special attention to all of us.

The scholarly work of Peter Meusburger was always permeated by honest curiosity, cheerfulness, and a fine sense of humour in the best Austrian traditions. He loved to point out by employing simple everyday examples the weaknesses and unrealistic features of self-important scientific concepts, or to reveal, with a content smile on his face, some erroneous assumptions behind widely accepted and taken for granted theories by presenting well elaborated results of in-depth studies. The impressive combination of purposefulness and peaceful harmony, a precise sense of reality and cheerful optimism, which were so unique to his personality, radiated from him to those in his environment. It was simply fun to be and work with him. The following sentence of him vividly lives in my mind: "Thanks God, nothing happens the way one plans." This special wisdom, so characteristic to him, always made him see, instead of problems, enemies and hopelessness, wonderful new opportunities to learn, think, and work together with others.

The memorial service of Peter Meusburger took place in Heidelberg on 12th January 2018. We lost an excellent, internationally renowned scholar, a devoted supporter of Hungarian geography, and, what is even more important, an extraordinarily great person with him. We will keep him in our memories and strive to forward to others all what he gave us.

Ferenc Gyuris

Manuscript reviewers

2015–2017

The editors of the Hungarian Geographical Bulletin would like to thank the following people who have offered their assistance in reviewing manuscript submissions to our journal issues between Number 1 in 2015 and Number 4 in 2017. Their efforts and useful comments have been of great service for the authors and the journal.

BAŃSKI, Jerzy (Warsaw)
BLAŽEK, Jiří (Prague)
BOLT, Gideon (Utrecht)
BOROS, Lajos (Szeged)
BOTTLIK, Zsolt (Budapest)
BREUER, Hajnalka (Budapest)
CENTERI, Csaba (Gödöllő)
DOBROVOLNÝ, Petr (Brno)
FARKAS, György (Budapest)
GÁL, Tamás (Szeged)
GUSTAFSSON, Harald (Lund)
GYÖNGYÖSI, András Zénó (Budapest)
GYŐRI, Róbert (Budapest)
HARDI, Tamás (Győr)
HENN, Sebastian (Jena)
ILLÉS, Sándor (Budapest)
IRIMIÁS, Anna (Budapest)
IUGA, Liliana (Budapest)
JAKAB, Gergely (Budapest)
JÁSZBERÉNYI, Melinda (Budapest)
JORDAN, Peter (Vienna)
KARÁCSONYI, Dávid (Budapest)
KOLOSSOV, Vladimir (Moscow)
KOVÁCS, Attila (Szeged)
KOVÁCS, Dezső (Gödöllő)
LANGER-RÉDEI, Mária (Budapest)
LÓCZY, Dénes (Pécs)
MADARÁSZ, Balázs (Budapest)
MÉSZÁROS, Róbert (Budapest)
MIGGELBRINK, Judith (Leipzig)
MIKA, János (Eger)
MIKA, Mirosław (Kraków)
MILOŠEVIĆ, Dragan (Novi Sad)
NAGY, Egon (Cluj-Napoca)
NAGY, Erika (Békéscsaba)
PÁSZTOR, László (Budapest)
POGONYI, Szabolcs (Budapest)
PROBÁLD, Ferenc (Budapest)
PRZYBYLSKA, Lucyna (Gdańsk)
RAJKAI, Kálmán (Budapest)
RYDER, Andrew (Portsmouth)
SAVIĆ, Stevan (Novi Sad)
SCOTT, James (Joensuu)
SISÁK, István (Keszthely)
SIWEK, Tadeusz (Ostrava)
SKARBIT, Nóra (Szeged)
SOLARZ, Marcin Wojciech (Warsaw)
ŠTRBA, L’ubomír (Košice)
SÜLI-ZAKAR, István † (Debrecen)
SZABÓ, József (Debrecen)
SZABÓ, Judit Alexandra (Budapest)
SZABÓ, Szilárd (Debrecen)
SZALAI, Zoltán (Budapest)
SZATMÁRI, Gábor (Budapest)
TÁTRAI, Patrik (Budapest)
TÓTH, Adrienn (Budapest)
TÓTH, Géza (Budapest)
TÓTH, Tibor (Budapest)
UNGER, János (Szeged)
UZZOLI, Annamária (Budapest)
VAINIKKA, Joni (Oulu)
VAN DER WUSTEN, Herman (Amsterdam)
VÁRADI, Zsuzsanna (Budapest)
VARGA, György (Budapest)

GUIDELINES FOR AUTHORS

Hungarian Geographical Bulletin (formerly Földrajzi Értesítő) is a double-blind peer-reviewed English-language quarterly journal publishing open access **original scientific works** in the field of physical and human geography, methodology and analyses in geography, GIS, environmental assessment, regional studies, geographical research in Hungary and Central Europe. In the regular and special issues also discussion papers, chronicles and book reviews can be published.

Manuscript requirements

We accept most word processing formats, but MSWord files are preferred. Submissions should be single spaced and use 12pt font, and any track changes must be removed. The paper completed with abstract, keywords, text, figures, tables and references should not exceed **6,000 words**.

The Cover Page of the article should only include the following information: title; author names; a footnote with the affiliations, postal and e-mail addresses of the authors in the correct order; a list of 4 to 8 keywords; any acknowledgements.

An abstract of up to **300 words** must be included in the submitted manuscript. It should state briefly and clearly the purpose and setting of the research, methodological backgrounds, the principal findings and major conclusions.

Figures and tables

Submit each illustration as a separate file. Figures and tables should be referred in the text. Numbering of figures and tables should be consecutively in accordance with their appearance in the text. Lettering and sizing of original artwork should be uniform. Convert the images to TIF or JPEG with an appropriate resolution: for colour or grayscale photographs or vector drawings (min. 300 dpi); bitmapped line drawings (min.1000 dpi); combinations bitmapped line/photographs (min. 500 dpi). Please do not supply files that are optimised for screen use (e.g., GIF, BMP, PICT, WPG). Size the illustrations close to the desired dimensions of the printed version. Be sparing in the use of tables and ensure that the data presented in tables do not duplicate results described elsewhere in the article.

REFERENCES

Please ensure that every reference cited in the text is also present in the reference list (and vice versa).

Reference style

Text: In the text refer to the author's name (small capitals with initials) and year of publication. References should be arranged first chronologically and then further sorted alphabetically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', placed after the year of publication.
Examples: (Ridgewell, A.J. 2002; Maher, B.A. *et al.* 2010) or Ridgewell, A.J. (2002); Maher, B.A. *et al.* (2010).

Journal papers:
Aagaard, T., Orford, J. and Murray, A.S. 2007. Environmental controls on coastal dune formation; Skallingen Spit, Denmark. *Geomorphology* 83. (1): 29–47.

Books:
Pye, K. 1987. *Aeolian Dust and Dust Deposits.* London, Academic Press.

Book chapters:
Kovács, J. and Varga, Gy. 2013. Loess. In *Encyclopedia of Natural Hazards.* Ed.: Bobrowsky, P., Frankfurt, Springer, 637–638.

Book reviews

Book reviews should be between 2,000 and 3,000 words (including references).

Submission

Submission to this journal occurs online. Please submit your article via http://ojs3.mtak.hu/index.php/hungeobull/about/submissions.

All correspondence, including notification of the Editor's decision and requests for revision, takes place by e-mail.