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From the Editors

Hungarian specialists traditionally address significant events organized by the international community of geographers with the publication of English-language collections of scientific contributions. Most of them were published in the series Studies in Geography in Hungary, such as the one dedicated to the 31st International Geographical Congress held in Tunis in 2008. Our journal welcomed the last but one congress in the row (Glasgow, 2004) similar to the present occasion which is an issue of the renewed Hungarian Geographical Bulletin (HGB) to commemorate the IGU Regional Conference to be organized in Tel Aviv, Israel, July 12–16. 2010 with a central theme *Bridging diversity in a globalizing world*.

Of 20 years of the democratic transition to market economy in Hungary heretofore, 10 were spent by this country as a member of NATO and more than 5 years in the framework of the European Union. During this period geography has experienced a profound transformation. So to say the subject found itself in a new environment, in spatial and temporal, economic and technological, financial and philosophical terms alike.

Geography in Hungary has long been labelled as a "national" academic discipline. It means that most of the topics in a volume of studies (our journal should be considered such a periodical) are related to the geographical aspects of natural trends occurring and socio-economic phenomena and processes taking place in the country and to the resulting issues. Here they will be represented e.g. by migration, viability of enterprises and EU regions, sustainable agriculture. At the same time these circumstances are affected increasingly by major international trends of various scales: globalization, European integration, transboundary cooperation.

The studies abound in facts and figures about Hungary: foreign readers can get acquainted with the territorial distribution of the top 500 industrial enterprises providing 85% of GDP and to learn about their concentration in the central region (more than three hundred of them was found here in 2009) and in the western part of the country as a result of restructuring. Economic potential of NUTS2 regions was examined through the occurrence and profile of, revenues and profit generated by these leading firms (author: Tibor Tiner). Spatial mobility was the topic of the contribution by Géza Tóth and Áron Kincses who traced regional distribution of immigrants that arrived in the third millennium. The number of foreigners at extended stay has been over 170 thousand recently making up nearly 2% of the resident population of Hungary and having grown by more than 60% over seven years. A general trend has reversed as Hungary turned from a sender country into a target one: about two hundred thousand people left the country after the revolution of 1956 and even more "remained in the West" during the subsequent thirty years of socialist regime. The starting point of an essay by Gábor Michalkó and Tamara Rátz was that Hungary owes much of its attraction to thermal waters, a prominent natural treasure. 51 settlements across the country have certified spas; the most important resort is Budapest with seven thermal baths. Hungarian spa destinations also appear on the domestic and international property market as second homes are being purchased by foreign citizens extensively in these resorts. István Pomázi and Elemér Szabó focused on European integration with description of the socio-economic and ecological situation within NUTS3 units that belong to seven countries of the Carpathian Convention, some of whom became EU member states recently, while others entered into partnership relations with the organization. The authors have come to the conclusion that structural change in most cases had brought depopulation, unemployment and poverty to inhabitants of mountain regions and the almost only positive shift was a dramatic drop in air and water pollution due to shrinking economic output by traditional sectors.

Some articles dealt with investigations rooted in physical geography. Ádám Kertész, Balázs Madarász, Béla Csepinszky and Szabolcs Benke reported about an experiment promoting sustainable agriculture, with the application of conservation tillage in winter wheat and maize cultivation on plots in Transdanubia in an area of more than 100 hectares. The SOWAP experiment resulted in reduced soil loss and improved water management on the conservation parcels basically with the same yields as on the conventional ones. Endre Dobos, Joël Daroussin and Luca Montanarella provided description of the physiography bloc of a global soil and terrain information system (SOTER). Thus an initially analogue procedure of soil mapping has turned into a DEM-based GIS building generated from Shuttle Radar Terrain Model which contains layers of hypsometry, slope conditions, relief intensity, and potential drainage density. Éva Kis and Ferenc Schweitzer studied a geological section on the south-eastern part of Tenerife, Canary Islands where loess-like deposits and sediments affected by pedogenesis were investigated using grain size parameters. Based on the parameter values this method is aimed to characterize these deposits and to identify the environmental conditions that prevailed during their formation.

Almost all the essays in the present issue of our bulletin have had expressed methodological connotations. A wide variety of methods were deployed, e.g. indices for revenue differences of enterprises such as range, Hoover-index involved in the regional comparisons (Tiner); thematic mapping (Michalkó and Rátz); path analysis and potential method (Tóth and Kincses) applied. Mathematical-statistical analysis figured in the essay by Pomázi and Szabó, observations and measurements formed the basis of the field experiment conducted by Kertész *et al.*, as remote sensing applications like interpretation of radar images did in the contribution by Dobos *et al.* Laboratory analyses of sediment samples led to the conclusions drawn by Kis and Schweitzer.

This volume of HGB, however, extended it was conceived could not provide a cross-section of Hungarian geography, but in some way it reflects the major trends in research activities.

Hungarian Geographical Bulletin 59 (2) (2010) pp. 89–106.

Far from the core – regions and industrial parks in economic shadow in Hungary[1]

Part one

Tibor Tiner[2]

Abstract

The economic development of NUTS2 regions in Hungary can be evaluated in different ways. It is their economic potential which is put in the focus of this paper. This potential can be measured by total revenues of leading companies operating on their territories in the first place, and then by number, profile and profit of these firms settled into industrial parks of the regions. The results of an analysis showing close correlation between their geographical position and success (or failure) in business might be used by the experts of the regional development agencies in decision making. This article is an attempt to evaluate the level of development of NUTS2 regions on the basic data for the leading 500 companies. The second part of the paper (Hung. Geogr. Bull. No 3. 2010) will deal with economic efficiency of top firms which are settled into industrial parks of less favoured regions. Analyses are going on the basis of financial and statistical indicators published by different institutions and firms (e.g. Central Statistical Office, Creditreform Ltd.) electronically or in printed version. The study also deals with a few regional effects of economic crisis burst in 2008.

Keywords: NUTS2 regions, revenues, regional inequalities, industrial parks

Introduction

To understand the problems the counties of Hungary chosen to be studied face nowadays it is necessary to give a brief survey about the economic environment of the country. After a relative prosperous 10 years' period (1995–2005) by 2006 Hungary's economic development slowed down and GDP growth remained below 4 per cent in that year. Fiscal consolidation has become the focus of economic policy. In 2007, the government's austerity program has

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decreased Hungary's large budget deficit, but the reforms have diminished domestic consumption, reducing GDP growth to less than 2 per cent.

The global financial crisis in 2008 hit Hungary's vulnerable economy extremely hard, with its large external debt, reliance on external financing and high level of foreign currency borrowing by its citizens, In this emergency situation the country was secured by heavy loans from the International Monetary Fund (IMF) and other financial institutions. The borrowing has helped to balance a large current account and state budget deficit, and resulted in a partially overvalued currency, supported a low stock of foreign reserve and secured a high level of short-term foreign currency debt.

Hungary's growth prospects are likely to improve beyond 2009, owing to the loan offered by the IMF and different European Union funds – EU subsidy of 22.4 billion EUR is available to Hungary until 2013 – and the country's traditional growth factors including relatively low wages and high skills of labour, advanced infrastructure and advantageous geographical position. According to experts' estimation the considerable volume of foreign direct investment (FDI) transfeHrred into Hungary may help to get over the crisis within 2–3 years. Its relative value exceeds the (weighed) average of Central East European (CEE) countries considerably *(Figure 1).*

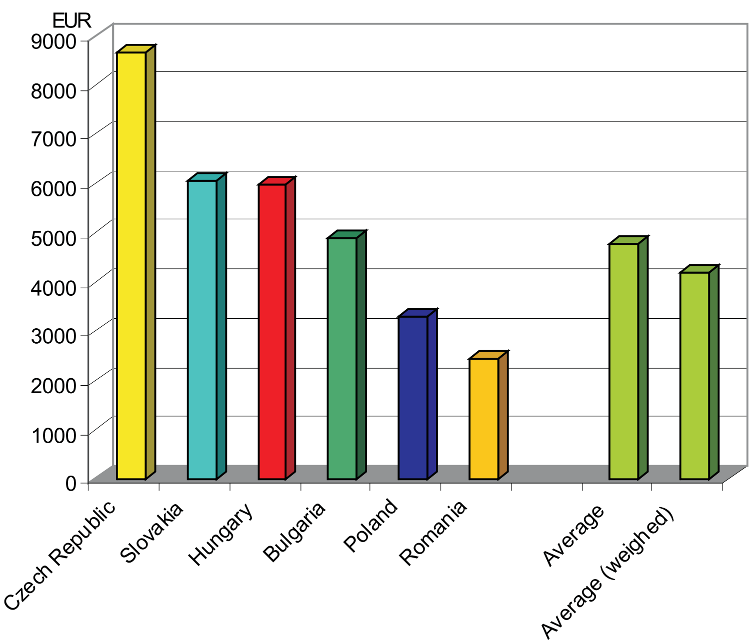

Fig. 1. FDI stock per capita in Central East European countries, 2009. *Source:* WIIW, 2010

Additionally it is worth mentioning that Hungarian economy is shifting towards a service profile, the rate of which from the GDP has reached 67 per cent in 2009. (Among the developed EU members this rate is over 70 per cent.) From year to year the ratio of large EU-projects serving the development of tertiary sector of the country increases steadily at the expense of projects in industrial development. The industrial/service projects ratio changed from 79:21 per cent (2004) to 57:43 per cent (2009) (ITD Hungary, 2010; Kukely, Gy. 2008).

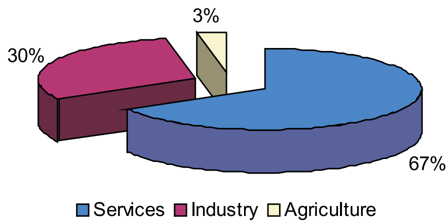

Fig. 2. GDP ratio per sector of economy in Hungary, 2009. *Source:* Hungarian Investment and Trade Development Agency, 2010

Attention should be drawn to the decreasing weight of agriculture within the country’s economy (*Figure 2*). Being one of the key factors of rural economy in Hungary, declining incomes from farming activities have led to serious problems not only for farmers but for all larger companies investing into agriculture production and food industry.

According to latest forecasts Hungary's industrial and trade data are improving as the country's export market recover, but the construction sector, retail and unemployment data is expected to deteriorate, GKI Co. (Economic Research Company, Budapest) claimed in a projection prepared together with Erste Bank. Following a contraction in 2009 the institute anticipates Hungary's economy to stagnate in 2010 as external demand picks up, European Union funding boosts investments, sentiment among the country's economic players improves and businesses start restocking inventories (GKI 2010).

The topic of the paper requires to answer some questions. Which regions may be considered developed or underdeveloped in Hungary? Whether the gap between developed and less developed regions is narrowing or widening? Whether a county being part of a developed region and situated relatively far from the dynamically developing core of the NUTS2 region it is incorporated within (e.g. Zala County in Western Transdanubia) can be regarded a stagnating or declining administrative segment of Hungarian economy? The present research takes into consideration the results of studies on the regional transformation and structural changes of Hungarian industry in general, considering industrial parks as special elements (Kiss, E.É. 2001, 2003; Nikodémus, A. 2002; Horváth, K. 2007).

Problematic NUTS2 regions and the counties incorporated have a moderate dynamism of economic development. They are characterised mainly by processing industry, food industry and have agricultural character, which goes together with both personal income and rate of unemployment below the national average.

14 counties from six regions[3] were selected into this category. In spite of a large number of industrial parks with fairly good regional accessibility these counties have only few important industrial firms and service companies with large annual revenue and efficient production.

The facts mentioned above also pointed out that unfavourable position of the counties within these regions derives mainly from their weak economic structure and it is not due to transport logistical reasons. There is more evidence for the relative favourable transport logistic conditions of all regions of the country.

Hungary's strategic position in the heart of the continent – as well as its role as one of the major transport junctions in the Central East European region – makes it increasingly important as a regional distribution centre. Thanks to Hungary's relatively developed transport infrastructure and an established background in logistics (11 large logistical regions), companies settled close to main international transport corridors can benefit from outstanding efficiency and added value.

The latest World Bank Logistics Performance Index (LPI) ranked Hungary highest of the Central East European countries and the Baltic States in 2008. Creating a complex parameter of LPI the survey evaluates the logistics services of 150 countries according to factors including speed of customs clearance, transportation costs, average import transaction and export lead times *(Table 1)*.

Table 1. Ranking of CEE countries and the Baltic States according to Logistics Performance Index, 2008

Rank	Country	LPI	Customs	Infrastructure	International shipments	Logistic competence
1.	Hungary	3.15	3.00	3.12	3.07	3.06
2.	Czech Republic	3.13	2.95	3.00	3.05	3.00
3.	Poland	3.04	2.88	2.69	2.92	3.04
4.	Latvia	3.02	2.53	2.56	3.31	2.94
5.	Estonia	2.96	2.75	2.91	2.85	3.00
6.	Slovakia	2.92	2.61	2.68	3.09	3.02
7.	Romania	2.91	2.60	2.73	3.20	2.86
8.	Bulgaria	2.87	2.47	2.47	2.79	2.84
9.	Lithuania	2.78	2.64	2.30	3.00	2.70
10.	Croatia	2.71	2.36	2.50	2.69	2.83

Source: World Bank report on LPI, 2009

[3] Baranya, Somogy and Tolna countries in Southern Transdanubia Region; Veszprém County in Central Transdanubia Region; Vas and Zala counties in Western Transdanubia Region; Heves and Nógrád counties in Northern Hungary Region; Hajdú-Bihar, Jász-Nagykun-Szolnok and Szabolcs-Szatmár-Bereg countries in Northern Great Plain Region; and Bács-Kiskun, Békés and Csongrád counties in Southern Great Plain Region.

Database and methodology

The statistical basis of the investigation is the group of the leading 500 productive companies of Hungary (the top half of one thousand firms in industrial, agricultural and service sectors excluding banks and insurance companies) selected by their annual revenues and profit in HUF. They provide more than 85 per cent of total annual production value of Hungary, measured in HUF.

Their published data were analysed and compared to each other for the year of 2005 and 2009 firstly on a regional level, and secondly by counties (but only for the 14 counties mentioned above). In the third phase there will be analysed the activities of the relative small group of top 500 firms producing their products or services inside the industrial parks.

Simple mathematical and statistical methods are used in this empirical work to measure the most considerable regional and sub-regional inequalities and the level of concentration (Sikos T.T. ed. 1984; Nemes Nagy, J. ed. 2005) and their changes during the period 2005–2009.

The following indices[4] were calculated for the regions and the 14 counties:

- Range *(P)*
- Range ratio *(K)*
- Relative range *(Q)*
- Dual index *(D)*
- Hoover-index *(H)*
- Hirschman–Herfindahl-index (concentration index) *(C)*

For the purpose of calculation of *H* index the official data for labour statistics, i.e. the rate of economically active population of the regions were used for 2005 and 2009.

Economic features and transport position of NUTS2 regions in Hungary

Each of the seven NUTS2 regions of Hungary has specific features of economy which predestine their economic potential and the trends for the near future. This statement is also valid for the counties belonging to them.

Central Hungary (Budapest and Pest County) from the economic viewpoint can be characterized by its substantial contribution to GDP, a high concentration of businesses and the growing significance of financial and logistics services, as well as dynamic real estate development and attractivity to foreign investors (Kiss, E.É. 2000). The region is the country's most important transport

[4] For the content and explanation of these parameters see Nemes Nagy, J. ed. 2005.

node with the junction of 6 radial motorways of Hungary. The density of the trunk road network in the region exceeds the national average. Part of the high-quality railway network belongs to TEN corridor No. X running along the river Danube, making it deeply integrated into the Pan-European transport system. Budapest's Ferihegy Airport is an international air traffic hub with three terminals and high passenger traffic.

There are 35 industrial parks in Central Hungary (2009), mainly serving logistics companies but also offering excellent conditions for automotive and electronics manufacturers and innovative industrial companies. The proximity of the capital as a key factor is of great importance. The Infopark in Budapest serves similar R&D purposes as Technology Park Berlin-Adlershof in Germany (Kulke, E. 2008).

The local labour force has the professional qualifications required by multinationals in the service and commercial sectors, as well as sophisticated industries producing high added value (Brinszky-Hidas, Zs. 2003).

The region's key role is in education and research is also worth mentioning. More than a quarter of the country's secondary school students attend institutions in Central Hungary, while 27.9 per cent of those in higher education pursue their studies here. The region also has the largest capacity in Hungary for the education of economists and technical experts and 62.6 per cent of the country's scientific researchers and developers work here. Two thirds of the state R&D budget was invested in Central Hungary and the majority of the country's research centres are headquartered in Budapest (Mátyás, B. 2002).

Central Transdanubia (Fejér, Komárom-Esztergom and Veszprém counties) is located at the meeting point of two large European development zones. It is therefore directly affected by Europe's overall development and plays a key role in the country's in economic growth. The region has an excellent communications and transportation infrastructure and is intersected by important railways, public roads and motorways. Two Helsinki corridors, the M1, M6 and M7 motorways and pass through Central Transdanubia and the M8 is currently under construction.

Foreign direct investment received by Hungary over the past decade amounts to EUR 317.8 billion, of which 8.7 per cent arrived in Central Transdanubia. The region boasts among the highest industrial production per capita in the country. Tatabánya (seat of Komárom-Esztergom County) and its surroundings and Székesfehérvár (seat of Fejér County) showed a particularly dynamic growth between 1995 and 2006.

Top industries include the automotive industry (Suzuki, Rába Mór, AFL Hungary, Lear Corporation, Continental, Denso, Valeo, Visteon and Hankook Tire are all based in the region), electronics and information technology (Albacomp, IBM Data Storage, Nokia, Sanyo, Philips, Videoton, Foxconn and Sanmina SCI) and the aluminium industry (Inotal and Suoftec). Major companies also operate in mechanical engineering and steel (Dunaferr, Alcoa-Köfém and Le Belier), the food industry and chemicals. In addition, Ajka crystal and Herend china are brands recognised all over the world.

The region is bordered to the north and east by the international waterways of the River Danube, extending over 140 kms, but with few river harbours. There are also several minor, and some major, currently abandoned military airports in the three counties of the region, providing opportunities for large-scale expansion of air traffic and transportation. The region's infrastructural provision is above the national average and includes 32 industrial parks (Kovács, Z. 1998; Kiss, E.É. 2003).

Western Transdanubia (Győr-Moson-Sopron, Vas and Zala counties) is considered one of the most developed parts of the country mainly owing to the advanced economic structure of Győr-Moson-Sopron County in the north. Manufacturing, the service sector and agriculture appear to be developing at more or less the same rate, while the standard of living is also above the national average. The same applies to the proportion of inward investment in industry and the export orientation of the region's businesses.

Besides Central Hungary and Central Transdanubia this region also has high proportion of enterprises founded with foreign capital. The geographical and cultural proximity of Austria has resulted in close business ties in many areas, e.g. within the West/West Pannonia Euregion (i.e. with Burgenland).

Western Transdanubia is the most industrialized area of the country in terms of the employment of its population. Several multinational automotive and electronics companies have established operations here. Most profitable companies with advanced technologies accumulated in 27 industrial parks with the Győr (Raab) Industrial Parks as the flagship (Balogh, L. 2003; Fancsali, J. 2005; Mónus, Á. ed. 2007).

Several firms of the region have joined the Pannon Automotive Cluster established in 2000 and having 96 members all over the country. This cluster has provided an opportunity for local small and medium sized enterprises (SMEs) to become influential suppliers. In additional sectors of economy, this encourages the formation of product clusters, and the synergies thus created in turn have a beneficial effect on the development of the region.

The main industries in the region based on total employment are the machine industry, textiles and foods. Around 70 per cent of the workforce is distributed between these sectors. The economic development of the Western Transdanubia Region is above the national average and GDP per capita is the second highest in the country. The region’s economic structure is highly developed and ranks above its peers in terms of attracting foreign capital, the ratio of industrial investments and export orientation.

Southern Transdanubia, a region comprising three counties (Baranya, Tolna and Somogy), is situated in the south-west of the country. It has home to 953,000 people, making it the most sparsely populated region. Southern Transdanubia is considered to be Hungary's gateway to the south, and as such plays an important role in the country's foreign relations. Its links to Croatia and the Adriatic Sea offer a perspective on co-operation with southern and south-western countries. Today Southern Transdanubia is ranked sixth of the country's regions in terms of GDP per capita.

As many as 1,300 companies with foreign ownership have invested in Southern Transdanubia and the number of companies owned by Hungarians is rising steadily. This is partly thanks to the establishment of 19 industrial parks in the region so far, offering a host of communications services and supporting facilities for newly established businesses (Nyakacska, M. 1998; Csiba, Zs. and Pap, N. 2007).

The manufacturing sector is dominated by agriculture and food processing, energy production; tourism is also important. Some 8.6 per cent of the region's GDP derives from the agricultural sector. The region holds a prominent position on a national level in the production of maize and is one of the country's most important wine growing regions. The wines of Southern Transdanubia are famous all over Europe, but the high-tech sectors have also seen significant development, encouraged by a sophisticated technical infrastructure. Protecting the environment has always been a high priority in the region as illustrated by extensive reclamation following the closure of the coal mines – acknowledged all over in Central East Europe.

The regions main road arteries are the M6 and M60 motorways linking two county seats (Pécs and Szekszárd) to Budapest. The railway network is dense with Budapest–Gyékényes–Rijeka as the main international line. The region has a direct railway connection Pécs–Osijek and transfers to Vienna and Zagreb. There are four airports in the Southern Transdanubia, with the Pécs–Pogány Airport holding international status. The region also has a river port on the Danube at Mohács, opened to traffic in November 2008.

Northern Hungary (Borsod-Abaúj-Zemplén, Heves and Nógrád counties) has been a traditional industrial region of Hungary from the late 19th century. Its coal mining, metallurgy, heavy machinery production and chemical industry provided job for 2.5 million – mainly unskilled and low educated – people during the socialist era. After the regime change (1989–1990) restructuring of the region's economy started, but this positive process has slowed down after the turn of the millennium and now the region has to cope with more serious problems than those of Transdanubia. Northern Hungary which borders on Slovakia to the North comprises 28 industrial parks altogether, but only few of them accommodate prosperous companies (Lafferton, Gy. 2003; Kiss E.É. 2008). The M3 and M30 motorways link the region with Budapest.

County seats Miskolc and Eger can also be reached from the capital via Inter City rail services.

From its industrial heritage Borsod-Abaúj-Zemplén County maintains only the chemical industrial traditions up to this day (BorsodChem, Tisza Chemical Co). The economic structure of this county has changed dramatically with the arrival of several MNCs (Robert Bosch Power Tools, AES, Jabil Circuit, Continental Tobacco) producing goods for world market. In addition, several small and medium sized enterprises are growing strong and creating new jobs. However, significant workforce cuts still affect some branches of industry. As a consequence, the unemployment rate continues to be the highest in the country. On the other hand the county has an abundance in available skilled labour and their retraining and vocational training are subsidized by the government.

Heves county's economy has experienced dynamic and impressive growth in recent years, while its export-orientation has also intensified. The country's economic output is concentrated in three regions: The county seat Eger with its microregion contribute 48 per cent of total sales, while Gyöngyös and Hatvan with the surroundings provide an additional 40 per cent. The structure of the economy has undergone significant changes in recent times. The importance of the mining industry has declined, while that of the processing industry – primarily the machine industry, metal processing and the furniture, food, and textiles sectors – has increased.

The smallest county in North Hungary is Nógrád which belongs to the less favoured NUTS3 regions in Hungary against its proximity to Pest county and Budapest. It has moderate industrial and service production; only 4 industrial parks can be found on its territory. While the Hungarian capital experienced a labour shortage during the previous years, Nógrád county had human capital reserves.

The *Northern Great Plain* NUTS2 region (Hajdú-Bihar, Jász-Nagykun-Szolnok and Szabolcs-Szatmár-Bereg counties) borders on Ukraine and Romania, making it the eastern gateway of the European Union. The Northern Great Plain is accessible via the Debrecen International Airport, the M3 motorway and hourly Inter City train services from Budapest.

The region is traditionally a farming area with a strong history of agricultural and food industry related machine manufacturing. That means its economic potential is low and only the larger cities (mainly the county seats) are home to a number of major investors, such as Stadler (automotive, Szolnok), TEVA (pharmaceuticals, Debrecen), E.ON (energy supply, Debrecen) and Lego (toys, Nyíregyháza). In total, some 100,000 businesses operate in the region, but only few of them belong to the club of leading 500 companies of the country. There are 33 industrial parks in the region, but only 2 or 3 of them have a considerable economic importance (Kovács, T. 2001; Kiss-Majtényi, M. 2004; Percze, I.J. 2004).

The Northern Great Plain has long-standing traditions in the health and wellness industry, including spas and health resorts, excellent clinics and medical universities. It is hoped that these will be enriched by further biotechnology, organic food and herbal companies in the near future.

Southern Great Plain (Bács-Kiskun, Csongrád and Békés counties) borders on Serbia to the south and on Romania to the east. Its natural resources support both industry and agriculture. Meanwhile, its spas' waters of curative power, rare species of bird and gastronomic specialities make for an idyllic tourist destination.

Two Helsinki corridors (IV. and X/B) cross the region. The M5 motorway leads from Budapest to Szeged and the Serbian border directly. In the near future the a dual carriageway (M43) will run from Szeged to the Romanian border. The region has a public port on the Danube at Baja on the west and one on the River Tisza at Szeged. The region has twelve civil and one military airport.

Southern Great Plain has 32 industrial parks offering their services to investors. Besides them two enterprise zones have been created on the periphery of the region, one in Csongrád county (Makó and its sub-regional enterprise zone) and another one in Békés county (in the area of Sarkad and Szeghalom) (Osváth, S. ed. 2004; Papp, J. 2008).

The combined share of industry and construction in the economy is more or less similar to that of agriculture, for which the region is well suited. Meanwhile, the service sector accounts for ca 60 per cent of the region's economic performance. The exploitation of the considerable R&D potential accumulated in the research centres operating e.g. in biotechnology and software industries, has already begun to accelerate ongoing industrial restructuring in the region.

Creating national logistics centres to reinforce the importance of the region derived from its geographical location may have a similar impact. New activities, such as electronics and mechanical engineering, are taking over from the region's traditional industries: textiles, leather and shoe production. The food industry continues to play an important role with several key brands (Pick salami, Csaba sausage), have acquired an international reputation. Mechanical engineering and the chemicals industry are also strongly export-oriented. Some of the region's industrial products also account for a sizeable share of national production (e.g. crude oil, natural gas, china products, roofing tiles and glassware). Foreign companies that have made a significant contribution to the region's development include Phoenix-Mecano, Knorr-Bremse, Masterfoods, Contitech Rubber, Hunguard, Linamar, Tondach and Henkel.

Processes on the level of the NUTS2 regions

Observing the regional distribution of total volume of *annual revenues* for the leading 500 firms of the country, a highly distorted structure can be experienced both for 2005 and 2009. Back to 2005 Central Hungary Region concentrated 227 leading firms (55.4 per cent) which had increased to 303 in 2009 (60.6 per cent). This fact reflects not only its absolute dominancy among regions, but also means that this NUTS2 region accumulates nearly two thirds of the total annual revenue of the top 500 firms. Moreover, its share has increased from 16,681 bn HUF to 26,417 bn HUF (from 60.7 per cent to 63.5 per cent) between 2005 and 2009. Besides Central Hungary only Northern Great Plain region was able to increase its share with 1 per cent *(Figure 3)*.

The second 'richest' region Central Transdanubia had only 63 leading firms in 2005 which diminished to 54 (-15.7 per cent) in 2009, but the region nearly managed to preserve its share within the total annual revenue (2005: 15,4 per cent, 2009: 15,2 per cent). This process marks a considerable revenue concentration process among the leading firms of the region also (revenue per firm: 66.1 bn HUF in 2005 and 117.5 bn HUF in 2009).

Since the turn of the millennium Central Hungary and Central Transdanubia together have given more than 75 per cent of the total annual revenue of the top 500 companies. Between 2005 and 2009 this imbalanced rate had grown further (from 76.2 to 78,8 per cent), because the rest 5 regions together produced only a modest increase during the period investigated *(Figure 4)*.

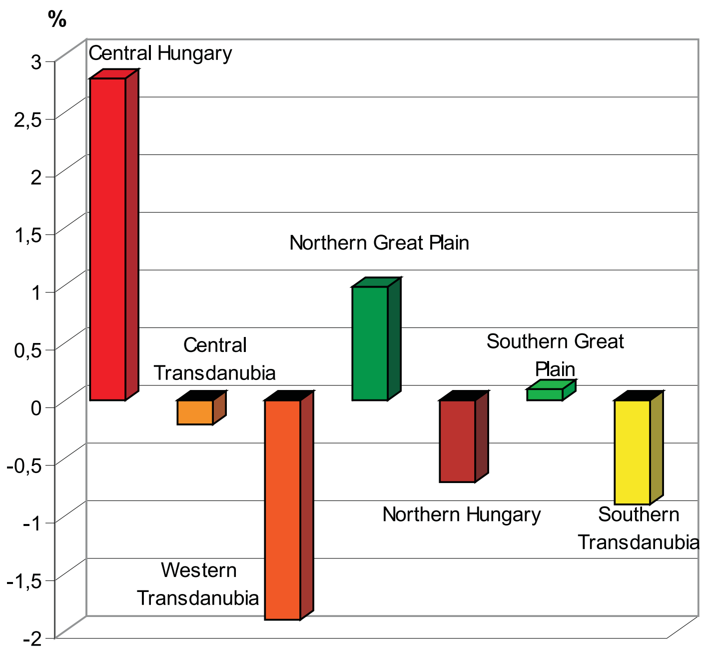

*Fig. 3.*The change of total annual revenues's rate by regions between 2005 and 2009

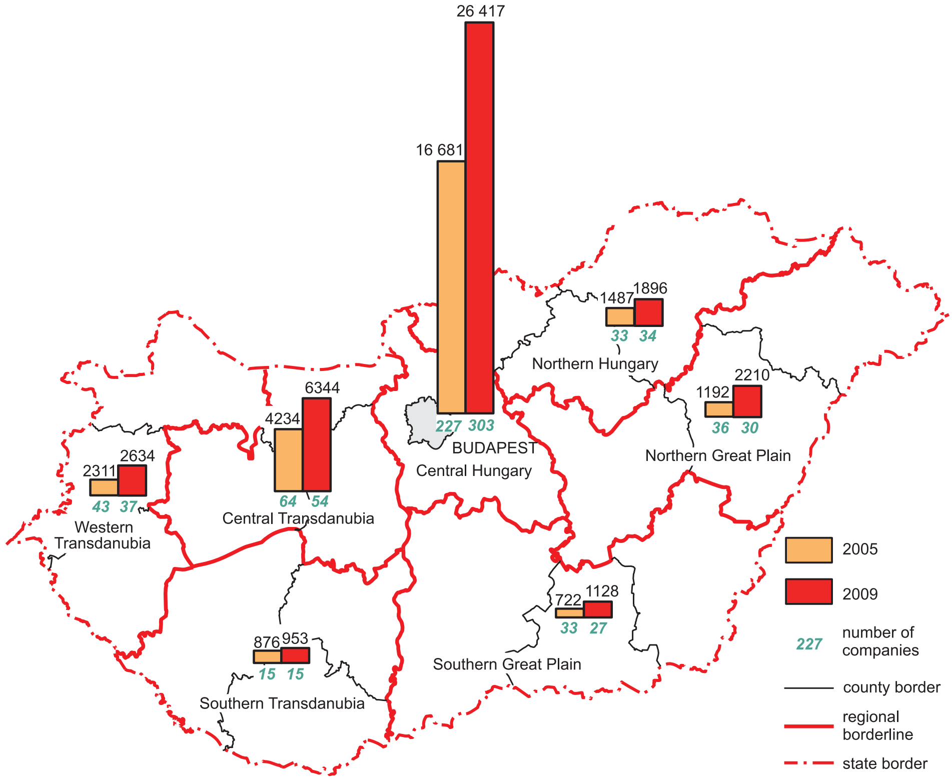

Fig. 4. Total annual revenue of leading 500 companies by NUTS2 regions in 2005 and 2009, bn HUF

The revenues of the two most developed regions demonstrate a considerable growth both in amounts and rate (2005–2009: 11,846 bn HUF or 56.6 per cent), opposite to the rest 5 regions (2005–2009: 2,110 bn HUF or 24.3 per cent), which marks 5.6 times difference in amounts and more than double growth in rate. Parallel to it the number of companies belonging to the top 500 companies has also changed in NUTS2 regions. Excluding Central Hungary a differentiated decrease could be observed in the value of this parameter in the rest of regions (*Table 2).*

Between 2005 and 2009 the relative annual revenue (revenue per company) has changed also in the regions, showing widening gaps between developed and lagging regions. But as for the rankings of this parameter Central Transdanubia has held the first place versus Central Hungary since 2005 *(Figure 5).*

Finally, calculating the indices showing the measure of regional inequalities for the leading 500 companies and its change, the results demon-

Table 2. Number of companies belonging to the top 500 by revenue (2005–2009)

Region	2005	2006	2007	2008	2009	Change 2009/2005	
						number	per cent
Central Hungary	265	277	286	292	303	+ 38	143.4
Central Transdanubia	63	65	62	56	54	- 9	85.7
Western Transdanubia	40	43	39	41	37	- 3	92.5
Southern Transdanubia	15	15	16	15	15	0	0.0
Northern Hungary	37	33	36	35	34	- 3	91.9
Northern Great Plain	34	36	33	36	30	- 4	88.2
Southern Great Plain	35	32	28	28	27	- 8	77.1

Source: Creditreform Ltd. 2006–2010

strate a general increase for all parameters *(Table 3)*. These figures forecast unfavourable tendencies and reflect inefficient efforts to diminish them up till now.

Table 3. Value of indices for revenue differences in NUTS2 regions

Index	2005	2009	Difference (+)
Range (P)	15.8050	25.4640	+ 9.6590
Range ratio (K)	19.0400	27.7200	+ 8.6800
Relative range (Q)	4.0250	4.2870	+ 0.2620
Dual index (D)	7.9610	9.2850	+ 1.3240
Hoover-index (H)	33.1500	34.3800	+ 1.2300
Hirschman–Herfindahl index(C)	0.4129	0.4377	+ 0.0248

Source: calculated by the author

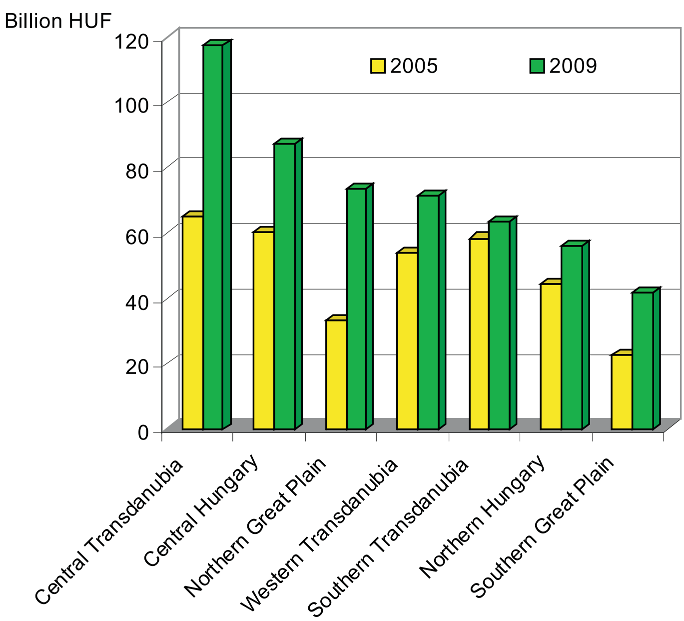

Fig. 5. Annual revenue per company by NUTS2 regions, bn HUF

Turning to the regional distribution of total volume of the *profit* for the firms investigated, the regional structure nearly goes to extremes. In 2005 Central Hungary has concentrated more than 70 per cent of the profit of the top 500 firms. Its profit share has increased from 1,585.9 bn HUF to 2,390.7 bn HUF (from 71.4 per cent to 77.8 per cent) between 2005 and 2009. 68 per cent of the total profit of the leading 500 firms has been generated at companies located in Budapest *(Figure 6).*

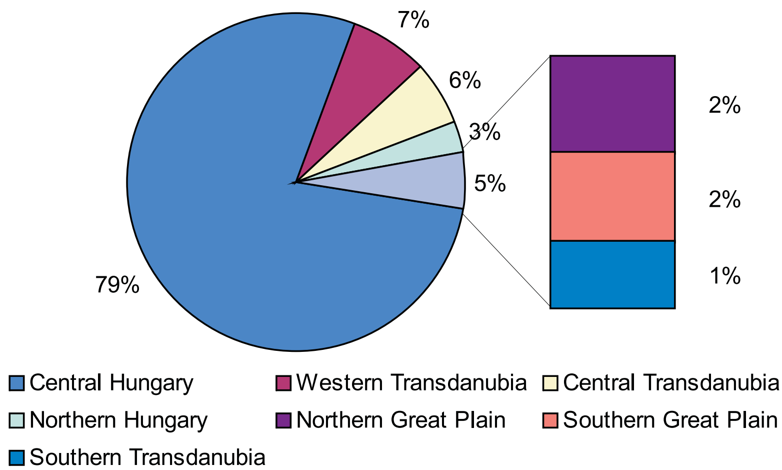

Fig. 6. The rate of total annual profit by regions in 2009

Comparing the change of revenues with that of profits in case of NUTS2 regions a highly negative tendency can be seen. Between 2005 and 2009 in case of profits of leading companies a serious decline or stagnation could be observed in all of the regions except Central Hungary. This process reflects heavy concentration of profit into Budapest and its agglomeration zone *(Figure 7).*

In 2009 Western Transdanubia was the second most profitable region (its favourable position was due to the economic efficiency of firms concentrated in the Győr Industrial Park). The region has nearly reached 230 bn HUF profit opposite to its main competitor Central Transdanubia, ranking third. In 2005 the aggregate profit of leading firms in Central Transdanubia still exceeded that in Western Transdanubia (161.8 bn HUF).

Since 2005 three NUTS2 regions (Central Hungary, Western and Central Transdanubia) together give ca 90 per cent of the total profit of the top 500 companies in Hungary. Between 2005 and 2009 this very high rate had increased further (from 89.1 to 91.2 per cent), because the rest four regions together produced only a very low increase of profit (from 242.1 bn HUF to 270.6 bn HUF) during the period investigated *(Figure 8).*

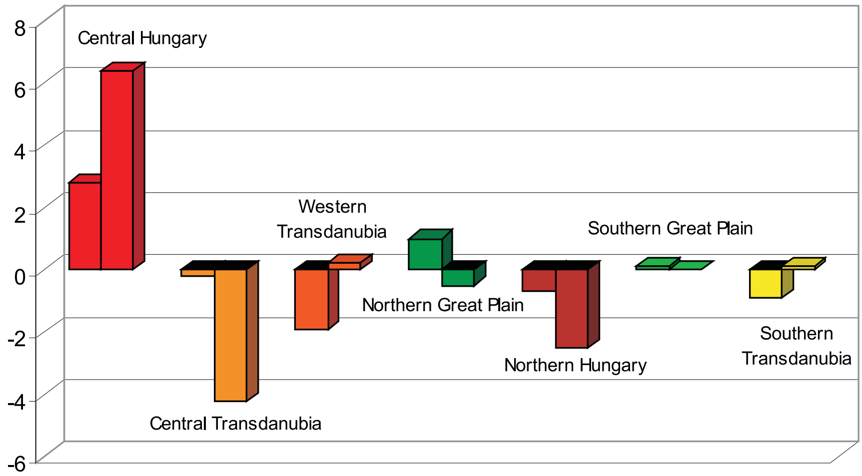

Fig. 7. Change in total annual profit's rate by regions in 2009 (right side columns) compared to its shares in 2005 and to the change of total annual revenue's rate (left side columns)

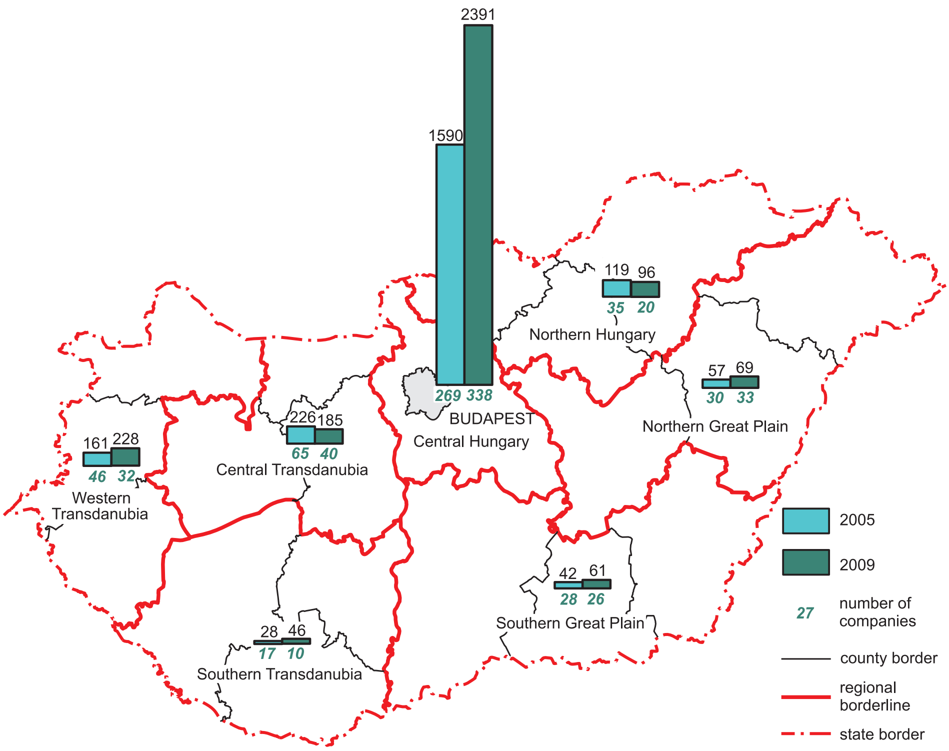

Fig. 8. Total annual profit of leading 500 companies by NUTS2 regions between 2005 and 2009, bn HUF

The profit increase of Central Hungary (801 bn HUF between 2005 and 2009) demonstrates a heavy concentration process, opposite to the rest six regions, where the profits of the market leaders showed a very modest growth (52 bn HUF) for the same period. Parallel to it the majority of NUTS2 regions show dramatic fall in the number of companies belonging to the top 500 ones by profit (*Table 4*).

Table 4. Number of companies belonging to the top 500 by profit (2005–2009)

Region	2005	2006	2007	2008	2009	Change 2009/2005	
						number	per cent
Central Hungary	269	275	289	326	338	+ 69	125.7
Central Transdanubia	69	68	68	47	41	- 28	59.4
Western Transdanubia	45	47	46	35	32	- 13	71.1
Southern Transdanubia	22	17	12	8	10	- 12	45.5
Northern Hungary	38	35	34	29	20	- 18	52.6
Northern Great Plain	29	30	26	32	33	+ 4	113.8
Southern Great Plain	28	28	25	23	26	- 2	92.9

Source: Creditreform Ltd. 2006–2010

The three leading regions have experienced growth and fall in amounts of profit while preserving their leading position over the regions situated in the rest of the country.

Between 2005 and 2009 the relative annual profit (profit per company) has changed also in the regions, showing a wide gap between developed and lagging regions. But as for the rankings of this parameter Western Transdanubia has got the leading position from Central Hungary since 2005 *(Figure 9).*

Calculating the indices showing the measure of measure of regional inequalities in the profit of the top 500 Hungarian firms, and its change the results demonstrate a considerable increase in *P, D, H* and *C* indices, a minor decline in *K*-index and a minimal decrease in *Q* index *(Table 5)*.

Table 5. Value of indices for profit differences in NUTS2 regions

Index	2005	2009	Difference
Range (P)	2.1970	3.0310	+ 0.8340
Range ratio (K)	73.0700	63.3400	- 10.7300
Relative range (Q)	6.9110	6.8920	- 0.0190
Dual index (D)	15.0170	20.8840	+ 5.8670
Hoover-index (H)	39.8000	46.6000	+ 6.8000
Hirschman–Herfindahl index (C)	0.5283	0.6146	+ 0.0863

Source: calculated by the author

These figures – similar to the annual revenue data – reflect negative tendencies (except K-index) and the stabilization of a distorted regional structure of profit distribution.

To be continued

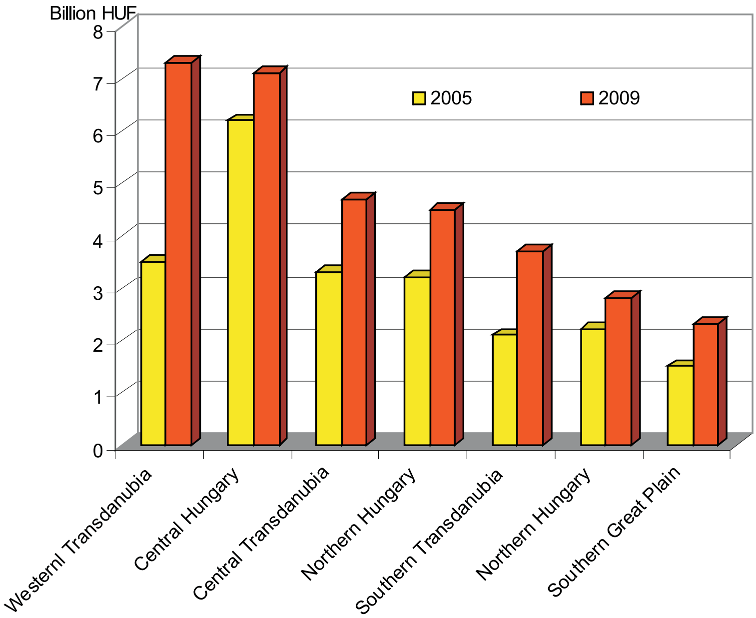

Fig. 9. Annual profit per company by NUTS2 regions, bn HUF

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Regional distribution of immigrants in Hungary[1]

Géza Tóth[2] and Áron Kincses[3]

Abstract

The purpose of this study is to analyse the territorial characteristics of foreign nationals those having migrated to Hungary. It is aimed to explore the triggers of choice of usual plan of residence and the differences by citizenship. Interrelationship between the proportion of migrants having resided in a particular area and the access by public road to it will be investigated with the help of path analysis. Firstly comparative studies on the geographical distribution of immigrants and that of former international migrants already settled in the country are to be conducted. Secondly the spatial disparities in the distribution of immigrants at micro-regional level will be identified by the potential method.

Keywords: immigrants, regional distribution, path analysis, potential method

Introduction

Since the regime change (1990) Hungary has had an international migration surplus, i.e. the number of foreigners having migrated to Hungary exceeded that of Hungarian citizens who left the country. Foreigners have become an ever increasing demographic factor in Hungary as natural population change has had a negative trend leading to an approximately 30–40 thousand population loss annually along with a concomitant positive migration balance of 10–20 thousand. On January 1 2008, 174,697 foreign citizens were on an extended stay in the country making up 1.74% of the resident population. It means that out of one hundred people almost two are foreigners. During the seven years following the turn of the millennium the ratio of foreigners increased by 61% on the national level (*Table 1*).

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Table 1. Summary data of Hungarian population

Year (January, 1)	Resident population	Foreign citizens staying in Hungary	
		Number	As a percentage of total population
2001	10,200,298	110,028	1.08
2002	10,174,853	116,429	1.14
2003	10,142,362	115,888	1.14
2004	10,116,742	130,109	1.29
2005	10,097,549	142,153	1.41
2006	10,076,581	154,430	1.53
2007	10,066,158	166,030	1.65
2008	10,045,401	174,697	1.74

Source: HCSO

Over seven years, foreigners increased in number by one-and-a-half times. Out of them, those who arrived from the countries of the Carpathian Basin (Austria, Slovakia, Ukraine, Romania, Serbia, Croatia and Slovenia) account for the majority, surpassing by 5 per cent those, who arrived from the rest of the world. Most of the former came from Romania, Ukraine and Serbia. Beside these groups a significant number of citizens of EU15 countries (mainly Germans and Austrians) live in Hungary. In the following the attention will be focused on the citizens of the neighbouring countries (*Table 2*).

Territorial distribution of foreigners

In 2001, 17% of Hungary's resident population lived in Budapest, 20% in county rank towns, 27% in other towns and 36% in villages. By 2008, in terms of proportion, those living in other towns increased up to 31% while the population of villages dropped down to 32% while there were no changes in the first two categories.

As far as foreign residents were regarded, Budapest was already strongly over-represented (35%) in 2001, which coincides with international trends, as capital cities are primary target destinations for migrants. This impact is showed in a more expressed way by those who arrived from outside the European continent (77% of Asians live in the capital city). Working-age people account for an even larger proportion when taking into consideration all towns, while in the villages the pensioners account for a bulk of migrants.

Over the analysed seven years, on the one hand, the pull force of Budapest strongly increased among foreigners (43%), concomitant with a decrease in the proportion of county rank towns, along with constant rates of smaller towns and villages.

Table 2. Foreign citizens staying in Hungary by citizenship (January 1)

Country	2001	2002	2003	2004	2005	2006	2007	2008
Austria	694	785	750	780	544	1,494	2,225	2,571
France	511	601	711	765	330	1,316	1,506	1,481
Netherlands	324	346	373	415	236	666	1,096	1,201
United Kingdom	624	700	872	963	440	1,451	1,911	2,107
Germany	7,493	7,676	7,100	7,393	6,908	10,504	15,037	14,436
Italy	542	563	545	551	404	777	1,020	1,207
EU–15	11,723	12,181	11,629	12,143	9,714	18,357	25,394	25,490
Croatia	917	931	800	902	837	778	813	852
Poland	2,279	2,227	1,945	2,196	2,178	2,364	2,681	2,645
Russia	1,893	2,048	1,794	2,244	2,642	2,759	2,760	2,787
Romania	41,561	44,977	47,281	55,676	67,529	66,183	66,951	65,836
Serbia	12,664	11,975	11,693	12,367	13,643	12,111	12,638	17,186
Slovakia	1,576	2,213	1,536	2,472	1,225	3,597	4,276	4,944
Slovenia	82	88	65	81	34	79	115	133
Turkey	455	544	469	557	615	756	886	1,120
Ukraine	8,947	9,835	9,853	13,096	13,933	15,337	15,866	17,289
Other European	20,584	21,088	21,552	22,915	24,493	24,307	25,314	26,272
Neighbouring countries	66,359	70,716	71,913	85,293	97,711	99,579	102,769	108,811
Europe	93,197	97,640	98,230	110,915	122,261	130,535	140,827	146,145
Asia	12,603	14,401	13,480	14,715	15,121	18,543	19,733	22,356
America	2,488	2,557	2,434	2,535	2,667	2,989	3,075	3,557
Africa	1,233	1,318	1,281	1,455	1,556	1,800	1,783	1,913
Other and unknown	507	513	463	489	548	563	612	726
Total	*110,028*	*116,429*	*115,888*	*130,109*	*142,153*	*154,430*	*166,030*	*174,697*

Source: HCSO, own edition

Reasons behind the territorial distribution of foreigners

According to the neoclassical theory (Hamilton, B. *et al.* 1984; Venables, A.J. 1998) flows of humans on the macro level are determined by the push and pull factors of capital and labour. On micro level it is the regional differences in incomes that generate a motivation to move (Hatton, T.J. and Williamson, J.G. 2005). The population tends to be increasingly mobile in areas where considerable disparities of incomes can be identified. Other motivating factors are the individual skills and abilities of the migrants as well as intentions to improve life circumstances (Borjas, G.J. 1996; Williamson, J.G. 2006). In the opinion of the authors, in the distribution pattern of foreigners, beside these main economic motivation factors identified by the literature an important role is played by the attraction of the metropolitan area of the capital city (Rédei, M. 2007; Papademetriou, D.G. 2006) as a significant focus of migration and also that of border areas due to the neighbourhood of source countries.

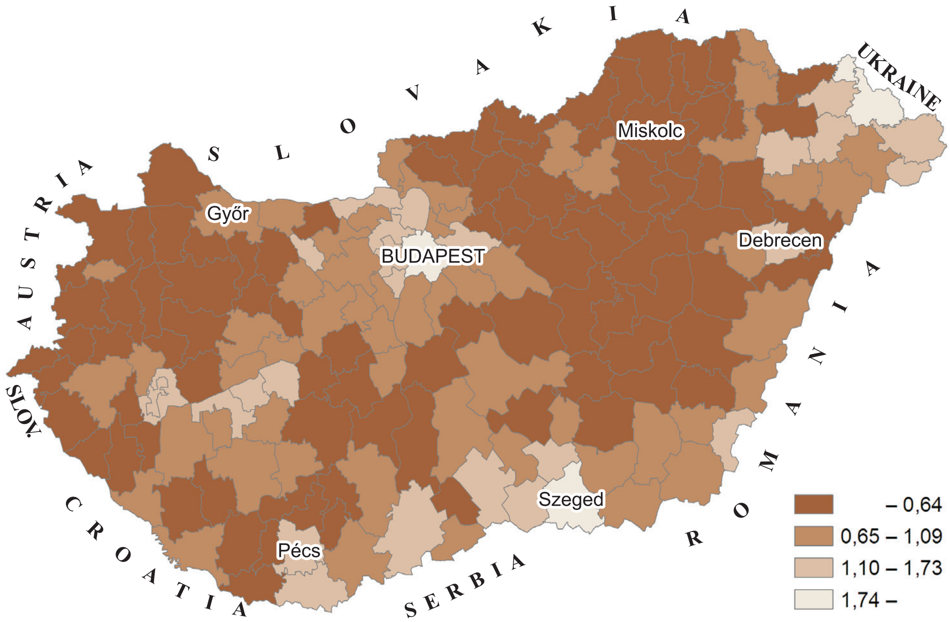
In consequence of a great number of citizens from the neighbour countries geographic location has a great significance in the case of migration affecting Hungary (Rédei, M. 2007). As it is illustrated by *Figure 1* in the surroundings of Lake Balaton, Budapest and Pest County as well as in micro-regions[4] on the Ukrainian, Romanian and Serbian borders, foreigners accounted for a greater proportion than elsewhere in 2001. Similar concentration of foreigners is not typical along the Croatian, Slovenian, Slovakian and Austrian borders. On the one hand this may be explained by the less numerous populations of these groups in Hungary, on the other hand, by smaller "differences in potential" compared with those that are observed along the Serbian and Romanian border sections. The above areas (centre and hinterlands) and their surroundings experienced an increase in the percentage of foreigners within the resident population from 2001 to 2008.

In Hungary the following general characteristic were found in the territorial distribution of international migrants. The overwhelming part of foreigners live in Budapest and its surroundings, a smaller proportion of them is a resident of micro-regions near the borders as well as in the surroundings of Lake Balaton. Citizens from the EU15, in addition to Budapest and its agglomeration, give preference to settle in the western part of the country (Illés, S. 2004), mainly in Győr-Moson-Sopron and Somogy counties.

Romanian citizens are the most diffused in their geographical distribution; they live in large numbers along the Romanian border, in the capital city and in Western Hungary. The Serbs cluster in a wedge determined by the common border and Budapest. The Slovaks are concentrated in Northern Hungary and in the surroundings of Budapest, while for the Ukrainians, in addition to Budapest, those micro-regions are the most attractive ones which are near to their source country. In short, it might be said that for those foreign nationals who have come to Hungary from the neighbouring countries Budapest and Pest County are unambiguously attractive destinations beside those micro-regions which are nearer to that country which corresponds to their citizenship, i.e. mainly close to the Romanian, Ukrainian and Serbian border sections. It is important to note that the foreigners show an interest to settle down also in places where a human resource injection is needed, like Southern Transdanubia or North East Hungary.

[4] The system of micro-regions (formerly attraction zones of micro-regions) covers the whole country. Micro-regions do not cross county borders. Every settlement belongs to one micro-region, though through their relationship settlements may be attracted by one or more central settlements. The present system of micro-regions has contained 174 micro-regions since 25th September 2007 on the basis of Act CVII of 2007. In most cases the professionals of regional analyses use this level in their work. The system of Hungarian micro-regions fits the first LAU level in the European regional breakdown. At the local level, two levels of Local Administrative Units (LAU) have been defined in the European Union. The upper LAU level (LAU level 1, formerly NUTS level 4) is defined for most, but not all of the countries. The second LAU level (formerly NUTS level 5) consists of about 120 000 municipalities or equivalent units in the 27 EU Member States.

Proportion of foreigners per 100 residents, January 1, 2001



Proportion of foreigners per 100 residents, January 1, 2008

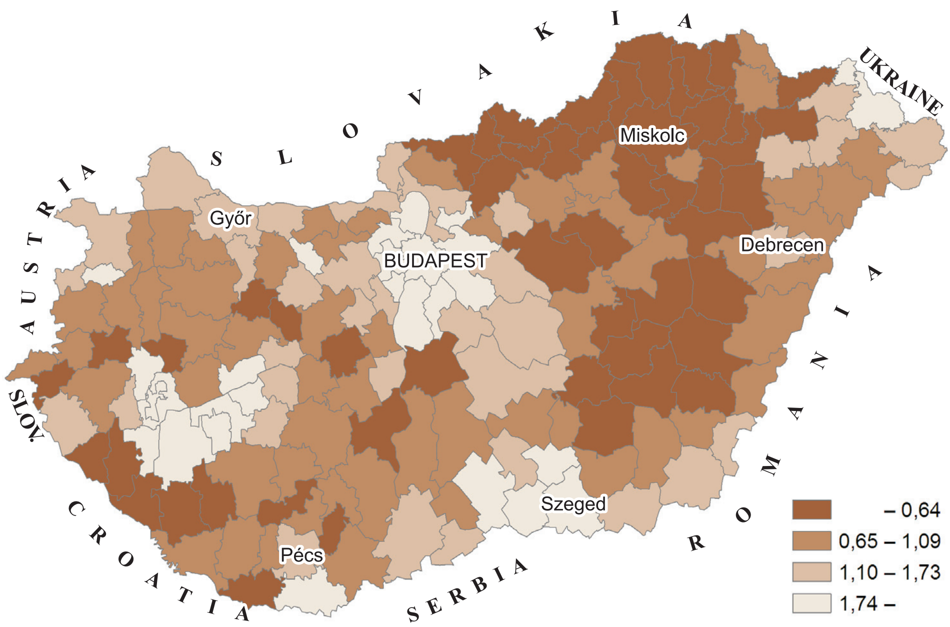


Fig. 1 Regional distribution of the foreigners by LAU1 level, 2001–2008. *Source:* HCSO, own edition

Previously, location theories observed the border regions as traditionally backward areas, first of all because borders hampered international trade flows and because they were threatened by possible military invasions (Anderson, J. and O'down, L. 1999). National borders have a negative effect on a regional economy, because these artificially cut off spatially interrelated regions and increase transaction costs. Different taxes, languages, cultures (though in the case of borders in concern these last two cases are not valid) and business practices hamper the cross border trade – these are a basis for potential political and social instability at border regions – which discourage domestic and foreign producers to settle down in these regions (Hansen, N. 1977).

A change in this unfavourable image, as a result of a greater international integration (Papademetriou, D.G. 2006) – with the help of eliminating trade barriers and international borders (Van Geenhuizen, M. and Ratti, R. 2001) – represents a new perspective of growth in border regions (Contessi, S. 2001; Traistaru, I. *et al.* 2002) in the first place because of geographical accessibility to large potential markets as occurred in 1993 in Europe with the establishment of a single market and after the establishment of NAFTA (Krugman, P. and Venables, A.J. 1996; Krugman, P. 1998).

Applying path analysis to examine the territorial distribution of foreign population groups

In the present analysis of the most populous groups of foreigners that live in Hungary (from Romania, Serbia, Slovakia, EU15 and Ukraine) the causes of their territorial distribution will be analysed. As it was seen, the literature put an emphasis of living standards and differences in payments as pull factors but the location of settlements is prioritised, too, and this geographic factor will be examined in a somewhat more detail.

With the help of path analysis, between 2001 and 2008, the average proportion of foreigners by micro-regions is to be examined by factors. In this analysis, in the first place it was aimed to identify correlation between public road access to micro-regions and the proportion of immigrants.

Zero order linear correlations of independent and dependent variables are broken down into two parts in the path models. One part is the effect that our independent variables directly have on a dependent variable; the other part is the effect that is produced by independent variables through other intermediate variables (Duncan, O.D. 1966; Alwin, D.F. and Hauser R.M. 1975; Székhelyi, M. and Barna, I. 2008).

Path analysis is a series of estimations of ordinary least squares built upon each other. In step 1 it is examined what an impact the primary variables have upon the indicators of a secondary group; there are as many regressions as secondary variables. In step 2 it is examined how the primary and secondary variables jointly impact the tertiary ones. At last a regression is found, where all variables are put together. The impact of significant indicators is analysed jointly with the explored paths (Németh, N. 2008).

The following indicators were involved in our analysis:

Accessibility

– For micro-regional centres, travel distance on public road from the "corresponding" border crossing in minutes (BORDER).
– For micro-regional centres, travel distance on public road from Budapest in minutes (BUDAPEST).

Economic situation

– Personal cars per thousand residents as an average of 2000–2007 (CAR).
– Shops and stores that sell food per thousand residents as an average of 2000–2007 (SHOPS).
– Earning per taxpayer as an average of 2000–2007 (EARNING)
– Active enterprises per thousand residents as an average of 2000–2006 (ENTERPRISES).

Social situation

– Natural increase/decrease per thousand residents, 2000–2007 (DECREASE).
– Migration balance per thousand residents, 2000–2007 (MIGRATION)
– Indicted cases per thousand residents as an average of 2001–2007 (CRIME).
– Ratio of those with secondary and higher qualifications to the resident population, %, 2001 (QUALIFICATION).

Territorial distribution of migrants

– Ratio of immigrants from a given country to the resident population, 2000 (RATIO).

These values are regarded as independent variables that explain the proportion of foreigners with a given citizenship, which constitute the dependent variable.

In this way concerning the territorial distribution of migrants four groups of variables were put together as a total. Over our examinations, there were more indicators in the individual groups of variables, which were excluded from our system as a result of preliminary calculations.

In relation to the single indicator groups the following hypotheses were devised.

Accessibility: the nearer is the given micro-region to Budapest as well as to the corresponding border section, the higher is the proportion of foreigners.

Economic situation: the more significant is the economic weight of a micro-region, the higher is the proportion of foreigners.

Social situation: the more favourable is the demographic situation and the higher is the educational attainment of the population as well as the lower is the rate of criminal offences, the higher is the proportion of foreigners in the micro-region.

Territorial distribution of former immigrants: the higher was the proportion of migrants in previous times, the higher it is going to be in the analysed period, too.

According to our presumptions the primary explanatory factors (accessibility) influence differences in secondary factors (economic situation, social situation), which were analysed in detail in an article on this topic (Hardi, T. 2008), which in turn exert an impact on tertiary factors (territorial distribution of migrants in previous times). Another assumption is that the primary and secondary explanatory factors have an influence on the proportion of migrants not only in an indirect but in an independent way. (The arrows in *Figure 2* are to illustrate this relationship in causality).

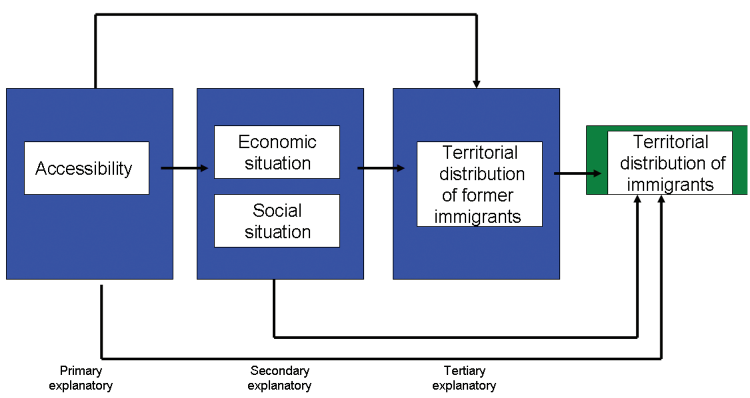


Fig. 2. Causality relations of the groups of explanatory variables. *Source:* own edition

As a starting phase for the path analysis with a simple multivariate regression along with all independent variables based on micro-regional data, an attempt was made to explain the proportion of foreigners by citizenship. Our results are summarised in *Table 3.* Of them, on the one hand it may be pointed out that the variables involved in the analysis jointly explain with an R^2 value of between 0.83 and 0.99 the proportion of the population with a proper citizenship in the resident population, on the other hand, significant differences by citizenship may be found in the weight of the explanatory factors. Further it should be stated that the proportion of earlier migrants by micro-region has the most significant explanatory meaning in all cases, i.e. the newly arrived foreigners are distributed in line with the existing pattern.

Table 3. Regression results

Dependent variable	Denomination	EU15	Serbia	Romania	Slovakia	Ukraine
β1	Border	-0.212	-0.014	0.006	-0.123	-0.022
β2	Budapest	0.034	0.008	-0.065	0.016	0.016
β3	Car	-0.058	0.039	0.170	0.100	0.023
β4	Shops	0.077	-0.017	-0.023	0.044	0.027
β5	Earning	-0.413	0.006	0.051	0.032	0.053
β6	Enterprises	-0.096	-0.016	-0.138	-0.182	0.025
β7	Decrease	0.006	0.001	0.038	-0.014	-0.001
β8	Migration	0.150	0.007	0.044	-0.031	0.004
β9	Crime	-0.016	-0.003	-0.015	0.086	-0.018
β10	Kpfe	0.215	-0.022	-0.059	0.095	-0.016
β11	Ratio	0.838	0.983	0.863	0.817	0.971
R^2	–	0.830	0.990	0.920	0.820	0.960

With the help of the path analysis, however, only with the geographic location of micro-regions (distance from the corresponding border and from Budapest) it was attempted to explain the proportion of foreigners and to show the importance of the geographic proximity. The location may have a direct and, through other variables, an indirect influence, which will also be quantified. As we have two independent primary variables so the betas of binary linear regressions are broken down into indirect and direct parts by this procedure in an additive way. The schematic system of our path analysis is illustrated by *Figure 2*.

As a next step the relations will be analysed among accessibility and the ratios of migrant groups to a resident population at micro-regional level, in the beginning irrespective of their indirect or direct role.

Table 4 is to illustrate steepness at a "simple" binary regression; R is to measure closeness at this stochastic relationship. R^2 is to show in percentages how the geographic location explains the dispersion of micro-regional distribution for foreigners with a given citizenship. So we can conclude that the geographic location explains in itself in 22–30% of the micro-regional variances for foreigners with a given citizenship; that is why the geographic location plays a significant role when the foreigners choose a place of residence in Hungary. To be fair, it has to be noted, based on *Table 3*, that for the foreigners plays an even greater role in an informed decision to choose a domicile. They will settle down with a high probability in those micro- regions where their compatriots already live in greater numbers, who will help them in the process of management of migration, in the adaptation, in solving administrative problems, in looking for a job, in the issue of housing in general the process of integration.

In the terminology of *Table 4,* the nearest corresponding border when analysing the countries of EU15 is the Austrian border, while in other cases the borders corresponding to citizenships. In a regression the steepness at these variables being negative means that when moving away from the border, the analysed group with a foreign citizenship as a rule accounts for a decreasing proportion, whereas positive regression indicates an increasing proportion. In a similar way, if those betas, which belong to the access time of Budapest are negative, then when moving away from the capital city the foreigners, on average, will account for a decreasing proportion of the resident population, however, in case of a positive steepness for an increasing proportion. As it can

Table 4. Binary regression results between accessibility and migrants' proportions

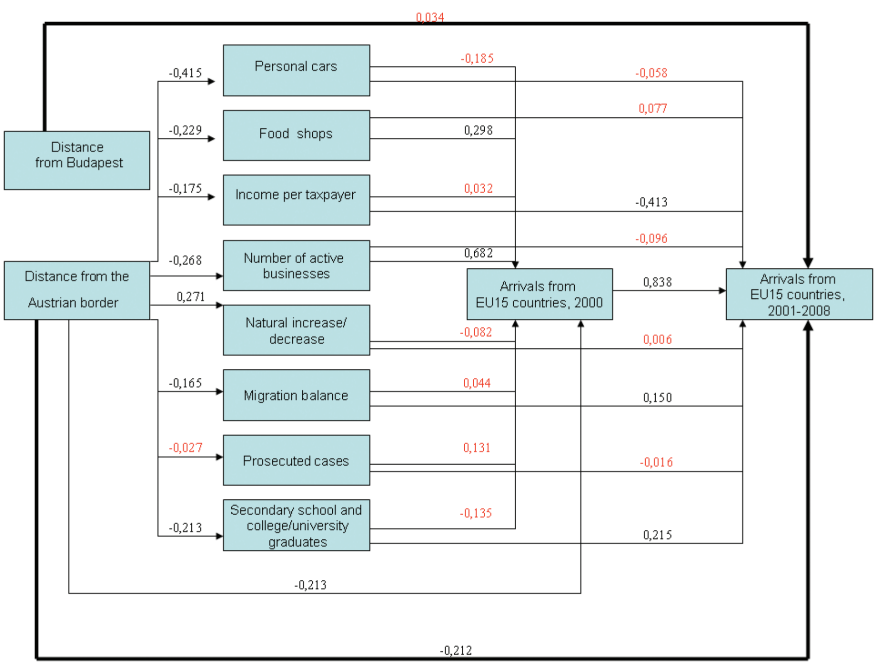
Coefficients	Time to access the nearest border crossing point, 2008	Time to access Budapest, 2008
	EU15	
β	-0.509	0.141
R^2	0.221	
	Romania	
β	-0.193	-0.488
R^2	0.259	
	Serbia	
β	-0.575	0.203
R^2	0.284	
	Slovakia	
β	-0.516	0.076
R^2	0.236	
	Ukraine	
β	-0.489	0.228
R^2	0.303	

Source: HCSO, own calculation

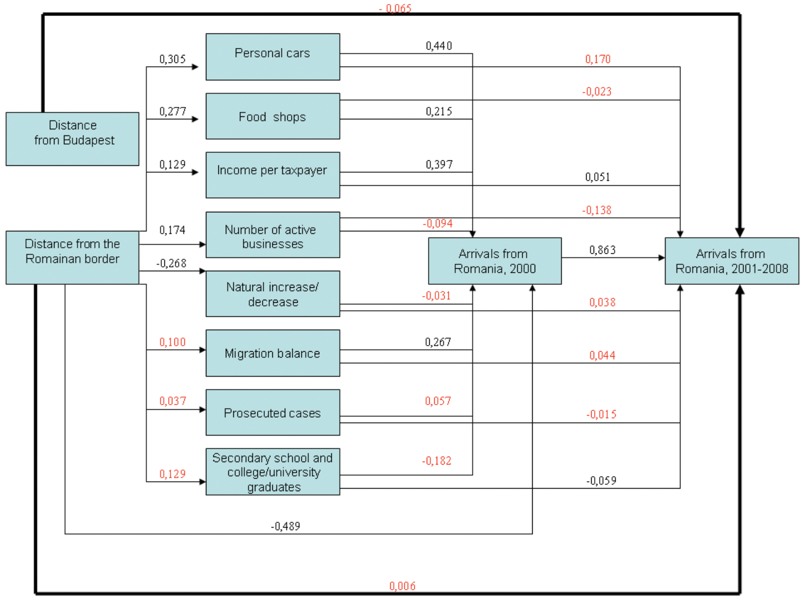
be seen at data on *Table 4* – with the exception of those who migrated from Romania – in all cases the distance measured from border crossings is longer than the distance measured from Budapest, which is shown by the difference between standardized betas. That is in addition to the central character of the capital city, borders play a significant role in the geography of migration.

In the further part of the path analysis the beta value was broken down into direct and indirect paths. To this effect, in the first place it was analysed that out of primary characters (accessibility) which and how influence the secondary ones (economic situation, social situation). This operation began with the distances measured from the border:

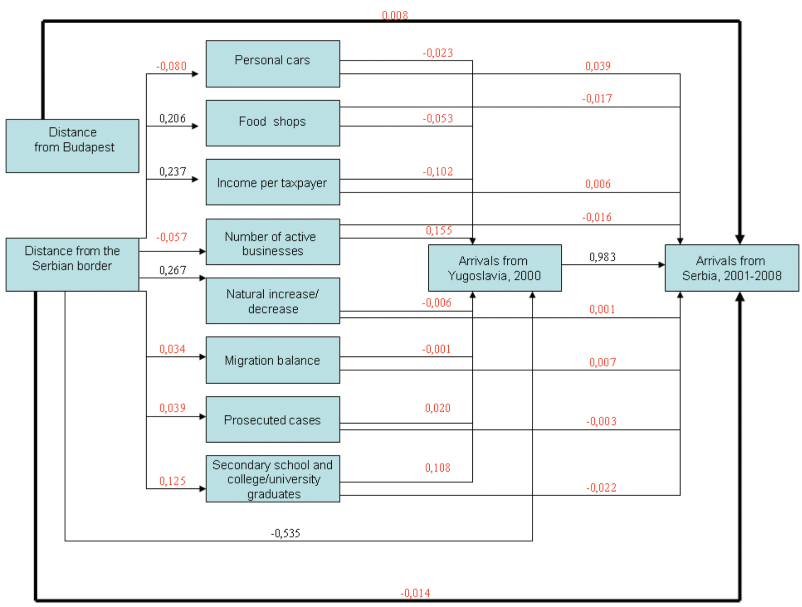
The distance measured from the Austrian border – except indicted cases – produces a significant effect on all analysed secondary factors (in case of *Annex 1–5* non-significant values are marked with grey). Signs in most cases are negative that is why there is higher development, better provision and school attainment, etc. nearer to the border. There is only one positive sign for natural change (increase/decrease), which is in conjunction with the present demographic processes in Hungary. The closest correlation may be seen between car ownership and the distance from the Austrian border (*Annex 1*).



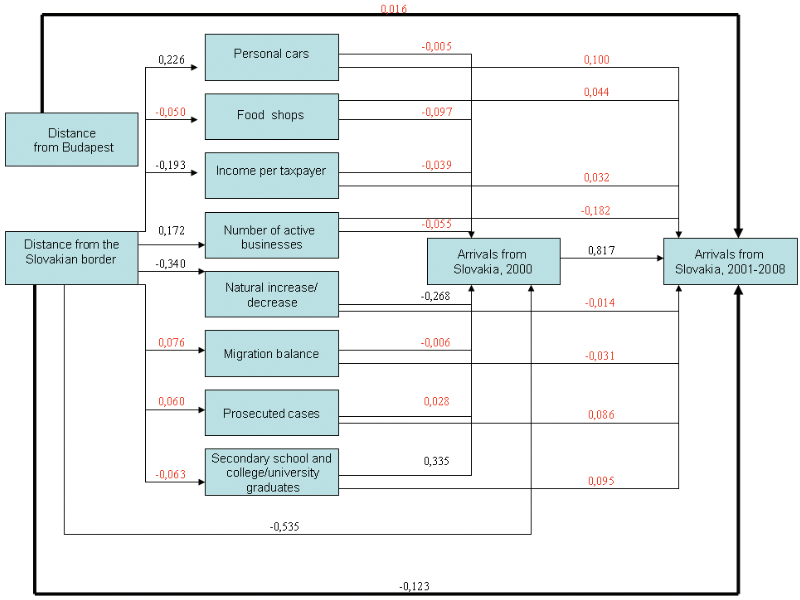
Annex 1. The role of distance from the Austrian border in explaining the tatio of immigrants from EU15 countries within total population in 2001–2008. *Source:* HCSO, own edition



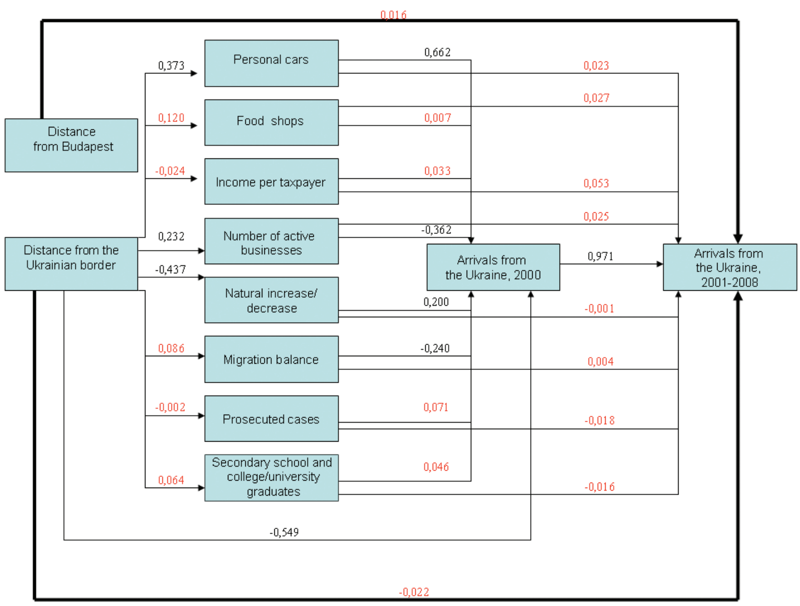
Annex 2. The role of distance from the Romanian border in explaining the ratio of immigrants from Romania within total population in 2001–2008. *Source:* HCSO, own edition



Annex 3. The role of distance from the Serbian border in explaining the ratio of immigrants from Serbia within total population in 2001–2008. *Source:* HCSO, own edition



Annex 4. The role of distance from the Slovak border in explaining the ratio of immigrants from Slovakia within total population in 2001–2008. *Source:* HCSO, own edition



Annex 5. The role of distance from the Ukrainian border in explaining the ratio of immigrants from Ukraine within total population in 2001–2008. *Source:* HCSO, own edition

The distance measured from the Romanian border (*Annex 2*) is insignificant in connection with the migration balance, criminal offences and educational attainment; concerning other secondary indicators it exerts a different influence as we may have seen before. Against the distance measured from the Austrian border, here the signs are mainly positive that is the socio-economic situation is improving when moving away from the border; so the border zone may be characterized unambiguously as a periphery. In this respect the distance measured from the border is in the closest correlation with the car density. However, natural change shows a decrease when moving away from the border.

The distance measured from the Serbian border produces a significant effect on only three secondary indicators (*Annex 3*). When moving away from the border there is an improvement in provision with food shops, in income per taxpayer and in natural increase.

The distance measured from the Slovakian border exerts a significant influence on car ownership, income per taxpayer, density of enterprises and natural increase (*Annex 4*). When moving away from this border there is an increase in car ownership as well as in enterprise density and a decrease in productivity and natural increase.

At last the distance measured from the Ukrainian border exerts a significant influence on three secondary variables too (*Annex 5*). When moving away from the border there is an increase in car and enterprise density as well as a drop in natural change. The distance measured from the border is the closest for this last indicator. Distances measured from the Serbian, Slovakian and Ukrainian borders were in the closest correlation with the natural increase.

Closeness among primary and secondary indicators may be analysed with the help of a determination coefficient, which shows how accessibility indicators explain difference from the average of socio-economic indicators. It may be pointed out that the inequality indicators first of all explain dispersion at the migration balance, car ownership and productivity (accessibility interprets more than one third of dispersion in case of all the three). In spite of this, the weighed determination coefficient for criminal offences is only 5%, the lowest for the analysed indicators.

After analysing how the primary and secondary explanatory factors relate each other we should focus our attention on how these variables impact the tertiary ones.

In 2000, the ratio of arrivals from EU15 countries to the resident population was directly and significantly influenced by the distance measured from the Austrian border as well as the effect of this may be felt through specific data of food shops and the business density (*Annex 1*). Of these three paths the direct one is the strongest. In this case the sign is negative, i.e. considering 2000 there was also a decrease in arrivals from EU15 countries when moving away from the border.

In one respect, in 2000, the distance measured from the Romanian border produced a direct and significant effect on the ratio of those who came from Romania as well as its effect could be felt through the provision with cars and food shops and the productivity (*Annex 2*). Of the analyzed paths the direct impact of the distance measured from the border is the strongest and has a negative sign, i.e. there was also a decrease in the ratio of arrivals from Romania in 2000 along with an increase in distance.

In 2000, there was a significant correlation between arrivals from Romania and the distance measured from the Romanian border, an impact was also felt through car and food shop provision as well as productivity (*Annex 2*). At the analyzed paths the distance from the border has the strongest direct effect with a negative sign, i.e. there was a decrease in the ratio of arrivals from Romania along with an increase in distance already in 2000.

In 2000 only the distance measured from the Serbian border has a significant effect on the ratio of arrivals from Yugoslavia; there is no significant correlation through the secondary factors. There is a decrease in the share of migrants along with an increase in the distance measured from the border (*Annex 3*).

In 2000, on the one hand, the distance measured from the border had a direct effect on the ratio of those who came from Slovakia; on the other hand, it also had an indirect effect through the natural increase/decrease. Of the two indicated paths the direct one is the stronger and it has a negative sign, i.e. there is a decrease in the share of immigrants along with an increase in distance (*Annex 4*).

At last, in 2000, there was a direct, significant correlation between the distance measured from the Ukrainian border and the ratio of migrants from Ukraine to the resident population (of all border sections here is the strongest direct impact), as well as an indirect effect expressed through car and business density as well as natural increase/decrease (*Annex 5*).

When observing how tertiary variables impact dependent ones it can be pointed out that this is significant in all cases and shows the strongest standardized beta-coefficient. It means that based on our model, the share of migrants is mostly influenced by the territorial distribution of earlier migrants. The highest standardised beta-coefficient can be observed with the immigrants from Serbia.

Considering the model as a whole, in 2001 and 2008, there was a significant correlation between the distance from the border and the average share of immigrants from the EU15 and Serbia. It is not true at the distance measured from Budapest, which is not significant in any case when considering its direct impacts. Of course it does not mean that there is no correlation between the distance measured from Budapest and the ratio of immigrants within the resident population. That has effects not in a direct way but rather through different socio-economic factors. So this part of the path analysis is not detailed separately in the present article, but due to the later results these calculations are also shown in *Annex 1–5.*

After identifying the "path strengths" in our model identification started as to the accessibility impact upon the territorial distribution of migrants. The question is how accessibility indicators (directly or, through other factors, indirectly) impact the ratio of immigrants by citizenship.

When look at the variable for the distance measured from the Austrian border, as it can be seen in *Annex 1* this primary factor has a direct impact of -0.2123. On the one hand indirect paths may go over the primary, secondary and tertiary variables, at this time all ways have to be added together from the onset to the dependent variable, while the proper path sections have to be multiplied together, i.e. (irrespective of significances): (-0,4148*-0,1847*0,838)+(-0,2291*0,2976*0,838)+(-0,1749*0,0324*0,838)+(-0,268*0,6817*0,838)+(0,2714*-0,0822*0,838)+(-0,1653*0,0435*0,838)+(-0,027*0,1306*0,838)+(-0,2125*-0,1349*0,838)=-0,15463.

Furthermore through the primary and secondary variables: (-0,4148*-0,058)+(-0,2291*0,07725)+(-0,1749*-0,413)+(-0,2682*-0,0958)+(0,2714*0,00642)+(-0,1653*0,1496)+(-0,027*-0,0163)+(-0,2125*0,21524)=0,03599.

Or through the primary and tertiary variables: -0,2126*0,838=-0,1782.

So the indirect effects as a total: -0,15463+0,03599+-0,1782=-0,2968.

Together with the direct effects: -0,2968+-0,2123=-0,5092. I.e. a partial steepness appearing in *Table 4* is obtained.

Total paths were calculated for the analyzed citizenships and for both accessibility indicators. The results are contained by *Table 5*.

In general it can be pointed out that in all cases accessibility indicators has no direct impact but first of all an indirect one described by socio-economic indicators.

An analysis of the foreigners' places of residence in Hungary by an indicator on location potential

As it was seen, the attractive target area in Hungary for a foreigner migrant is one where his/her compatriots with the same citizenship live (Sík, E. 1999). So with the help of a location potential indicator it could be visualised how the foreigners with a different citizenship see the area of the country as a potential destination to settle down. The used accessibility potential was calculated from the Hansen type gravitational model (Hansen, N. 1977).

During the research, in the way that was described previously a gravitation analogy based model was calculated with a linear resistance factor (Tóth, G. and Kincses, Á. 2007). For accessible destinations, volumes were

Table 5. The role of direct and indirect paths in explaining the share of immigrants within total population (standardised B coefficients)

Coefficients	Access time for the nearest corresponding border crossing, 2008	Access time for Budapest, 2008
	EU15	
indirect	-0.297	0.106
direct	-0.212	0.034
total	*-0.509*	*0.141*
R^2	0.221	
	Romania	
indirect	-0.199	-0.424
direct	0.006	-0.065
total	*-0.193*	*-0.488*
R^2	0.259	
	Serbia	
indirect	-0.562	0.195
direct	-0.014	0.008
total	*-0.575*	*0.203*
R^2	0.284	
	Slovakia	
indirect	-0.393	0.060
direct	-0.123	0.016
total	*-0.516*	*0.076*
R^2	0.236	
	Ukraine	
indirect	-0.467	0.212
direct	-0.022	0.016
total	*-0.489*	*0.228*
R^2	0.303	

Source: HSCO, own edition

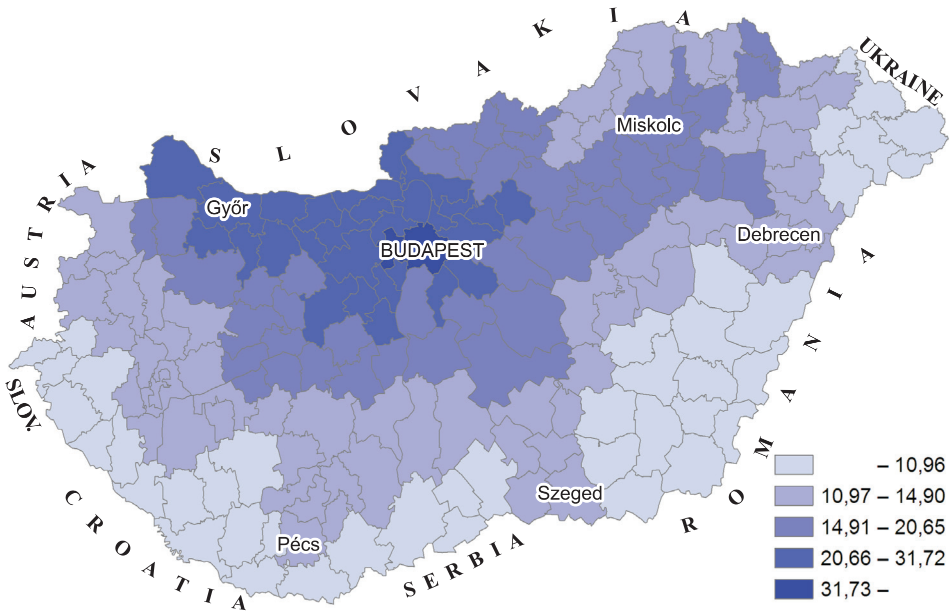
determined based on the population with a corresponding nationality in single micro-regions. This present analysis takes into account what accessibility conditions are in a given area, i.e. accessible destinations in the area. Based on our model, the potential in point I of the space:

$$P_i = \sum_{j \neq i} \frac{B_j}{d_{ij}} + \frac{B_i}{d_i}$$

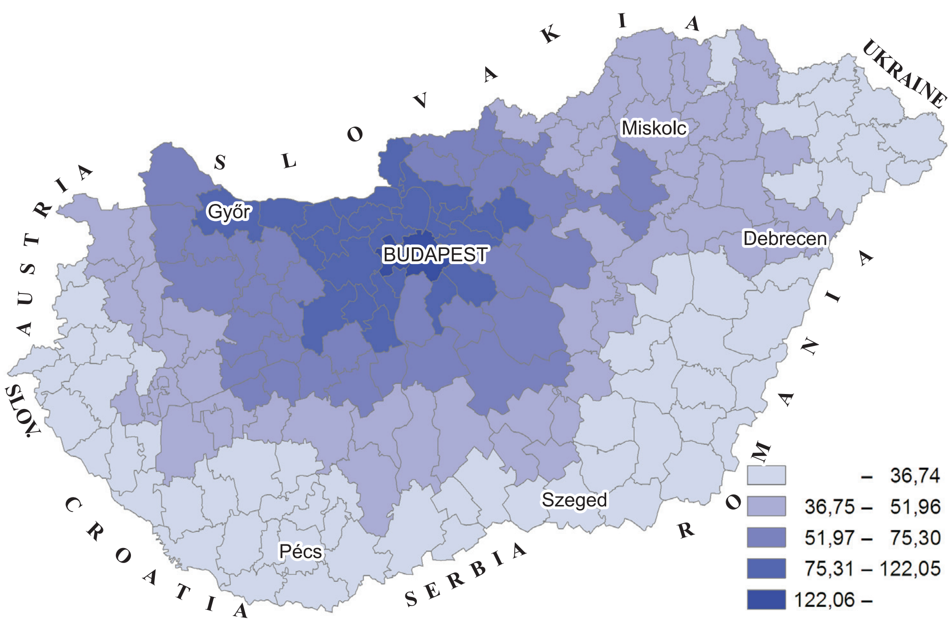
where B_i, B_j volumes for accessible destinations d_{ij} distances between I and j micro-region centres in minutes, while d_i is the own distance (in minutes), which can be calculated in a way that for the area of a given micro-region regarded as a circle, a radius is determined, which is considered as proportional with intra-micro-regional public road distances and the time required to cover this radius is regarded as an own distance.

In case of EU15, Serbian, Romanian, Slovakian and Ukrainian citizens micro-regional potential values are mapped in 2001 and 2008 (*Figure 3*).

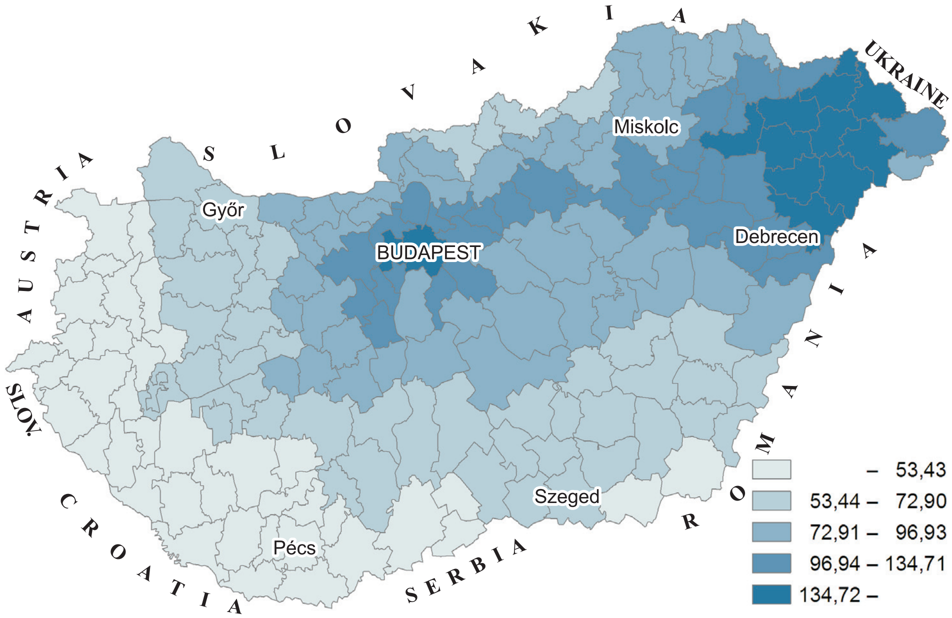
Slovakian citizens, 2001



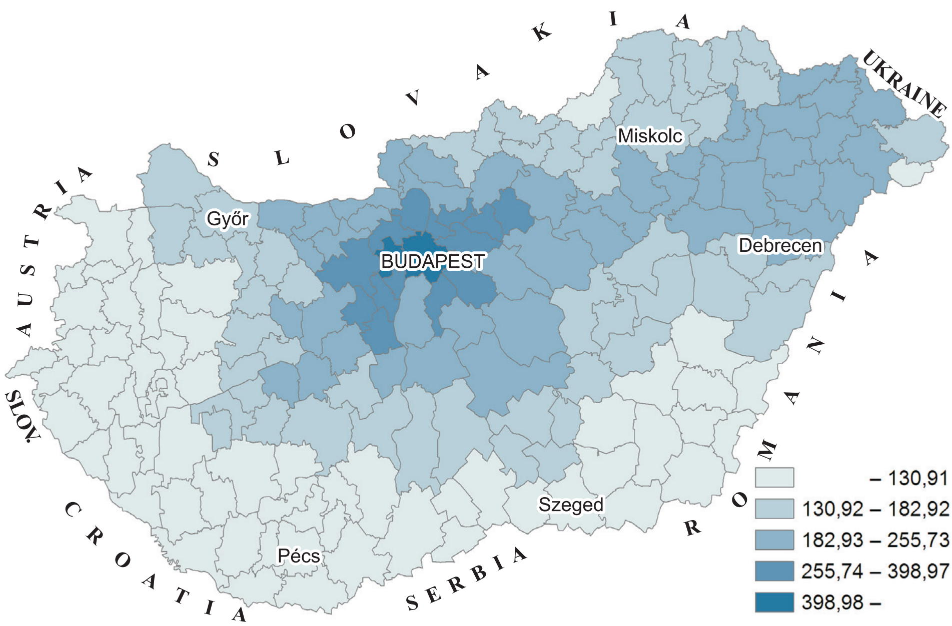
Slovakian citizens, 2008



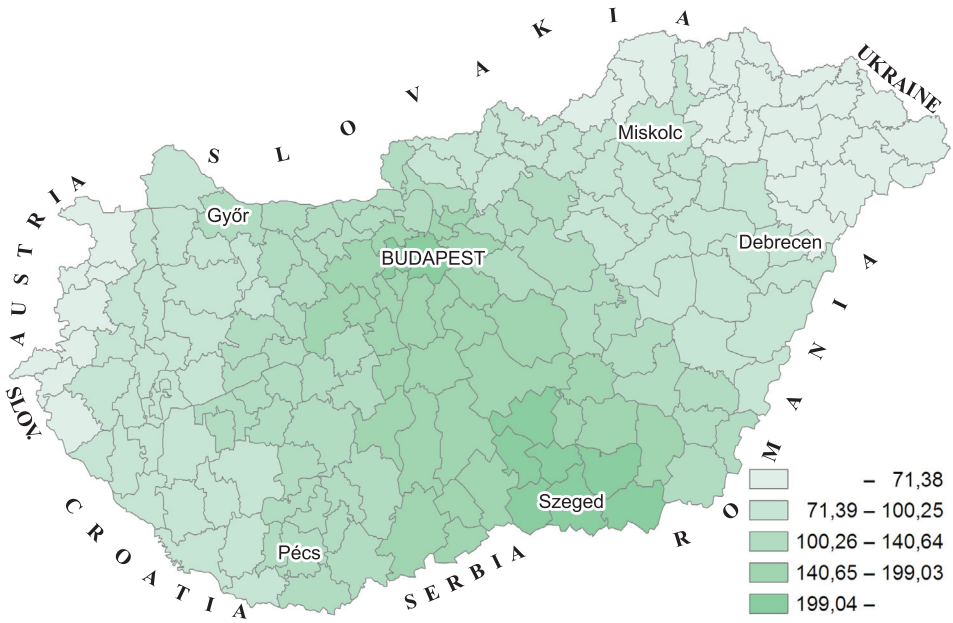
Ukrainian citizens, 2001



Ukrainian citizens, 2008

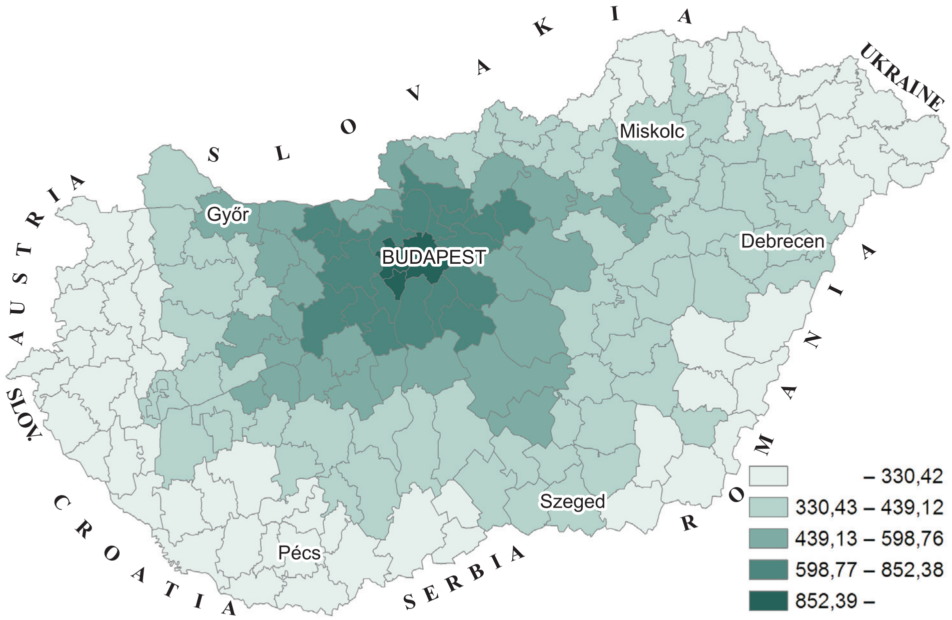


Serbian citizens, 2001

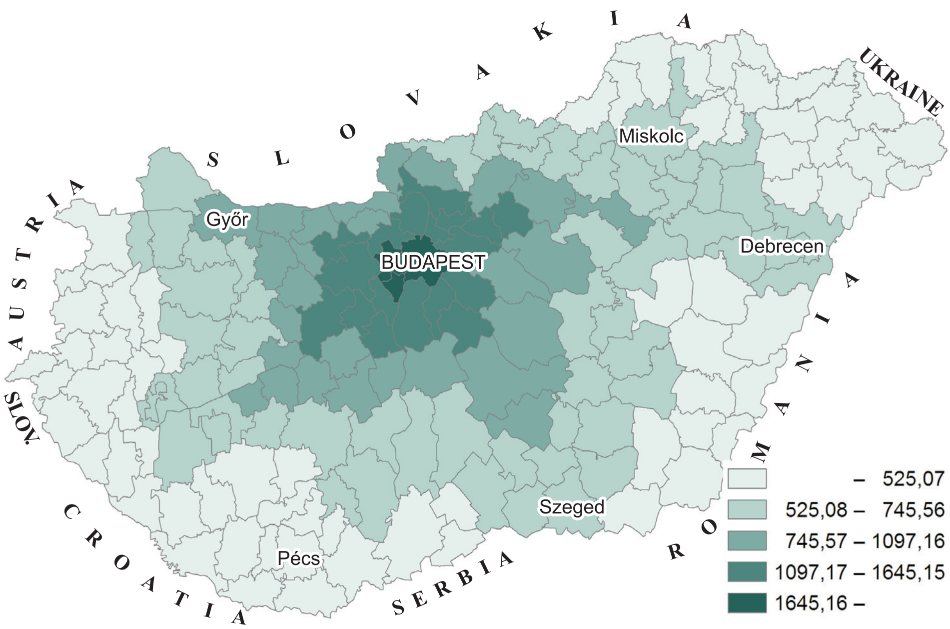


Serbian citizens, 2008

Romanian citizens, 2001



Romanian citizens, 2008



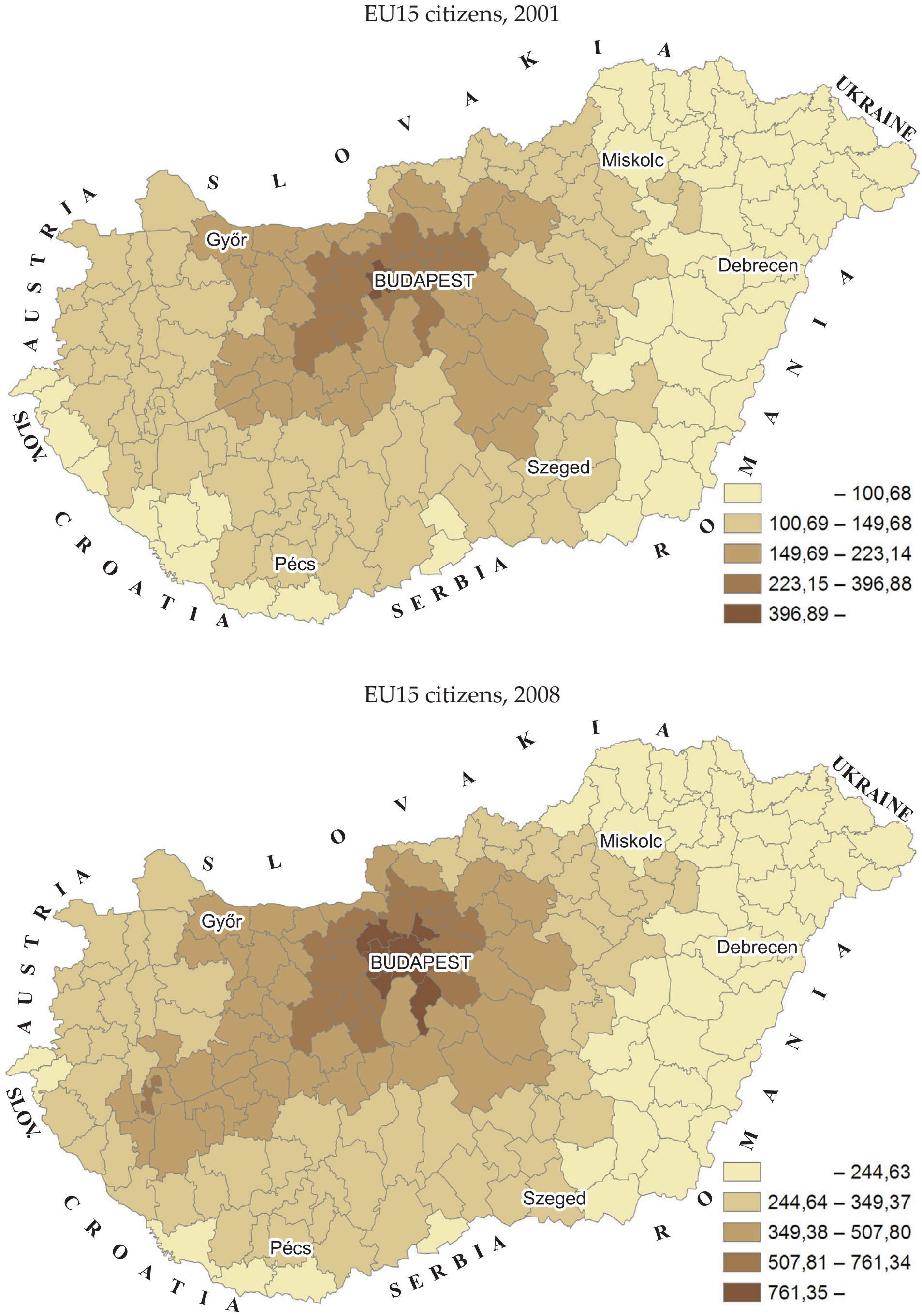


Fig. 3. Results of potential models. *Source:* HCSO, own edition

As it can be seen from these *figures* there are differences in the distribution of location potential by micro-region in case of foreign citizens staying in Hungary.

Channels can be identified between Budapest and the source countries with the exception of those who arrived from Romania, for whom Budapest and its surroundings represent an attraction, but they can be found on the whole territory of the country. Strong potential corridors can be identified for the Ukrainians trending in an east–west direction, for the Austrians in west–east, whereas for both the Serbs and the Slovaks in north–south.

Summary

Budapest and its gravity zone accounts for the residence of a predominant part of the foreign migrants, while a smaller proportion of them live in micro-regions along the border as well as in the surroundings of Lake Balaton. Budapest and Pest County are unambiguously attractive destinations for those foreigners who arrived in Hungary from the neighbouring countries, but they also prefer micro-regions located nearer to the country relating to their citizenship, mainly in the vicinity of the Romanian, Ukrainian and the Serbian border.

During the path analysis the variables involved in the analysis jointly explain in a decisive way the ratio of the population with a proper citizenship to the resident population, thus our hypotheses has fulfilled. On the other hand, however, significant differences by nationality can be pointed out in the weight of the explanatory variables. One of the most important findings of our analysis is that for the average proportion of foreigners between 2001 and 2008, the strongest explanatory force was in all cases the ratio of those compatriot immigrants who came earlier. I.e. the new immigrants follow the existing spatial pattern in their distribution. In case of all citizenship groups, accessibility indicators have no direct effect but an indirect one, which is first of all described by socio-economic indicators.

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Hungarian spa destinations in the tourism-oriented property market

Gábor MICHALKÓ[1] and Tamara RÁTZ[2]

Abstract

Hungary is ranked among the most important spa and health tourism destinations in the world. The number and variety of mineral and medicinal waters result in a unique supply in Eastern Central Europe. In Hungary, 51 settlements have certified medical spas, with Budapest, the capital city offering 7 medical spas alone. In addition to their favourable impact on tourism development, the wide range of baths and spa hotels of international standards also affect the real estate market in a positive way. Tourists, who wish to regularly benefit from the medicinal qualities of the waters and the associated medical treatments, may decrease their costs of stay either by buying their own property or by investing in a time-share accommodation facility. Of course, real estate transactions in spa destinations are not always explained by health tourism related motivations; buyers may plan to rent out their property and may be attracted by the expected return on their investment, or may simply wish to repeatedly enjoy the tourist milieu of a given destination. In this article, the spatial characteristics of Hungarian spa destinations' domestic and international tourism demand will be analysed. In addition, the tourism-oriented characteristics of the spa towns' housing markets (with special emphasis on second homes and other properties with leisure-related functions) are to be assessed and foreign citizens' activities on the property market of these settlements evaluated. The research is based on the census and the tourism statistics of the Hungarian Central Statistical Office as well as the registry of foreigners' real estate transactions drawn up by the Ministry of Local Government.

Keywords: health tourism, real estate market, spa destination

Introduction

Spa destinations play a unique role in the Hungarian history of tourism. Both the currently operating spas and the remains of historic spa facilities are witnesses to the flourishing spa culture of the Roman province of Pannonia, that

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of medieval Hungary during the Ottoman occupation, and that of the Austro-Hungarian Monarchy (Farkas, K. 1962). As recognition of this heritage, the first International Balneology Congress was held in Budapest in 1937 (Vitéz, A. 1980). Health spas also contributed to the development of domestic and international tourism in the years of socialism (1947–1990) (Grove, D. 1977). Following the change of the political system – particularly due to the Széchenyi Development Master Plan announced in 2000 –, health tourism based on the country's spas was identified as the primary product of Hungarian tourism (Mundruczó, Gy. and Szennyessi, J. 2005). Today certified medical spas operate in 51 settlement, with Budapest, the capital city offering 7 medical spas alone[3].

Hungarian health spas can attribute their uniqueness to the high temperature of thermal waters and their varied mineral composition. Several spa towns offering health spas and spa hotels of international standards have become the most visited destinations in their regions. This trend has significantly contributed to the development of these towns; positive impacts can be experienced even in settlements where the spa itself is located on the periphery, sometimes even outside the administrative borders. In monofunctional spa towns health tourism is undoubtedly the catalyst of development, while in multifunctional settlements health spa facilities are among the synergic factor that contribute to economic development in general and tourism development in particular (Smith, M. and Puczkó, L. 2009). Although certain Hungarian spa towns attract either mainly domestic or mainly international customers, in the majority of spa destinations there is a rather balanced representation of both market segments. The construction of new spas, and the development and modernisation of the older ones stimulate not only tourism development, but also the property market.

Those tourists who wish to regularly benefit from the medicinal qualities of the waters and the associated medical treatments, may decrease their costs of stay either by buying their own property or by investing in a time-share accommodation facility. Of course, real estate transactions in spa destinations are not always explained by health-tourism-related motivations; buyers may plan to rent out their property and may be attracted by the expected return on their investment, or may simply wish to repeatedly enjoy the tourist milieu of a given destination. In the domestic market it was recognised rather early, already in the socialist era, that spa towns are 'good places' where it is worth to buy or build a summer cottage or a second home, which led to relatively stable demand for the spas all year round (Marton-Erdős, K. 1985). Second homes could, of course, be used to accommodate relatives and friends, i.e. as a means of nurturing social relations, but could also be used as rental property

[3] http://www.antsz.hu/portal/down/kulso/ogyfi/gyogyfurdok_20090829.pdf

in tourism. Foreign citizens appeared in larger numbers in the Hungarian real estate market only after the political changes in 1989–1990, and they also preferred to buy property in spa destinations. Both foreign and domestic customers' decisions to purchase property may have been motivated by investment goals as well, since the plots, houses and apartments are generally easily sold or rented out in spa towns.

The main aims of the paper are to understand the impact of the Hungarian spa towns' facilities and amenities on the willingness of Hungarian and foreign citizens to buy real estate, and to present the spatial characteristics of the process. Consequently, an overview of the spatial characteristics of domestic and international tourist demand in Hungarian spa towns will be provided. In relation with this, the touristic features of real estate markets of the spa towns are to be evaluated (with special emphasis on second homes and other properties with leisure function), and the eagerness of foreign citizens to buy property in these settlements assessed. The research is based on the 2001 census and the 1990–2006 tourism statistics of the Hungarian Central Statistical Office as well as the registry of foreigners' real estate transactions between 2001 and 2006, drawn up by the Ministry of Local Government[4].

Tourism geographic features of Hungarian spa destinations

Among the various tourism geographic features of Hungarian spa towns, the most influential factors that should be highlighted are their administrative status, functional role, and tourism milieu based on their location. Considering that these factors have a synergic effect on the development of second homes (leisure-related properties), it is necessary to briefly summarise their main characteristics.

Concerning their administrative position, the majority of the 49 spa settlements selected for the purposes of the research have town status, only 4 are classified as village (Cserkeszőlő, Csokonyavisonta, Igal, Parád). In several cases, a settlement received town status due to the additional demand generated by spa and health tourism. Following the political changes of 1989–1990 the designation of urban status to Hévíz (1992), Zalakaros (1997), Harkány (1999), Visegrád (2000) and Bük (2007) might most probably be attributed to their significant tourist demand as opposed to their relatively small population of 2–3 thousand. Of course, the importance of town status lies not in the

[4] The database used in this paper was completed within the framework of the authors' 2007–2010 research project "Health tourism and quality of life in Hungary". Since the data used in the study were purchased in 2007, the latest figures are available for the year 2006. However, since the analysis is based on longitudinal data for the period 1990–2006, the main conclusions of the study are not affected.

title as such, but in the higher amount of state funding allocated for towns, as well as the increasing opportunities for successful participation in EU projects, which may all contribute to the development of the spa and health tourism infrastructure in the given settlement. In addition, town status, if used in an adequate way, may also result in stronger lobbying power and more intensive marketing communication (Pirisi, G. and Trócsányi, A. 2009).

The functional evaluation of spa destinations brought to the surface those specific features that impede the formulation and verification of hypotheses concerning real estate purchases. The settlements classified as 'spa towns' by the authors include both the capital of Hungary and several regional and county centres. Budapest is no doubt a spa destination, since 7 health spas operate within its territory, and these spas form the basis of the city's health tourism industry. The regional centres also have their own health spas, but among them it is only Miskolc in the northeast of Hungary that can boast of a traditional spa culture as well as a separate leisure district built around the cave spa of Miskolctapolca. In Debrecen, Szeged and Győr, only recent investments brought about significant development in the health tourism sector, resulting in internationally competitive spa services that contribute to the already rich tourism supply of these regional centres (in the case of Pécs, the local spa does not have a noteworthy impact on the tourism industry of the city). Besides the capital and the five regional centres, five additional county seats have health spas (i.e. 11 centres out of 20). While Eger, Nyíregyháza and Szolnok are characterised by long spa traditions, related to the medieval Ottoman occupation of Hungary in the case of the first two, and to the Austro-Hungarian Monarchy's heritage in the case of Szolnok, in Békéscsaba and Kaposvár the spa may be considered a supplementary service rather than a primary attraction. In the capital as well as in the regional and county seats, tourism is interconnected to the settlements' other functions: the sizeable population, and the economic, cultural, scientific and educational roles create a wide range of tourist services, notably VFR (visiting friends and relatives) and MICE (meeting/incentive/congress/exhibition) tourism, that are also related to health tourism in many ways (Page, S. 1995). Pure health tourism function exists only in some spa towns, since in lakeside settlements (e.g. Balatonfüred, Gárdony) health tourism is interconnected with leisure tourism, while in settlements with significant built heritage (e.g. Gyula, Kalocsa, Visegrád, Sopron) there is a synergic relationship between health tourism and cultural tourism.

The tourist milieu of spa destinations (Michalkó, G. and Rátz, T. 2006) may be evaluated on the basis of their administrative status and consequent urban functions. The spa culture of villages where tourism industry is the key economic activity (e.g. Igal, Csokonyavisonta) may be characterised by a rural environment, but a similar rural milieu can be experienced in the peripheral leisure districts of larger spa towns (e.g. Mezőkövesd–Zsóry-fürdő;

Orosháza–Gyopárosfürdő). A typical small town milieu can be found either in settlements where the health spa itself contributed to the urban development of the place significantly (e.g. Hévíz, Harkány, Zalakaros), or as the combined consequence of the historical development of the settlement and current urban functions (e.g. Püspökladány, Kiskunfélegyháza). Budapest, the capital city, reflects a unique urban milieu, due to its size and development, but certain features of this milieu may also be experienced in the regional centres and county seats. As a further category, the lakeside holiday towns offer a particular atmosphere, due to the specific characteristics of the summer season's leisurely lifestyle.

The spatial characteristics of tourist demand in spa destinations

Hungarian spa destinations may be categorised according to the number of registered guest nights as well as the origin of the guests. Concerning guest nights, settlements can be differentiated as those with significant, moderate and low demand, while concerning the origin of guests, there are predominantly domestic vs mainly international destinations as well as destinations with a relatively balanced demand.

Based on the number of registered guest nights, 18 spa towns belong to the first group that generates **significant demand** (more than 100,000 guest nights annually), accounting for 38% of the settlements included in this study. Within this group 5 regional centres (Debrecen, Győr, Miskolc, Szeged, Pécs) and 3 county seats (Eger, Nyíregyháza, Szolnok) can be found *(Figure 1a,b)*. In these cities it is rather difficult to differentiate between health tourism demand and other forms of urban tourism demand. In the case of Bük, Hajdúszoboszló, Harkány, Hévíz, Sárvár and Zalakaros, a relatively small population is combined with a dominant health tourism function. In towns located along the borders of the country, such as Komárom at the Hungarian–Slovakian border, Gyula at the Hungarian–Romanian border, and Sopron at the Hungarian–Austrian border, shopping tourism and cultural tourism play an equally important role. In Balatonfüred and Gárdony spa and health tourism exists in symbiosis with lakeside holiday tourism.

The number of spa settlements with **moderate demand** (the number of guest nights being between an annual 10,000 and 100,000) is 20, accounting for 42% of the settlements included in the study. These towns lack the regional functions, but several have county seat status with subsequent urban roles (e.g. Békéscsaba, Kaposvár). However, as opposed to the traditional spa culture of the large county centres (leading back to the Ottoman heritage in Eger, or to the Austro-Hungarian Monarchy's traditions in Nyíregyháza), the medium-sized county centres do not possess such a historic spa culture that could serve

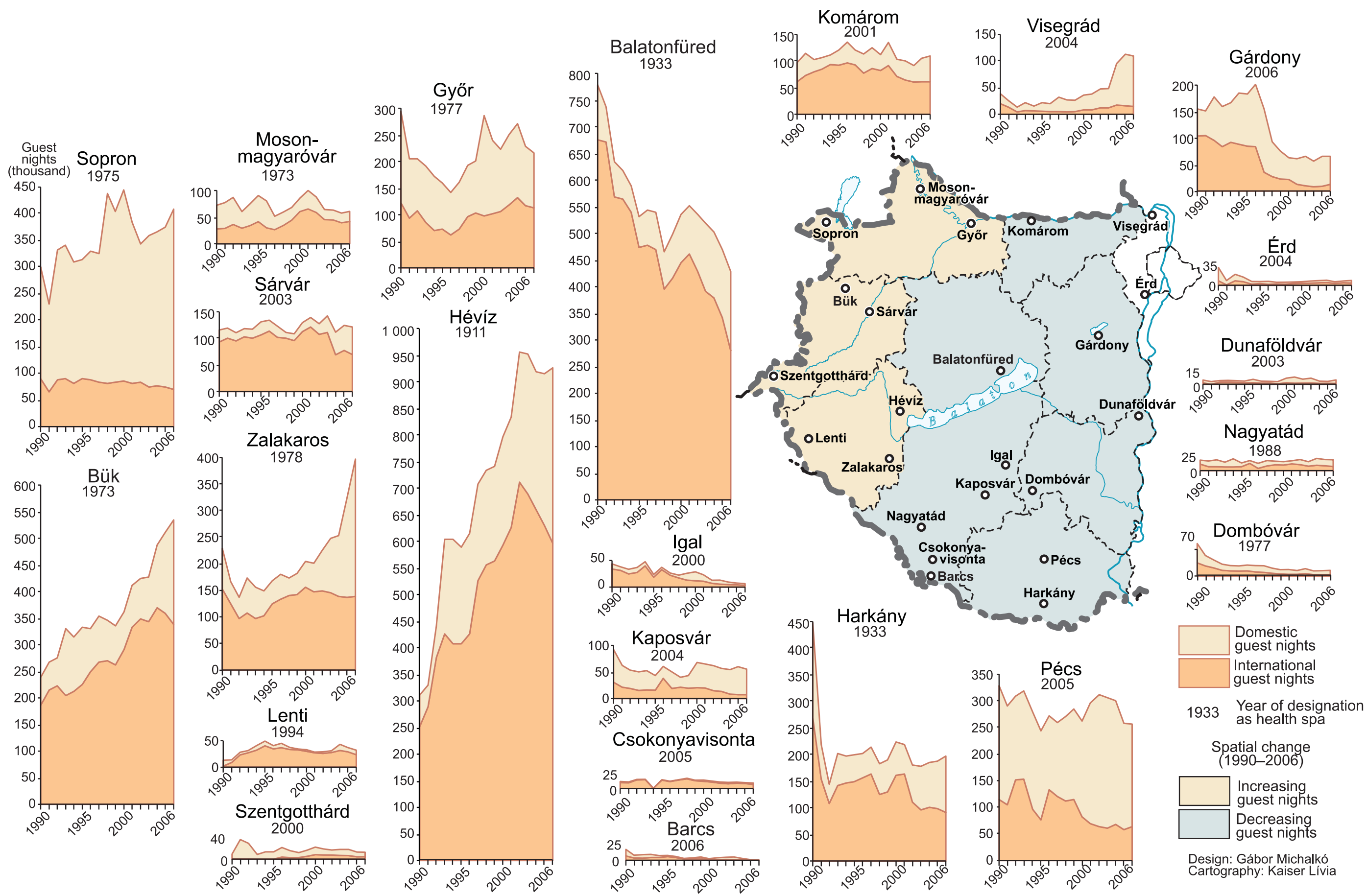

Fig. 1a. Guest nights at spa destinations in Transdanubia, 1990–2006

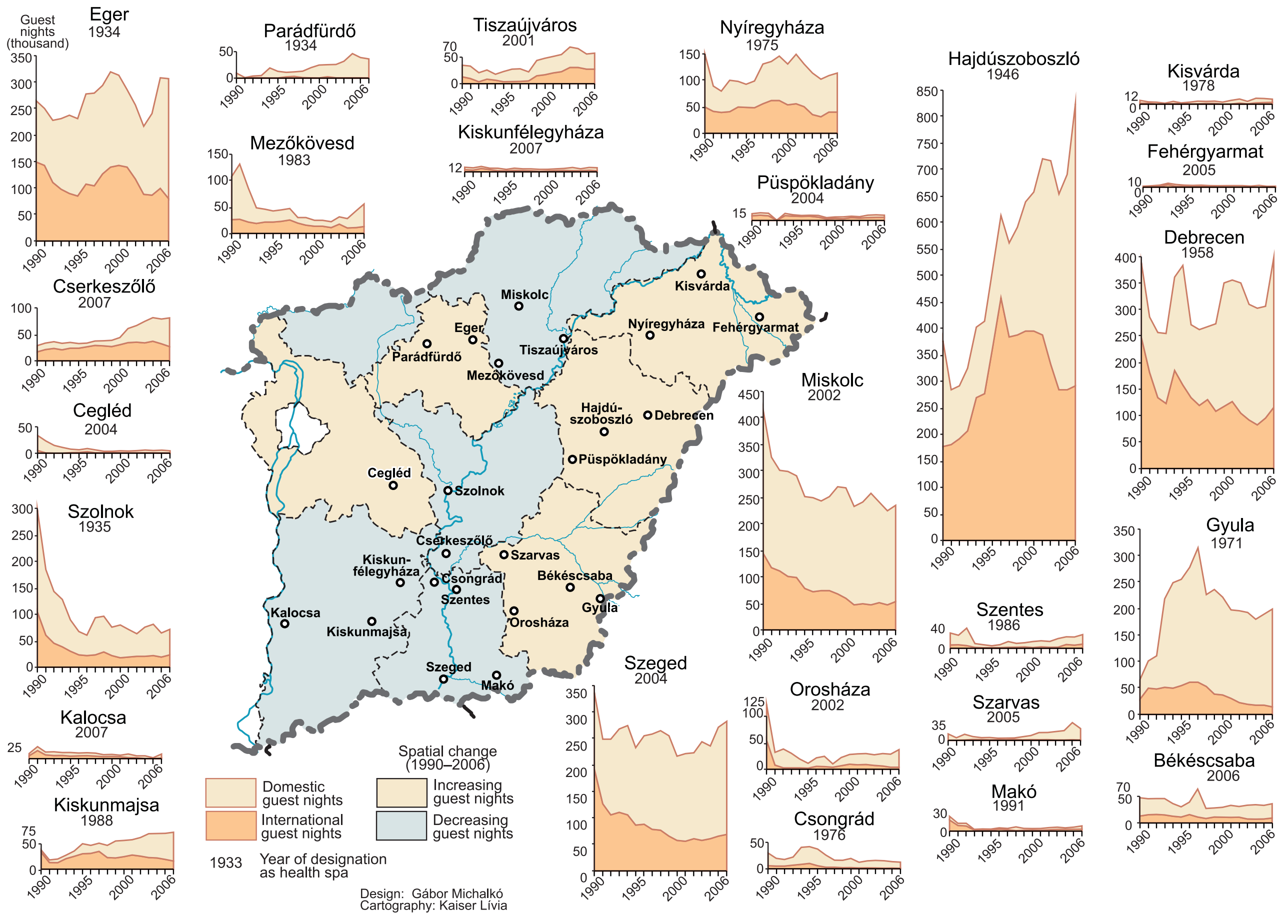

Fig. 1b. Guest nights at spa destinations in Eastern Hungary, 1990–2006

as primary attraction in the health tourism market. In the group of spa towns with moderate demand, Cserkeszőlő, Csokonyavisonta, Igal, Kiskunmajsa and Parádfürdő may be classified as monofunctional spa towns, while the economic structure and the tourist demand of other settlements are affected by further activities, such as culture in Visegrád, retail in Lenti, and industrial and/or agricultural activities in Tiszaújváros, Szentes, Szarvas, Szentgotthárd, Orosháza, Mezőkövesd, Mosonmagyaróvár, Kisvárda, Dombóvár, Csongrád and Nagyatád.

Among the spa destinations with **low demand** (with guest nights between 1,000 and 10,000), neither regional nor county centres are found. Most of these settlements are located either on the borders of Hungary (Barcs, Fehérgyarmat, Makó), or in the hinterland of major tourist destinations (Cegléd, Dunaföldvár, Érd, Kalocsa, Kiskunfélegyháza, Püspökladány).

Between 1990 and 2006, domestic guests accounted for an annual average 59% in spa destinations, and international guests accounted for 41% (excluding Budapest). Dominant domestic demand (higher than 67%) characterised 20 spa towns (42% of the settlements included in the study), while dominant international demand was registered in 6 settlements (13%). The majority of spa towns attracting predominantly domestic guests are located in the eastern part of Hungary, whereas all the spa towns that are characterised by a mainly international clientele are situated in the western part of the country. No relationship could be found between the origin of demand and the geographical location of a destination: the composition of demand is not affected either by the destination's distance from the borders or its closeness to the capital city, Budapest (i.e. the gate of international tourism in Hungary, and the major sending area in domestic tourism). The share of domestic guests is the highest (92%) in Parád, in the Mátra Mountains: medical tourists using the services of the state-owned spa hospital as prescribed by their doctor, accompanied by family members, account for the majority of the guests. The ratio of international visitors is the highest (83%) in Csokonyavisonta, near the Hungarian–Croatian border; however, this situation is rather the consequence of the demand of mainly German and Dutch guests staying at the traditional holiday centre of the township, than that of a cross-border Croatian demand.

Spa destinations as second homes of Hungarians

One aspect of the ample literature sources discussing second homes (Hall, M. and Müller, D. 2004) is the specific characteristics of the East European development in this field (Csordás, L. 1999). In the former socialist countries, before the change of the political system in 1989–1990, second homes formed one of the principal bases of private property ownership. In the centrally planned economies, purchasing real estate provided an opportunity to invest one's generally moderate savings in a profitable way on the one hand, and the possession of a second home raised the individual's social status, on the other hand. Consequently, leisure zones consisting of second homes were developed in the vicinity of larger cities, spa towns and waterside destinations. Additional factors in second home development were the era's political-economic characteristics: since international travel within the Soviet bloc was limited for political reasons, and the capacity of domestic tourism services (mainly holiday centres run by trade unions and companies) was insufficient to meet the growing domestic demand, buying or building second homes provided the only option to satisfy the population's leisure needs. Since adequate building materials were also scarce, the first leisure units in the late 1960's were more like small sheds on empty plots; ready-made wooden houses became popular in the 1970's, and stone buildings appeared in larger numbers mainly in the 1980's. The market of second homes experienced a boom in the 1990's: the new owners generally renovated the older buildings or demolished the sheds and wooden houses and had modern stone buildings constructed. The modernisation process was often accompanied by a change in the property's function: in several cases, the old/new owners changed residence and moved permanently to the former second home (e.g. the original owners spending their retired years in the former holiday home or their grown-up children settling down in the parents' holiday home).

The spa destinations play a special role in the Hungarian second home market. Compared to the use of leisure zones built around the larger cities and in waterside destinations, the use of holiday homes in spa destinations is less seasonal, which has resulted in a more favourable impact on the development of the given settlements. Most thermal health spas are fully or partly indoor facilities, i.e. they are available for guests throughout the year. The owners of second homes in the spa destinations can use the services of the spa any time of the year, but they can also rent out their property temporarily or offer it to friends and relatives. The less seasonal distribution of demand requires higher infrastructural development which has a positive impact on the destination's population, by attracting immigration and providing favourable opportunities to residents. In many cases, the holiday zones built around the spa town centres became semi-independent districts that contributed significantly to the overall economic and social development of the settlement.

The basis of research on second homes in Hungary is the 2001 census that included specific data collection on holiday homes. According to this database, 6% of all real estate units were used as second homes in 2001, and in 78 settlements, the share of second homes exceeded 50% of the total number of real estate units *(Figure 2).* These towns and villages may be classified as

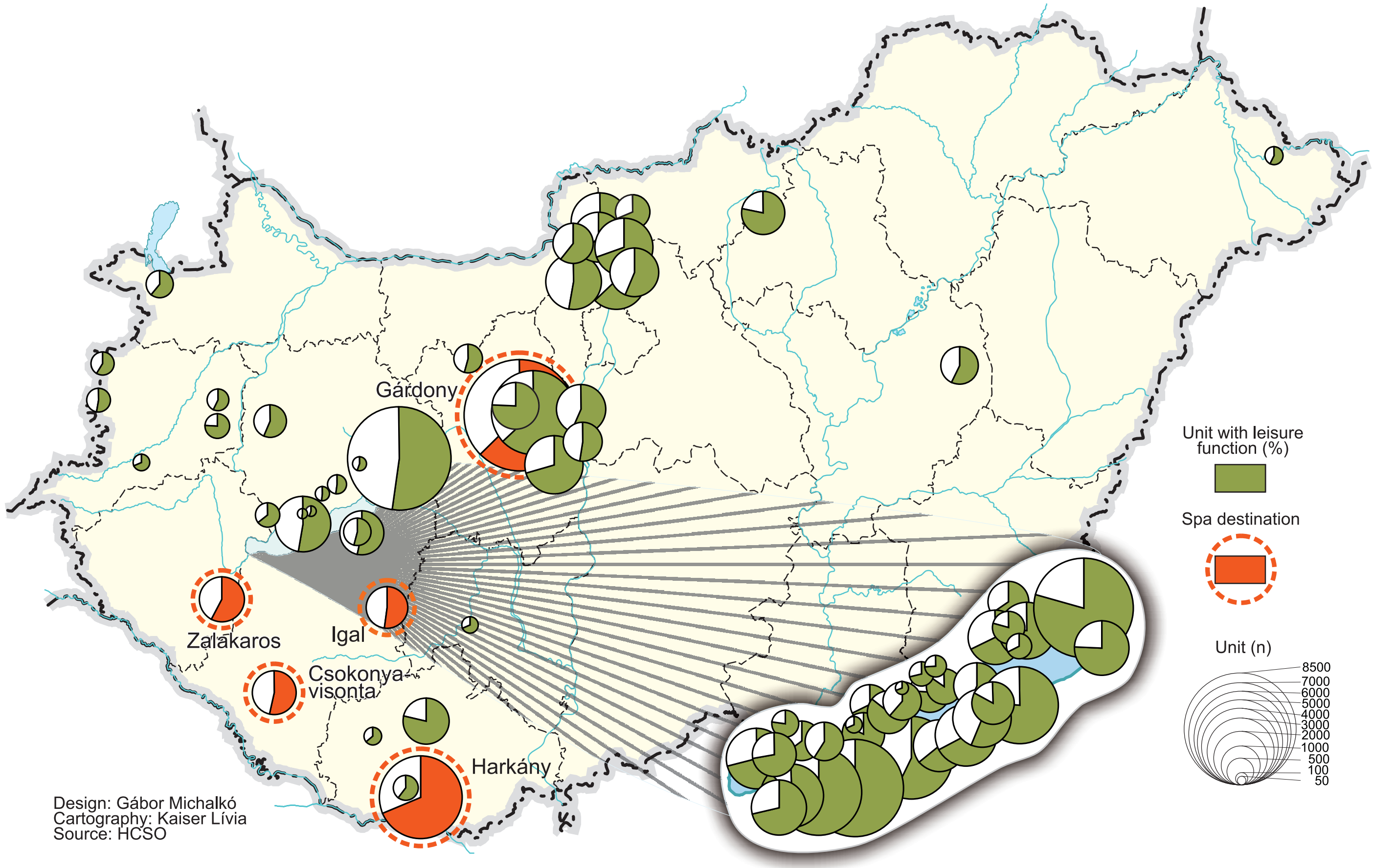

Fig. 2. Spatial distribution of real estates with dominant leisure function in Hungary, 2001

holiday settlements, the majority of which are concentrated in the picturesque Danube Bend, north of Budapest, as well as in the most popular water-based holiday destinations, in the Lake Velence and Lake Balaton regions.

Out of the 78 classified holiday settlements of Hungary, only five are spa destinations. Second homes account for more than 50% of all real estate units in Csokonyavisonta (53.3%), Gárdony (62.6%), Harkány (68.7%), Igal (51.9) and Zalakaros (57.8). All of the five spa towns are located in the western part of the country, and their population did not reach 10,000 persons in 2001, with the largest number of residents living in Gárdony (8,073 persons) and the smallest in Igal (1,351 persons). It shall be noted however, that despite the low population level, Three out of the five spa destinations have official town status (Gárdony, Harkány and Zalakaros), and while Gárdony's urban functions may be explained by its population size and the surrounding gravity zone, the town status of Harkány and Zalakaros, awarded after the political changes of 1989–1990, can be attributed, without doubt, to the settlements' dominant health tourism function.

Although the share of second homes within the overall property market cannot be considered dominant in Balatonfüred (35.2%), Visegrád (32.5%), Cserkeszőlő (25.6%), Hévíz (23.2%), Parád (19.4%), Hajdúszoboszló (17.2%) and Bük (15.6%), their ratio is still noteworthy. In further 23 spa towns the share of second homes is between 1 and 10%, i.e. rather low, while in the remaining 14 settlements the figure is negligible, i.e. less than 1%.

Real estate purchases by foreigners in Hungarian spa destinations

Buying real estate abroad is one of the main subjects in the field of tourism-migration research (Williams, A. and Hall, M. 2000). Studies within this area focus mainly on travel associated with property purchase, the age aspects of the phenomenon, with special attention to the involvement of the elderly, as well as to the main directions of international migration and tourism flows. Due to the lack of suitable databases, relatively few studies discuss the interrelationship of buyers' citizenship and their spatial preferences. In fact, such analyses were first carried out in Hungary, by Illés, S. and Michalkó, G. who examined the spatial and temporal aspects of foreigners' decisions on real estate purchase (Illés, S. and Michalkó, G. 2008; Michalkó, G. and Illés, S. 2008).

A data collection system based on uniform standards concerning real estate purchases by foreign citizens was adopted in Hungary in 2001. The available database allows the analysis of the number and citizenship of foreigners who bought real estate to be performed on settlement level. Between 2001 and 2006, 36,434 foreign citizens purchased real estate in Hungary. During this period, German nationals represented the largest group of buyers (33.1%), followed by Austrians (14.7%), Romanians (9.6%), Dutch (8.6%), Irish (6.3%) and British (4.1%), altogether accounting for 76.4% of the international customers. Concerning the spatial distribution of the purchased property, fairly characteristic territorial preferences could be identified by citizenship.

Germans preferred settlements in the Lake Balaton region (the largest lake in Central Europe, the main summer holiday destination of Hungary), while most *Austrians* bought property in towns and villages in the vicinity of the northern section of the common borderland. *Romanians* also favoured the area along the middle section of the respective borderland zone (in addition to Budapest). *Dutch* citizens mainly purchased homes and farmsteads in two specific areas of the countryside located south of the south-west–north-east axis of Hungary. *Irish* buyers displayed a clear preference for Budapest: the share of the Hungarian capital was so high (94.9%) that there are hardly any properties in Irish possession in the countryside. Similarly, *British* customers also bought real estates mainly in the various districts of Budapest.

To a certain extent, in the Hungarian property market every spa destination is subject to foreign customers' interest. Between 2001 and 2006, 20.6% of all real estate transactions by foreigners were completed in Budapest, whereas spa towns in the countryside registered 9.8% of the demand. However, the distribution of buyers by citizenship shows a unique picture in Budapest as compared to the countrywide composition of foreign real estate purchasers: Budapest is mainly attractive for the Irish (28.9%), the British (10.9%), the German (9.2%), the Romanian (6.4%), the American (5.1%) and the Italian customers. In contrast, the other spa towns located in the countryside are mainly popular among the German (29.6%), the Austrian (16.8%), the Romanian (11.9%), the Serbian (5.1%), the American (5.0%) and the Dutch buyers (4.1%).

A more detailed analysis of the countryside spa destinations shows that 17 different nationalities accounted for at least 10% of the demand for property, which indicates a very varied demand *(Figure 3)*. Within single settlements, only Germans, Austrians, Romanians or Ukrainians were able to reach a dominant position, i.e. constituted more than 50% of all demand. German buyers proved to be dominant in the real estate market of 8 spa towns: in Cserkeszőlő (58%) in the eastern part of the country, and in Dombóvár (65%), Gárdony (58%), Harkány (53%), Hévíz (52%), Igal (86%), Komárom (54%) and Zalakaros (83%) in western Hungary. Austrians dominate the property market near the Hungarian–Austrian border in Mosonmagyaróvár (65%) and Sopron (68%), Ukrainian buyers play a key role in Kisvárda (55%) located close to the Hungarian–Ukrainian border, while Romanian customers made the majority of real estate transactions along the central axis of Hungary, and in Makó (61%), Püspökladány (92%) and Tiszaújváros (63%). An analysis of the settlements' main functions and the composition of the international demand

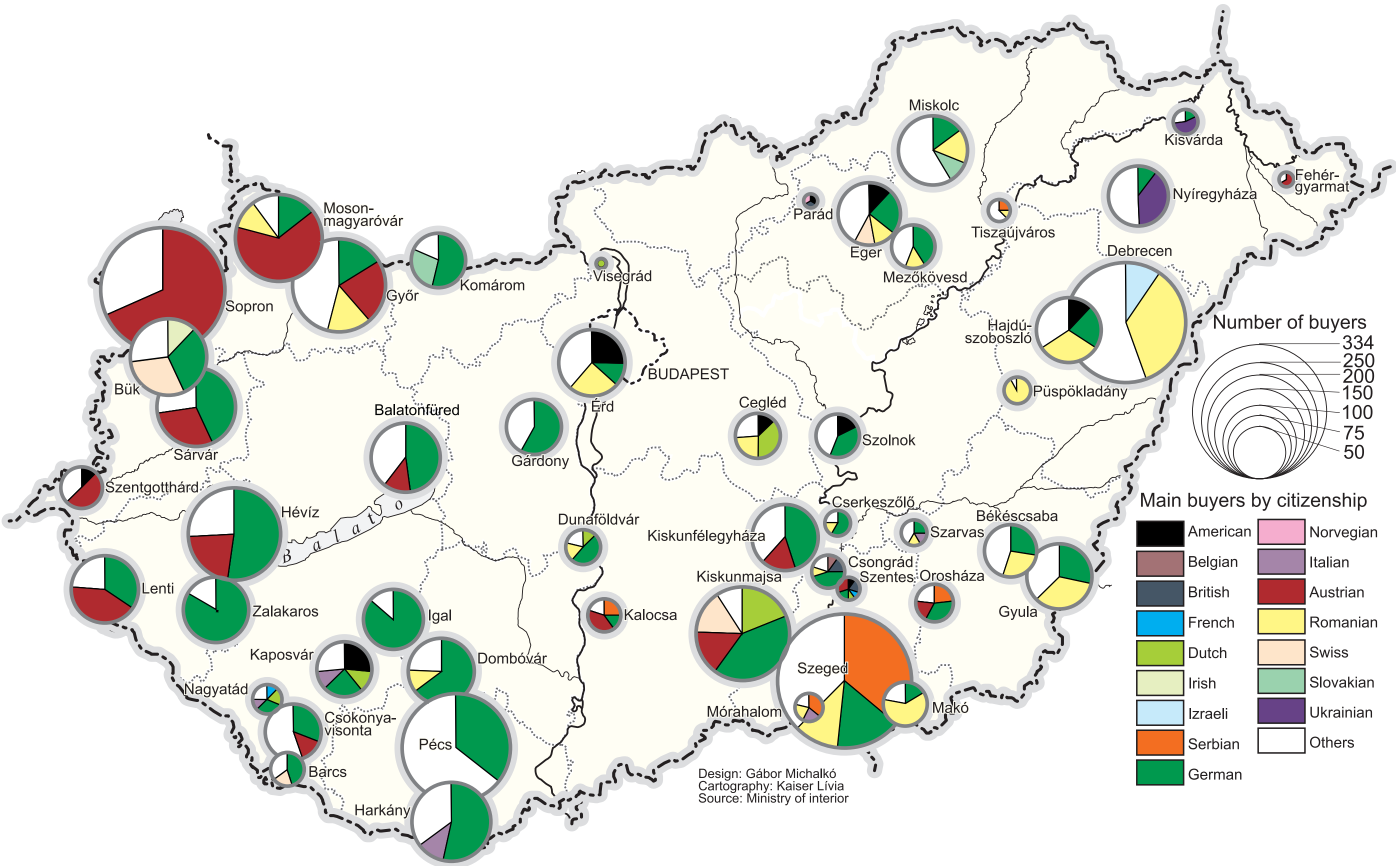

Fig. 3. Foreign real estate buyers in the spa destinations in Hungary, 2001–2006

in the real estate market suggest an influence of the geographical distance of the property buying decision, however, a health tourism oriented motivation only seems to affect the German and the Austrian customers. The dominant presence of Romanian and Ukrainian buyers is more likely to be explained by existential motives, such as the employment opportunities provided by certain settlements or areas.

In addition to the dominance of certain nationals within settlements, it is also important to analyse the most popular target markets within each nationality group, in order to make an effort to understand the relationship between health tourism oriented motivation and real estate purchase. However, there are very few settlements that are clearly favoured by a certain nationality – e.g. Szeged is the favourite market of the Serbian customers (66.5% of all transactions), Bük is most popular among the Irish (41.9%), Debrecen is the favourite of the Israeli (65%) and the Norwegian (43.6%) buyers –, and only the Dutch, the Swiss, the Irish and the German property purchasing decisions are likely to be explained by the attractiveness of a given destination's spa, in all other cases the spa is most probably only a supplementary factor in the decision-making process.

Conclusions

Hungarian spa towns play an exceptionally important role in the country's domestic and international tourism, due to their historic heritage as well as their present development and predicted potential. The country's spa heritage goes back to the Roman age and Ottoman occupation, when the basis of today's spa culture was laid; the investments realised within the framework of the Széchenyi Development Master Plan contributed to the development of the spa and health tourism infrastructure, while the National Tourism Strategy ensures the country's future competitiveness in this field.

Health spas are the main actors on the Hungarian health tourism market, and spa destinations are the major beneficiaries of health tourism demand. Despite the relatively even spatial distribution of spa towns, significant differences can be experienced in terms of economic and tourism development, and there is a strong competition in the tourism market among these settlements. Since the temperature and the mineral composition of mineral springs is suitable for health tourism development in each town, the level of demand is mainly influenced by the quality of the services, the tourist superstructure developed around the health spa (accommodation and restaurants), and the accessibility of the destination.

Hungarian citizens are likely to purchase property in spa towns: several leisure districts located on the periphery of these settlements were built as a consequence of Hungarians' demand for a second home. However, despite these favourable processes, spa towns cannot be considered the primary targets for domestic owners of second homes: out of the 48 spa towns included in the study, second homes accounted for more than 50% of all real estate units only in five settlements. Nevertheless, purchasing property in a spa town is generally a good investment, due to the continuous development of spa and health tourism, since the owners can easily sell their property or rent it out throughout the year. As a consequence, real estate prices are relatively high in the popular spa destinations, which may limit the number of domestic customers compared to international buyers with generally higher purchasing power.

Foreign citizens appeared in larger numbers on the Hungarian real estate market only after the systemic change in 1989–1990. Since spa destinations have always played a key role in Hungary's international tourism, many foreign citizens showed willingness to invest their savings in real estate in already familiar settlements where they earlier had had pleasant experiences. International demand for property in Hungarian spa destinations is quite varied: there is a significant difference in the buyers' nationality concerning the preference of the capital or the other spa towns, the common customer groups being the Germans, the Romanians and the Americans. Although the available statistical data are not suitable for analysing the relationship between health tourism-related motivation and real estate purchase decision, the monofunctional nature of certain target settlements suggests such a correlation.

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Main socio-economic and environmental trends in the Carpathian region

István Pomázi[1] and Elemér Szabó[2]

Abstract

The authors aim at analysing major socio-economic and environmental processes in the Carpathian region which represents a unique macro-region in Central Europe. The Carpathian countries have experienced major political, economic, social and environmental changes during the past 20 years. Their economy, industry, agriculture and transport sectors were originally developed at accelerated rates, increasing pressures on the environment. Since early 1990s, the GDP, industrial production and agricultural output fell significantly; shrinking economic output contributed to significant reduction of air and water pollution and sudden fall of agricultural chemicals. The most spectacular signs of decoupling can be seen in the case of traditional air pollutants like sulphur dioxide and nitrogen oxides clearly showing effects of fuel mix change. High unemployment, increasing poverty, depopulation of the rural mountain areas are common features in the Carpathians.

Keywords: Carpathian region, socio-economic and structural changes, environment pressures, decoupling

Introduction

At the Fifth Ministerial Conference "Environment for Europe" (Kiev, May 2003), the Carpathian countries adopted the "Framework Convention on the Protection and Sustainable Development of the Carpathians" consequently signed by all seven countries. The Carpathian Convention is a framework type convention pursuing a comprehensive policy and cooperating in the protection and sustainable development of the Carpathians. Designed to be an innovative instrument to ensure protection and foster sustainable development of this outstanding region and living environment, the Convention is willing to improve the quality of life, to strengthen local economies and communities. It aims as well at providing conservation and restoration of unique, rare and

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typical natural complexes and objects of recreational and other importance situated in the heart of Europe, preventing them from negative anthropogenic influences through the promotion of joint policies for sustainable development among the seven countries of the region (Czech Republic, Hungary, Poland, Romania, Serbia and Montenegro, Slovak Republic and Ukraine).

There are different approaches in the delimitation of the Carpathian region according to the purpose of the studies. One approach is traditional in physical geography such as Bulla, B. and Mendöl, T. (1947, 1999), who described the units of the Carpathian Basin in detail, as well as J. Kondracki's (1978) book on the Carpathian Mountains. World Wildlife Fund in the framework of the Carpathians Ecoregion Initiative followed an ecosystem approach (WWF 2001). European Academy (2006) published a comprehensive study about a broad range of the way of subdivision of the Carpathian Convention area. The Carpathian Project led by UNEP introduced the notion of Carpathian Space as a development area (Borsa, M. *et al.* 2009).

The socio-economic geographical approach should rely on solid statistical data and information which were not collected within natural borders but refer to multi-level administrative units. In this study the authors use three classes of EU territorial statistical units (NUTS1-2-3) for five EU member states. In the case of the remaining two countries (Serbia and Ukraine) the analysis bases on national statistical data which are not always comparable with the Eurostat standards and methodology.

General economic geographical overview

The Carpathian countries have experienced major political, economic, social and environmental changes during the past 20 years. Previously their economy, industry, agriculture and transport sectors were developed at accelerated rates, increasing pressures on the environment. In the late 1970s and during the 1980s, some economic contraction occurred, when the rate of economic growth declined and external debt reached high levels.

In the early 1990s, GDP, industrial production and agricultural output fell significantly, while diminishing economic output led to a significant reduction of air and water pollution. In most countries, the recent economic recovery did not lead to major increases in such pollution again. Decoupling of economic growth from environmental load is the result of economic and technological modernization and stricter enforcement of new environmental regulations.

The Carpathian economy today is based mainly on farming, forestry and mining, which remain predominant land uses. Over decades under command economy there was an intense and rapid conversion of farmland for the sake of the expansion of human settlements, industrial and mining activities, and infrastructural development. During the last two decades agricultural output, including plant production and animal husbandry, has decreased in the Carpathians and sizeable areas have reverted to fallow land. In the beginning of the 1990s, a sharp decline of agricultural production was accompanied by a decrease in the use of pesticides and fertilisers. With the increase of production since 1994, fertiliser consumption resumed, but the use of pesticides remains very low.

Forestry is a major economic sector in the Carpathian countries. Under communist regimes forests were over-exploited, with the total harvest exceeding the annual increment. Forests are getting younger and thinner, while extensive clearcutting has resulted in accelerated runoff during heavy rainfall and floods. Currently, there is a general trend toward stabilization of forest extent in the Carpathians. The process of industrial decline in many areas of the Carpathians has had beneficial effects through recovery from former pollution levels. However, forests will remain extremely vulnerable, as spreading poverty leads to extensive illegal logging for heating purposes.

The Carpathian countries are highly dependent on imported oil and natural gas, mainly coming from Russia (Kocsis, K. and Tiner, T. 2009). Over the past decade the Carpathian countries have restructured and downsized their coal industries by closing down inefficient (deep) mines and reducing the coal mining labour force. The geostrategic importance of the Carpathian region lies in the oil and natural gas pipelines traversing most of the countries on their way to Western Europe. In general, power production in the Carpathian region relies mainly on fossil fuels, followed by nuclear- and hydropower and renewable energy sources.

Main macro-economic and structural policy trends

An overview of regional environmental and socio-economic trends is impossible without the analysis of major historical and political changes which have taken place during the last three decades.

The Carpathian countries were all members of COMECON (Council of the Mutual Economic Assistance) and the Warsaw Pact military alliance (except Yugoslavia). Ukraine was part of the Soviet Union until its independence in 1991. In most countries radical political changes happened in 1989–1990/1991 that variously resulted in free elections and establishment of plural democracy and separated branches of power. Following a referendum Czechoslovakia was split into two independent countries (Czech Republic and Slovak Republic) in 1993. After formerly federal Yugoslavia gradually lost its territorial integrity and its republics gained independence, a series of Yugoslav Wars followed during the 1990s.

Since the early 1990s four countries (Czech Republic, Hungary, Poland and Slovakia) began their integration process with the European Union that culminated in accession on May 1, 2004. Romania also joined the EU on January 1, 2007. After the separation of the State Union of Serbia and Montenegro in 2006, Republic of Serbia is participating in the stabilization and association process while Ukraine is a part of European Neighbourhood Policy initiated by the EU.

Economic growth: from the 1970s until 2009

In all Carpathian countries, the political changes were followed by around ten years of economic decline and increasing poverty, along with stagnating or slightly increasing life expectancy for both sexes. All countries now have to face population decline and population loss by migration abroad even though there is an unprecedented increase in the case of Czech Republic. Ukraine has sunk in a deep demographic crisis.

In most Carpathian countries the development of industry, agriculture and transport sectors originally involved a great deal of energy consumption and had led to emission of pollutants at accelerated rates and increasing pressures on the environment. At the end of the 1970s or during the 1980s, some economic contraction occurred, when the rate of economic growth declined and external debt reached extremely high levels, in particular in Hungary and Poland. After the collapse of the Soviet Union, traditional economic and external trade ties severed, and a transition from planned to market economies began.

The long-lasting economic recession was accompanied by a reduction in overall environmental pressures, and the improvement of the state of the environment, without even any strong policy measures. In the late 1990s, some countries reached the level of economic output of late 1980s; others were facing recovery and stabilization. Since 1990 there have been great differences in GDP growth between the Carpathian countries. The highest economic growth rate has been reached by Poland followed by other Visegrad countries (V4 countries) while Romania witnessed two subsequent economic depressions in the early and late 1990s. In Ukraine after the collapse of Soviet Union there has been an almost decade long and very deep economic decline. In 2005, Ukraine was the only country which has not even reached its level of economic output in 1990. The economic transition towards market economy has been accompanied by high inflation rate, especially in Romania and Ukraine.

Since autumn of 2008 these countries were hit by global financial and economic crisis which is now penetrating into the social sphere. All Carpathian countries but Poland show marked turn-down in GDP. In 2009 Ukraine represented the highest rate decline (-15.3%), followed by Romania (-8%), Hungary (-6.3%) and Slovakia (-5.8%) (*Figure 1*). The deepening economic crisis has contributed to rising unemployment, e.g. the latter almost doubled in Hungary since 2002 (from 5.6% to 10.7%). (*Figure 2*).

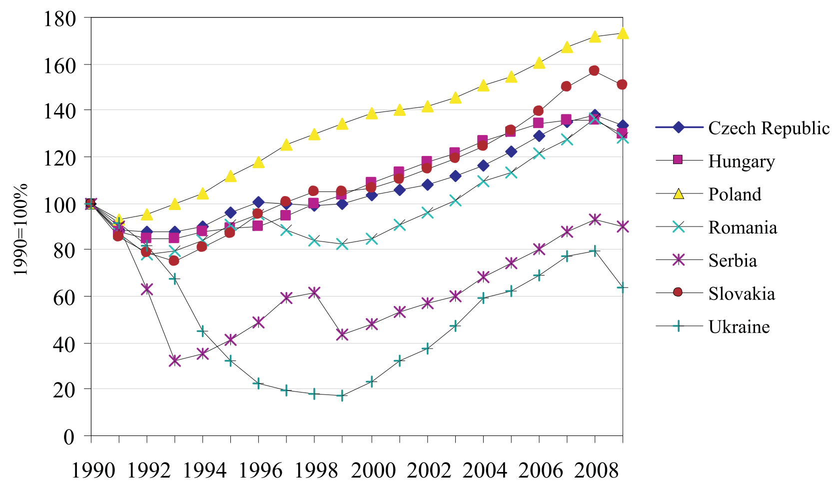


Fig. 1. GDP growth, 1990–2009. *Source:* World Bank (1980–2008), Eurostat (2009 preliminary data), Statistical Office of Serbia (2009 preliminary data), State Committee of Statistics of Ukraine (2009 preliminary data)

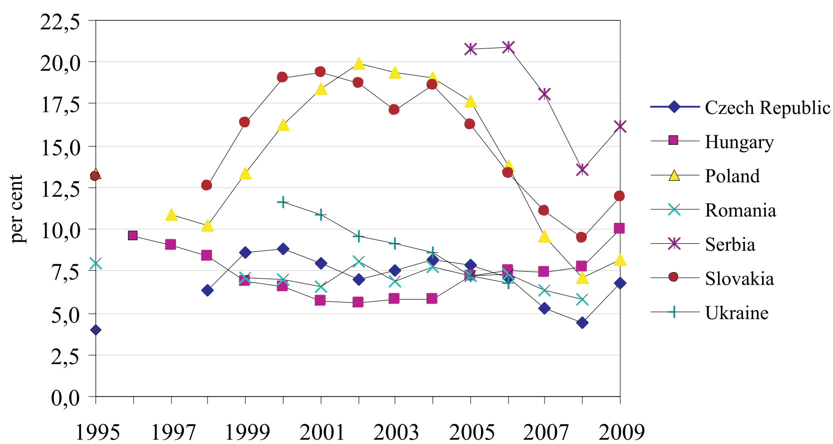


Fig. 2. Unemployment rate in the Carpathian countries, 1990–2008. *Source:* UNECE Statistical Division Database, compiled from official national and international (Eurostat and ILO) sources Data of 1998, 1999 and 2009 are from Eurostat database (2010)

Recent regional disparities

One can find two discernible axes of development in terms of GDP per capita across the Carpathian region (NUTS3 level). From higher to lower, the first goes from northwest to southeast, and the second from west to east. The most developed areas are located in the Moravian Carpathians and Bratislavský kraj, with over 10,000 EUR per capita, as well as in north Hungary with 4,600–8,900 EUR per capita. In most of the Romanian Carpathian counties, this figure is below 5,000 EUR per capita (*Figure 3*).

Employment

A certain duality has emerged in the recent development of employment and unemployment in the Carpathians. On the one hand, changes in employment, while being significantly different across countries, generally reflect the cyclical position and momentum of each economy, differences in the sectoral composition of economic growth, and the varying ability of markets to cope with the adjustments imposed by economic transformation. On the other hand, unemployment has been generally persistent, with most countries unable to achieve a significant reduction in their high rates of unemployment.

In 2008–2009, Serbia, Slovakia and Hungary had the highest unemployment rate (16.1%, 11.9% and 10.7%, respectively). In the case of the Czech Republic, Poland and Romania the national unemployment rates stood between 6–8% while Ukraine showed similar rate (6.8% in 2006). In all but one country (Romania) female unemployment rate exceeded males' one. According to data of 2008, the seven Carpathian countries could be divided into two main groups regarding the total unemployment: one is ranging from 4.5–8.1%, the other is over 9.5%. In most of the countries, the unemployment rate is more severe for both sexes among young people. In recent years, the unemployment rate for the age 15–24 has reached alarming levels in Poland, Romania, Slovakia and Hungary. For example, in 2008, in Hungary almost 20% of youth did not have jobs while in Poland, Romania and Slovakia this rate exceeded 2–3 times the national average of unemployment level (*Figure 2*).

Structural changes

Over the past decade, the national economies of the Carpathian countries have been significantly restructured. For example, the expansion of the service sector exceeded the growth rate of all the other sectors and in 2008 accounted for over 60% of the GDP in three countries. Hungary has the most robust service sector followed by Poland, the Czech Republic and Romania. The share of GDP within the service sector in Slovakia, Serbia (together with Montenegro until 2006) and Ukraine, while still having been high, was lagging behind at slightly below 60%.

Agriculture still plays an important economic role in Romania, Serbia and Ukraine. For the Visegrad countries, the GDP share from agriculture was around 4% (in Czech Republic 2.3%) in 2008 (*Table 1*).

Table 1. Structural changes in the Carpathian countries, 1990 and 2008 (Value added, % of GDP)

Country	1990			2008		
	Agri-culture	Industry	Services	Agri-culture	Industry	Services
Czech Republic	6.24	48.75	45.01	2.33	37.56	60.11
Hungary	14.54	39.06	46.40	4.31	29.45	66.25
Poland	8.26	50.11	41.63	4.18	30.35	65.47
Romania	23.74	49.94	26.32	8.05	33.96	57.99
Serbia*	..	..	..	12.96	28.44	58.61
Slovakia	7.41	59.14	33.45	3.61	41.22	55.17
Ukraine	25.57	44.57	29.86	8.33	36.89	54.78

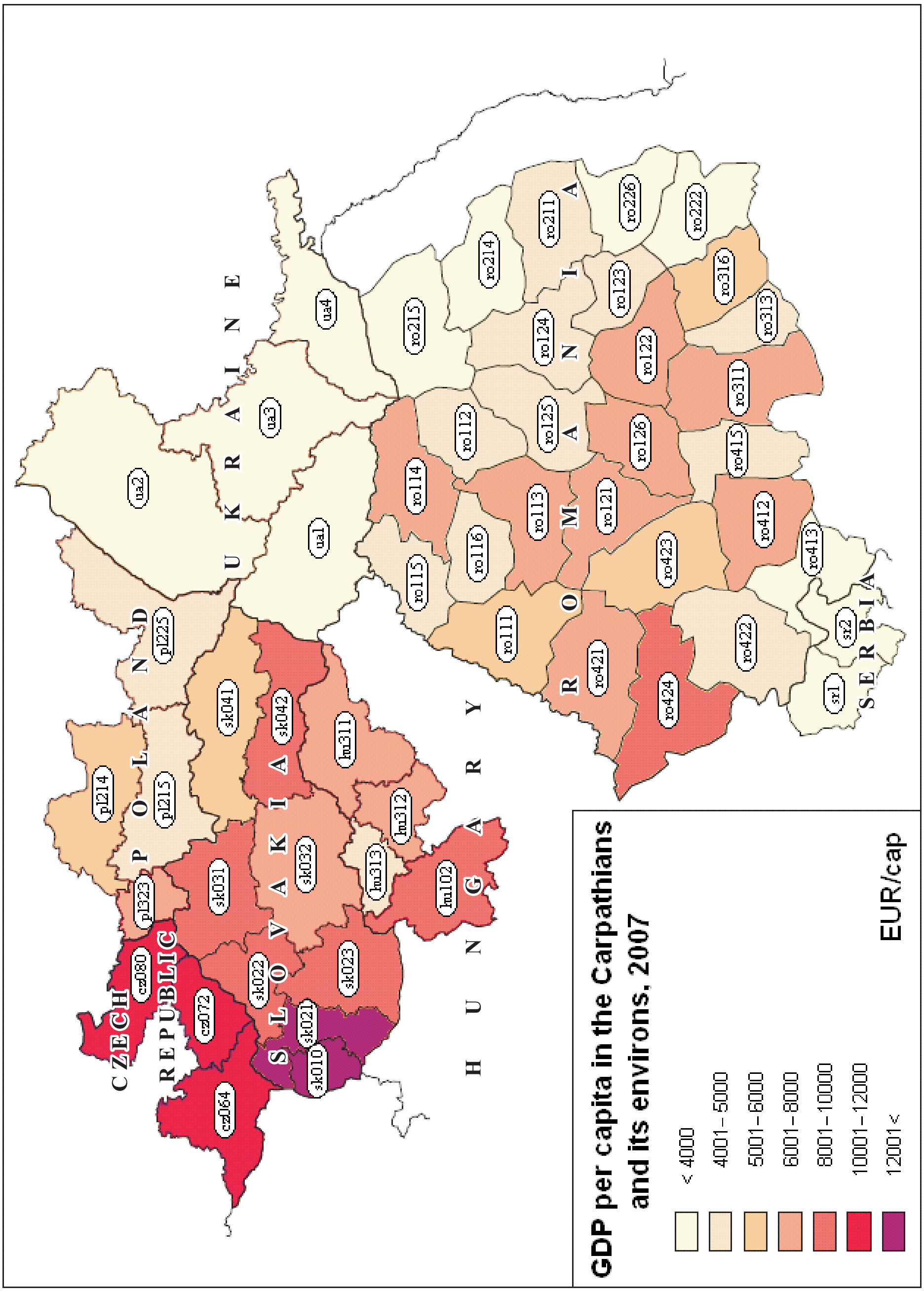
*Data for Serbia refer to 2007. ..= No data. Source: World Bank

Focusing on the Carpathian areas of the countries, economic activity in the last centuries was determined by the natural environment, folk customs, tribal relations and the economic policies of the governments that had control upon the region. As in the past, the economy and land use today is based on farming (closely associated with animal husbandry) and forestry. As compared to that of neighbouring lowlands, the economy of the Carpathians is far less developed. However, the situation varies considerably from country to country and region to region.

Decoupling impacts on the environment

Most probably, the existence of informal economy has a lot of negative environmental consequences such as illegal waste movement and disposal, illegal logging, illegal trade of endangered flora and fauna, not speaking about overall avoidance of environmental regulation and rules.

Pre-1989 approaches to the environment did not show adequate concern about the ecological aspects and potential negative consequences of human activities. The Carpathians are now confronted by a mix of challenges which require co-ordinated management. There are clear differences between northwest and southeast parts of the region. These differences are manifested in variations of state and foreign direct investments, unemployment rate,


GDP per capita in the Carpathians and its environs, 2007
< 4000
4001–5000
5001–6000
6001–8000
8001–10000
10001–12000
12001 <
EUR/cap
CZECH REPUBLIC
POLAND
UKRAINE
SLOVAKIA
HUNGARY
ROMANIA
SERBIA

poverty levels and some ethnic tensions. Development threats are therefore greater in the northwest, including hunting and tourism. Forests are expanding partly due to the lower farming pressure. Mass tourism only exists in some areas. Development pressures are much weaker in the southeast part of the Carpathians; yet the poorer regions with high unemployment generate further threat to the environment trough illegal cutting of restituted forest lands. For example, legislation passed in early 2000 in Romania could eventually increase private ownership and poverty could also result in high levels of forest clearance similarly to the experiences with the first round of privatization in early 1990s.

All the Carpathian countries with different pace of transition have undergone significant political, economic, social and environmental transformation in the past 20 years. In early 1990s, the GDP, industrial production and agricultural output fell significantly; shrinking economic output contributed to significant reduction of air and water pollution and sudden fall of agricultural chemicals (so-called environmental gratis effect). In most countries, the latest economic recovery did not entail similar extent of growth in traditional pollution. This decoupling process is the result of economic and technological modernization and stricter enforcement of new environmental regulations.

The most spectacular signs of de-coupling can be seen in the case of traditional air pollutants like sulphur dioxide and nitrogen oxides clearly showing effects of fuel mix change (switch from coal to natural gas). The biggest reduction of sulphur dioxide emissions occurred in Czech Republic, Hungary (90%) and Slovakia (85%), while it accounted for lower levels in Poland and Romania (nearly 60%). The figures show high fluctuations in Ukraine with down-turning trend reaching 50% in 2008 in comparison with 1990. In general, nitrogen oxides decreased to a lesser extent, within the range of 20–60% (*Figure 4A–E*).

←

Fig. 3. GDP per capita in the NUTS3 entities of the Carpathian Convention, 2007. Note: cz064 = Jihomoravský; cz072 = Zlínský; cz080 = Moravskoslezský; hu102 = Pest; hu311 = Borsod-Abaúj-Zemplén; hu312 = Heves; hu313 = Nógrád; pl214 = Krakowski; pl215 = Nowosądecki; pl225 = Bielsko-bialski; pl323 = Krośnieński; ro111 = Bihor; ro112 = Bistrița-Năsăud; ro113 = Cluj; ro114 = Maramureş; ro115 = Satu Mare; ro116 = Sălaj; ro121 = Alba; ro122 = Braşov; ro123 = Covasna; ro124 = Harghita; ro125 = Mureş; ro126 = Sibiu; ro211 = Bacău; ro214 = Neamț; ro215 = Suceava; ro222 = Buzău; ro226 = Vrancea; ro311 Argeş; ro313 = Dâmbovița; ro316 = Prahova; ro412 = Gorj; ro413 = Mehedinți; ro415 = Vâlcea; ro421 = Arad; ro422 = Caraş-Severin; ro423 = Hunedoara; ro424 = Timiş; sk010 = Bratislavský kraj; sk021 = Trnavský kraj; sk022 = Trenčianský kraj; sk023 = Nitrianský kraj; sk031 = Žilinský kraj; sk032 = Banskobystrický kraj; sk041 = Prešovský kraj; sk042 = Košický kraj; ua1 = Zakarpats'ka; ua2 = L'vivs'ka; ua3 = Ivano-Frankivs'ka; ua4 = Chernivets'ka; sr1 = Branicevski; sr2 = Borski. *Source:* Eurostat; State Committee of Statistics of Ukraine; Statistical Office of Serbia

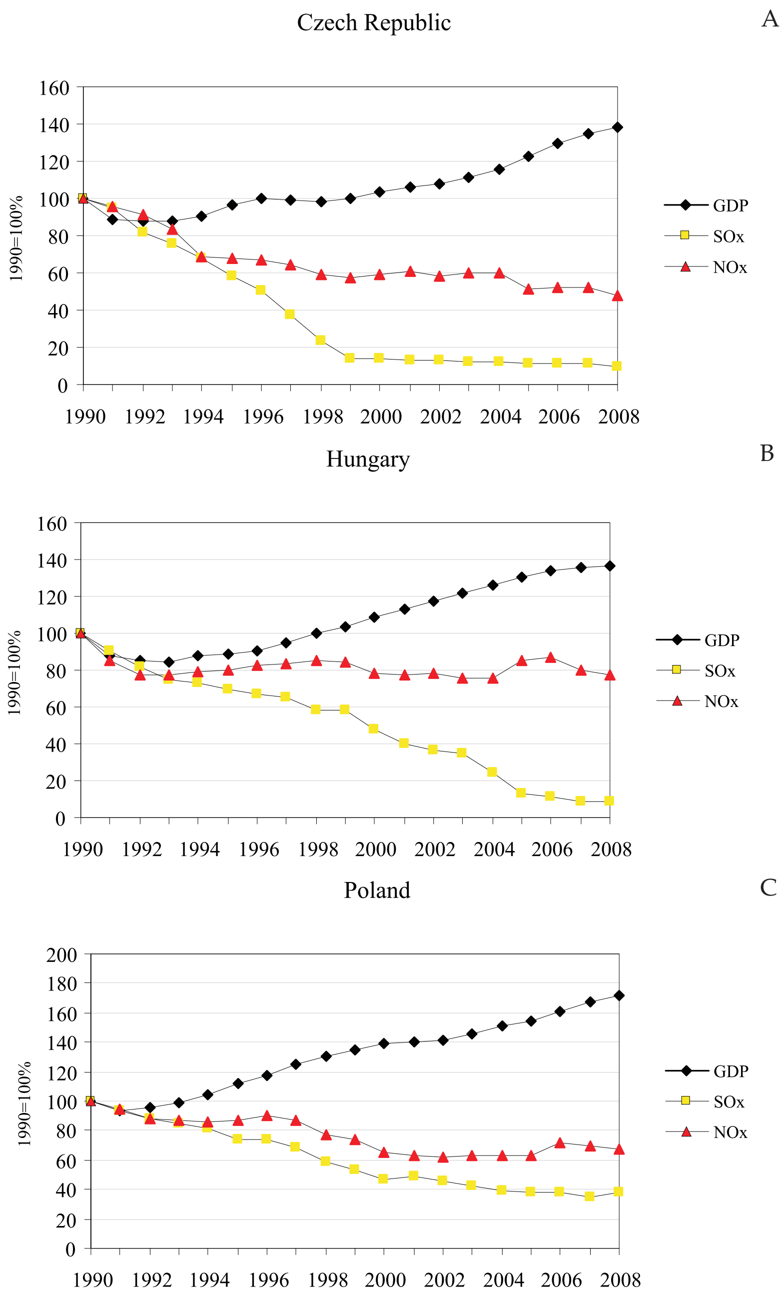
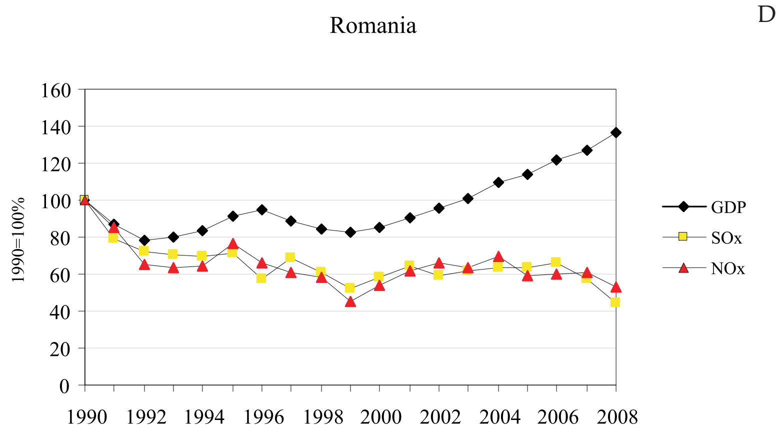


Fig. 4A,B,C. Decoupling of GDP from air emissions, 1990–2008. *Source:* GDP data are from World Bank, SO_x and NO_x data are from EMEP (European Monitoring and Evaluation Programme)



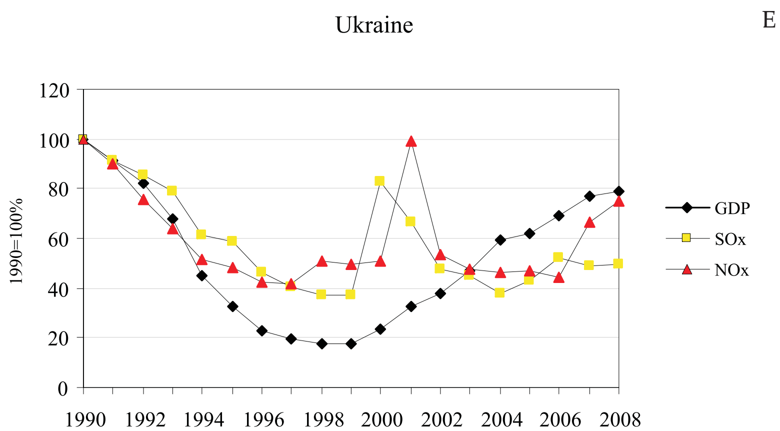


Fig. 4D,E. Decoupling of GDP from air emissions, 1990–2008. *Source:* GDP data are from World Bank, SO_x and NO_x data are from EMEP (European Monitoring and Evaluation Programme)

Decoupling of environmental pressures from economic growth requires integrated approach in the management of consumption and production patterns including more efficient use of natural resources. Resource productivity is a very important tool in measuring material consumption of the economy. In 2005, according to Eurostat calculation the resource productivity was 1.3 EUR/kg at EU27 level, at the same time it was around one eighth in Romania and one third in Visegrad countries. This means that resource efficiency in these countries four or eight times lower than EU27 level. This figure is much higher in comparison with EU15 average. Changes in the sectoral composition of the economy can be added to the growth of the productivity of resources on sectoral level. They include shift towards knowledge-based and service-based economy, which may decrease demand for natural resources and promote waste minimization but also may have an impact on the environment. Policies aimed at direct integration of environmental impacts of consumption and production patterns during the whole life cycle (i.e. integrated product policies) are needed.

In the past decade, the sectors of the economy have been significantly restructured. The expansion of the service sector (except for the last two years) exceeded the growth rate of all the sectors, and currently accounts for over 60% of the GDP.

Societal driving forces and pressures

Population trends

Over the last 20 years, population trends in the Carpathian countries have generally been characterized by features such as high rates of population loss in Romania and Ukraine and slight decreases or stagnation in Hungary and Slovakia. This is seen as a negative pressure, as healthy populations are needed to preserve cultural and economic traditions all over the world, and especially in mountain areas.

Since 1990, Ukraine has lost roughly 12% of its total population, or some 5.7 million people leading to a serious demographic crisis. During the same time period, the Romanian population decreased by around 8%. In both countries, international migration was a key contributing factor (*Figure 5*).

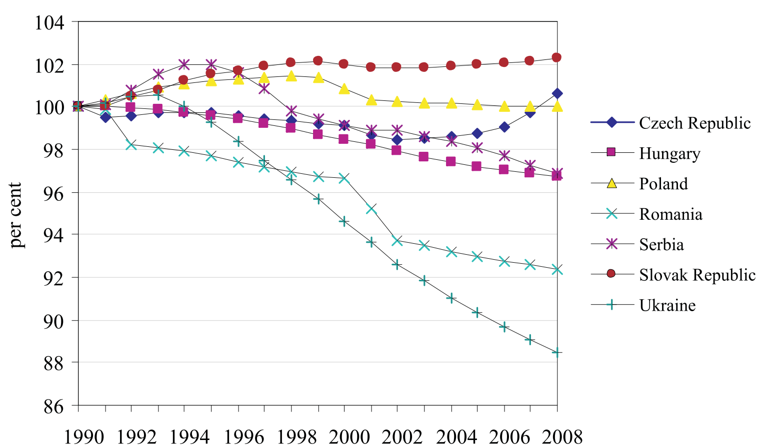


Fig. 5. Total population growth rate, 1990–2009. *Source:* World Bank

For example, between 1975 and 1999, nearly 700,000 people emigrated from Romania, most of them Romanians, Germans and Hungarians. Migration has increased in recent years due to the scarcity of work opportunities in the poorest areas of the Carpathian basin, and the proliferation of job offers in economically more developed areas, for example Romanians and Ukrainians crossing into Hungary or outside of the basin.

Population density varies significantly from region to region. Those with the highest population density are located in the Czech and Polish Carpathians, with over 175 inhabitants per sq km. The lowest densities occur mainly in the Romanian Carpathians, with less than 100 inhabitants per sq km (UNEP 2007).

There is a large Roma (otherwise known as "Gypsies") population, in the Carpathians, particularly in east Slovakia, northeast Hungary, west Ukraine and north Romania. These are some of the poorest regions of the respective countries and suffer from high unemployment and economic underdevelopment (Pomázi, I. *et al.* 2006). Communities are vulnerable, as residents are victims of poverty, social exclusion and discrimination. Addressing these concerns is becoming an increasingly important socio-political issue for national and sub-regional governments. Effectively integrated land and water management applied in a sustainable manner would be one of the tools that could be used to alleviate poverty in the region.

Roma are far fewer in number and less controversial in Poland. Estimates of their population in Poland range from 15,000 to 50,000. In contrast, Roma in the former Czechoslovakia numbered 500,000 in the 1980s when Poland became a transit point on the illegal migration route from Romania to Germany. The emigration of Polish Roma to Germany in the late 1980s reduced Poland's Roma population by as much as 75% (UNEP 2007).

Life expectancy

There is a mixed picture in the Carpathian countries concerning life expectancy at birth. In all countries the male population lives much less in comparison to both female population in the Carpathian countries and to EU-15 average. The situation is more than alarming in Ukraine where life expectancy of male population is 62 years, while in the Czech Republic it accounted 74 years in 2008. Concerning the female life expectancy there is a smaller gap between the above mentioned countries (80.5 vs. 74.0 years) (*Figure 6A*,*B*).

In early 2000s, the infant and child mortality rates were the highest in Romania, Serbia and Montenegro, and Ukraine among the Carpathian countries.

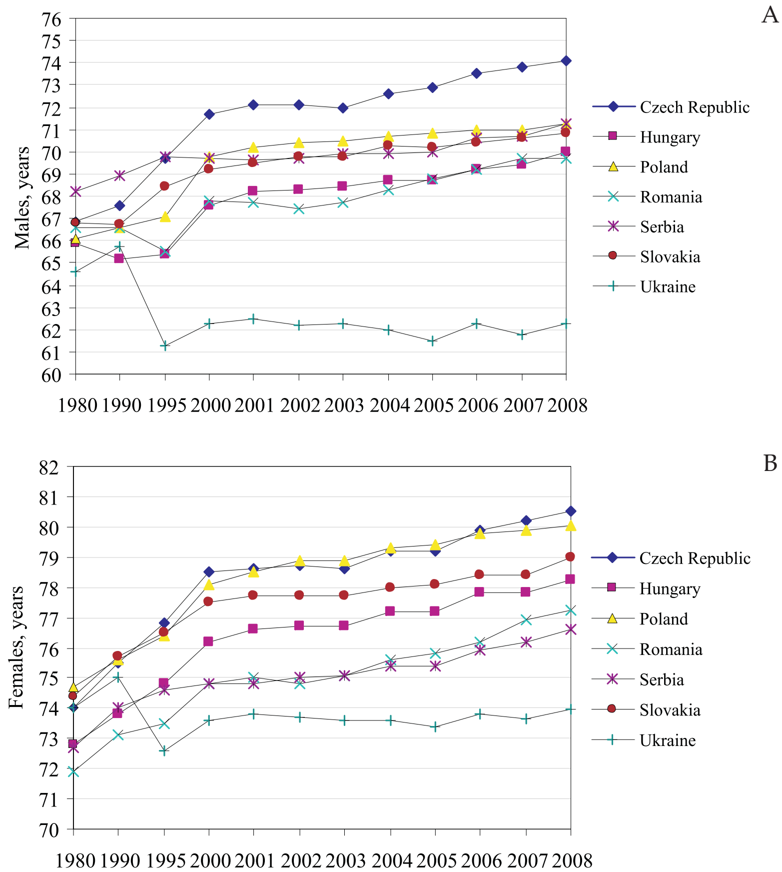


Fig. 6A,B. Life expectancy, 1980–2008. *Source:* UNECE

A general tendency in the Carpathian countries is the ageing of the population but there are some exceptions. For example, in Serbia and Montenegro the rate of young population is the highest among the Carpathian countries.

Poverty and environment

The interconnection between poverty and environment is an important and challenging topic of how human well-being is influenced by the natural environment and vice versa. It has become clear that ecosystems provide more than just goods for humans. They also secure critical life-supporting services and cultural and spiritual values for human societies.

Ecosystem services are the conditions and processes through which natural ecosystems, and the species constituting them, sustain and fulfil human life. They maintain biodiversity and the production of ecosystem goods, such as forage, timber, biomass fuels, natural fibres, and many pharmaceuticals, industrial products.

In addition to the production of goods, ecosystem services are the actual life-supporting functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well.

All people – rich and poor; living in developing or developed countries – depend on ecosystem services for their well-being. This is however only true in the long run. In the short run, the poor are more heavily dependent on these services than the rich.

For example, the rich can buy clean water or the technology to filter and purify water if it is contaminated. The poor, on the other hand, have limited resources to pursue these options and usually have no choice but to depend on natural water systems and/or public water supply systems, many of which do not meet the minimum standards for human consumption, especially in developing countries.

The same can also be said for extreme natural events like floods and storms. These tend to have a stronger impact on the poor because they do not have the resources to build adequate shelters or because their homes are built on land where the natural barriers to landslides and floods have been destroyed.

During the past decade an increasing number of flood events occurred which adversely affect the poor as well as the elderly people. The similar is true in the case of heat waves, and extremely cold winters. One of the most vulnerable social groups is the pauperized part of Roma population. Preliminary results of a research project clearly showed that there is a correlation between poverty and living environment (in terms of water supply, sanitation and waste disposal).

It has been documented that poor women and children suffer disproportionately in acquiring dwindling natural energy supplies for cooking and heating also amplified by the greater amount of time they spend in badly ventilated shelters when using highly polluting fuels like coal and firewood.

These examples point to a close relationship between the poor and ecosystems and demonstrate quite clearly the higher dependency of poor people on ecosystems for the improvement of their material situation.

The poverty and unemployment are interrelated social phenomena. Most of the Slovakian and Hungarian regions of the Carpathians are hit by unemployment with a rate over 13%. This figure is much less in Czech and Romanian Carpathians (under 8.5%) (*Figure 7*).

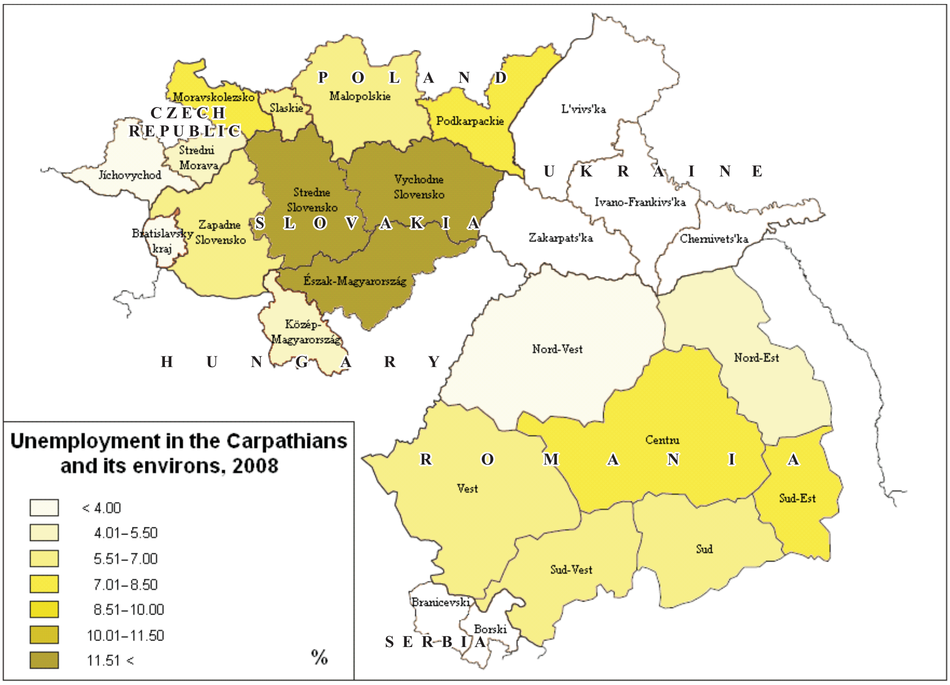


Fig. 7. Unemployment in the Carpathians and its environs, 2008. (County level data are not available for Ukraine and Serbia) *Source:* Eurostat

Rural depopulation and land abandonment

It's a well-known fact that typical *rural areas* are sparsely settled places away from the influence of large cities and towns. Such areas are distinct from more intensively settled urban and suburban areas, and also from unsettled lands such as outback or wilderness. People in rural areas live in villages, on farms and in other isolated houses, as in preindustrial societies. In modern usage, rural areas can have an agricultural character, though many rural areas are characterized by an economy based on logging, mining, petroleum and natural gas exploration, or tourism.

Lifestyles in rural areas are different from those in urban areas, mainly because availability of services is limited, especially that of public services. Some of the institutions such as the police stations, schools, fire stations, and libraries may be distant, limited in scope, or unavailable. Utilities like water, sewerage, street lighting, and public waste management might not be present. Public transport is absent or very limited, people use their own vehicles, walk, bicycle, or ride an animal, e.g., horse, donkey.

The urbanization rate represents the increase in the proportion of the urban population over the period. Urbanization has profound effects on the ecology of a region and on its economy. The rural areas contain most of the poverty and most of the low-cost sources of potential advance, whereas the urban areas represent most of the articulateness, organization and power.

There is a growing inequality between rural and urban areas in the Carpathians. This situation occurs for many reasons, and efforts to enhance the quality of rural life must include improvements in agricultural production, employment, infrastructure, environment and housing.

Rural conditions throughout the region have deteriorated during the transition period. There is a growing inequality between rural and urban areas, with most of the poor now living in rural areas. These areas are characterised by declining populations that are increasingly represented by women and the elderly. They have been affected by national population growth rates that have slowed down and even turned negative, as people have migrated to urban areas and other countries in search of employment. Migration has been a predominantly male phenomenon and women now make up a large percentage of the rural poor. Household members in rural areas are much older than those in urban areas and households are increasingly managed by the elderly and pensioners.

High unemployment is a common feature of rural areas. In most countries, the agriculture sector has accounted for the greatest decline in employment. Rural villages suffered, particularly those where agricultural concerns and heavy industries, now obsolete, were the main employers.

Rural infrastructure has often deteriorated considerably: many rural roads, irrigation systems are in poor condition, and erosion control measures fail to be taken. The roads, irrigation and drainage systems that were originally designed to serve the cultivation of large tracts of land as a rule have not been remodelled to suit the new smaller family farms. Power and water systems are prone to breakdown and other rural public and cultural facilities such as schools, libraries and community centres have also suffered from neglect.

Much of the environmental damage that occurred in rural areas during the socialist period has not been eliminated. Large-scale cultivation destroyed field roads, water courses, vegetation belts and other landscape features suitable for individual farming. Production centres with adverse ecological impacts were frequently placed in the very centre of villages. Environmental degradation has sometimes increased during the transition period, for example through the deforestation of valuable species, inappropriate tillage of soils and a failure to maintain a balance of nutrients in the topsoil (FAO 2003).

Perhaps the most critical threat in the mountain areas nowadays is the process of abandonment of agricultural land and of traditional farming practices, a phenomenon reflecting a post-war trend of rural depopulation and marginalization of wide agricultural regions. In a sense marginalization is a process that extends over areas that were not marginal in the past. Marginalization actually means "becoming marginal", rather than "being marginal". Far from representing just a linguistic nuance this issue is of fundamental importance when analysing the phenomenon of land abandonment and its economic and environmental consequences. Neglect of previously cultivated or otherwise managed land implies, generally speaking, far-reaching consequences in terms of loss of stability and resilience of ecosystems, given that a system whose equilibrium has been artificially altered needs continuous energetic input in order to be maintained as such.

Abandonment of traditional farming activities results in a number of impacts in the mountains, which can be summarized as follows: increasing natural hazards; loss of productive lands; diminishing terrain value; loss of natural capital and environmental quality; depletion of environmental services; loss of open or otherwise accessible spaces suitable for various purposes such as tourist, recreation and sport activities; loss of local cultivar, typical products and traditional farming practices; diminishing habitat variety and biodiversity; decline of traditional lifestyles and knowledge; permanent loss of cultural landscape; loss of cultural and social heritage and identity; decline of the human presence, and of the consequent territorial care (Conti, G. and Fagarazzi, L. 2004).

Conclusions

Current development patterns in the Carpathian region are leading to a loss of traditional knowledge, livelihoods, practices and values. It is therefore critically important that culturally sustainable and coherent policies be formulated and implemented for the Carpathians, in order to halt and reverse this trend before it is too late. Rural depopulation jeopardizes the preservation of the traditional character of the Carpathian countryside. Policy measures must be implemented, and incentives developed, so that people remain in their villages as guardians of the landscape, traditional knowledge and lifestyle. Education, communication and public participation, together with environmental democracy, could represent a basis for a path of sustainable environment and development in the Carpathians.

The ageing of the population and growing inequality between rural and urban areas are major concerns in the Carpathian region. In addition, increasing poverty and high unemployment rates are the greatest social problems in most areas which have a worsening trend currently as a consequence of the global financial and economic crisis. This situation occurs for many reasons, and efforts to improve the quality of rural life must include advancement in agricultural production, job creation, infrastructure development and in housing conditions.

One of the main current threats is the process of abandonment of agricultural land and traditional farming practices, a phenomenon reflecting a post-war trend of rural depopulation and marginalization of wide agricultural regions, especially hitting mountain areas.

In order for Carpathian regional development to become sustainable, more environment friendly practices and technologies will need to be implemented, along with appropriate policies to support the development of public transport, organic farming, renewable energy sources, sustainable forest management and tourism.

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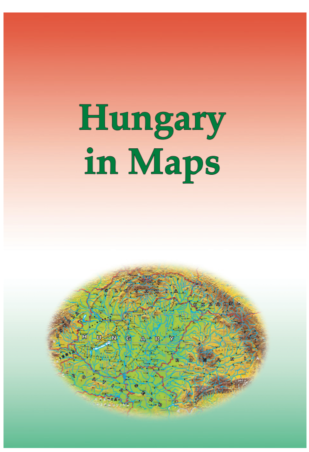
Hungary in Maps

Edited by
Károly Kocsis and Ferenc Schweitzer

Geographical Research Institute Hungarian Academy of Sciences
Budapest, 2009. 212 p.

'Hungary in Maps' is the latest volume in a series of atlases published by the Geographical Research Institute of the Hungarian Academy of Sciences. A unique publication, it combines the best features of the books and atlases that have been published in Hungary during the last decades. This work provides a clear, masterly and comprehensive overview of present-day Hungary by a distinguished team of contributors, presenting the results of research in the fields of geography, demography, economics, history, geophysics, geology, hydrology, meteorology, pedology and other earth sciences. The 172 lavish, full-colour maps and diagrams, along with 52 tables are complemented by clear, authoritative explanatory notes, revealing a fresh perspective on the anatomy of modern day Hungary. Although the emphasis is largely placed on contemporary Hungary, important sections are devoted to the historical development of the natural and human environment as well.

In its concentration and focus, this atlas was intended to act as Hungary's 'business card', as the country's résumé, to serve as an information resource for the sophisticated general reader and to inform the international scientific community about the foremost challenges facing Hungary today, both in a European context and on a global scale. Examples of such intriguing topics are: stability and change in the ethnic and state territory, natural hazards, earthquakes, urgent flood control and water management tasks, land degradation, the state of nature conservation, international environmental conflicts, the general population decline, ageing, the increase in unemployment, the Roma population at home and the situation of Hungarian minorities abroad, new trends in urban development, controversial economic and social consequences as a result of the transition to a market economy, privatisation, the massive influx of foreign direct investment, perspectives on the exploitation of mineral resources, problems in the energy supply and electricity generation, increasing spatial concentration focused on Budapest in the field of services (e.g. in banking, retail, transport and telecommunications networks), and finally the shaping of an internationally competitive tourism industry, thus making Hungary more attractive to visit.



This project serves as a preliminary study for the new, 3rd edition of the National Atlas of Hungary, that is to be co-ordinated by the Geographical Research Institute of the Hungarian Academy of Sciences.

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The role of conservation agriculture in landscape protection

Ádám Kertész[1]–Balázs Madarász[1]–Béla Csepinszky[1] and Szabolcs Benke[1]

Abstract

Because of population growth the global demand for food is rapidly increasing. As a consequence of this agriculture is expanding and becoming more intensive. Agricultural land use has the highest share among land use categories in the world therefore it is very important that farming activities are sustainable for the landscape and environment friendly. The aim of this paper is to present the positive role of conservation agriculture in landscape protection on the example of the results of the SOWAP (Soil and Surface Water Protection) project, supported by EU LIFE and Syngenta. Within the framework of the project tillage plots were established at two locations in Hungary, near Lake Balaton on Luvisol and Cambisol soils. The experimental program included soil erosion, biodiversity, soil microbiology measurements and agronomic traits. Runoff from the conservation tillage treatments was reduced by 66.8%, soil loss by 98.3%, TOC loss by 94.1%, nitrogen loss by 86.8%, phosphorus loss by 95.6% and potassium loss by 78.8% relative to values measured on the conventional plots. Soil moisture conditions have improved in the upper 20 cm under conservation tillage. Rainfall simulation experiments indicate the protection of plant residues resulting in the reduced number and volume of rills under conservation tillage. Yields of winter wheat, winter oilseed rape, sugar beet and maize were similar from plowed fields and conservation-tilled fields. There was a considerable improvement of biodiversity conditions on the conservation plots. The results of the SOWAP project give a reliable evidence that conservation agriculture is sustainable and it is an adequate tool for landscape protection.

Keywords: landscape protection, conservation agriculture, soil erosion, biodiversity

Introduction

World population is growing very rapidly. According to the United States Census Bureau the population of the world is 6.8 billion as of today and by 2020 it will reach 8 billion (UN 1996). It is well known that the rate of population growth is much higher in the third world. By 2020 84% of the estimated population will live in the third world. Demand for food will rise with popu-

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lation increase and food supply will be extremely important. From the aspect of geography the key question is where this huge amount of food will be produced. The answer is very simple: the food will come from the agricultural areas. The possible impact of intensified and expanded agricultural activity on the soils and landscapes has to be addressed properly. At least the present quality of soils should be preserved and the landscapes be protected.

The relationship between population growth and food supply has been recognized long ago. The theories of Malthus and Ricardo are notorious (Held, R.B. and Clawson, M. 1965). These concepts overemphasize the role of population increase and take no notice of technological development. If technological changes are considered part of a state of the art, complex and dynamic socio-economic environment the danger and risk related to food supply can be minimized. The development of landscape and environmental protection is also part of continuous technological change. Conservation agriculture is one of the most up-to-date methods of sustainability.

The solicitude about food supply and soil degradation can be supported by the striking fact, that altogether 22% of the Earth surface is cultivatable (Wicherek, S. 1999), however, only half of it is cultivated today. Reserves of cultivatable land diminish very quickly.

The objective of this paper is to present the positive role of conservation agriculture in landscape protection not only generally but also on the example of the results of the SOWAP project (see below), concerning soil erosion, runoff, soil moisture and those of the ecological studies.

Landscape protection is understood here in a very broad sense, but concentrating only on those aspects which are included in the SOWAP project to be able to show exact measurement data supporting the positive role of conservation agriculture in landscape conservation.

Landscapes and agriculture

In the developed countries of the world natural landscapes have been transformed by human activity and today human society is the main landscape forming agent. The public opinion about the impact of the society upon landscapes is that the landscape forming activities are associated with urbanization, industrial plants and facilities and transport lines. The reason for this is obvious: the above activities cause dramatic and sometimes irreversible changes in the landscape. A natural, or semi-natural landscape is going to be transformed to a man-made, artificial environment, the “green” will turn into “grey”. We are inclined to forget that replacing natural vegetation by agricultural fields and forests means also a change of natural conditions, it is also a landscape transformation, in spite of the fact that “green” remains “green”.

The influence of agriculture on the landscape and landscape functions is as important as that of other anthropogenic activities. Another significant aspect is that the percentage of agricultural areas among land use categories is the highest in the world hence the effect has extended over a very large territory (see *Table 1*). The table presents interesting data about the development of agriculture. It is surprising that while the percentage of agricultural land in Europe and in Hungary is decreasing, it is increasing in the world.

Table 1. Agriculture in Hungary, in Europe and in the World (The World Bank 2007)

Territory	Agricultural land (% of land area)		Land under cereals (thousand hectares)		Fertilizer consumption (100 g/ha of arable land)		Agricultural employment (% of total employment)	
	1992	2005	1992	2005	1992	2005	1992	2005
Hungary	70.7	65.4	2,803	2,940	796	993	11.3	6.0
Europe (EMU*)	49.7	47.5	32,976	31,419	2,332	2,059	7.3	4.9
World	37.7	38.3	704,675	677,585	925	1,020	41.8	–

*EMU – European Monetary Union

The areas used for agriculture today had been covered by some kind of natural vegetation before and this vegetation cover was removed, extirpated. The situation is even more alarming if the area was deforested. Landscape change begins with preparing the soil for agricultural production by various cultivation treatments.

In order to carry out a successful plant production the landscape will undergo several interventions over the year, especially in the vegetation period by various cultivation and plant protection procedures. The character of the interventions is critical for the future of the landscape (Tóth, A. and Szalai, Z. 2007).

As already mentioned global increase of agricultural area is needed to ensure growing food supply. Those areas which can be used for agriculture in the future are in the tropics. Areas with better conditions are already in use so that agriculture can expand only to land with unfavourable conditions, i.e. to slopes with shallow soils. Transforming them into agricultural areas will immediately lead to severe land and soil degradation problems (Jakab, G. and Szalai, Z. 2005).

Soil degradation has not been considered to be a major problem in many European countries until recently. In Europe, according to Oldeman, L.R. *et al.* (1991), water erosion endangers 12% of the total land area and wind erosion 4%, and an additional 16% of the cultivated land is prone to different kinds of soil degradation.

Conventional and conservation agriculture

Two thirds of the area of Hungary is used for agriculture (see *Table 1*) and roughly half of the country is arable land. These arable fields are important habitats of numerous plant and animal species. The intensive agricultural activity on hilly areas may lead to severe soil erosion and biodiversity loss. Conservation agriculture is a sustainable way of farming playing an important role in soil and biodiversity conservation.

Conservation agriculture is the new discovery of "old fashioned" agriculture (i.e. of the agriculture practised before the discovery and application of high-tech machinery in agriculture). Even before the usage of modern soil cultivation machines, inverting the soil was performed by using a plow or similar tools. Conventional agriculture is based on tillage and it is highly mechanised. Conventional agriculture causes severe land degradation problems including soil erosion, pollution, loss of biodiversity and wildlife, low energy efficiency and a contribution to global warming (Boatman, N. *et al.* 1999).

The SOWAP project (Soil and Surface Water Protection Using Conservation Tillage in Northern and Central Europe, 2003–2006, EU LIFE Project, ID. Number: LIFE03 ENV/UK/000617) defined *Conservation Tillage* as tillage practices specifically intended to reduce soil disturbance during seedbed preparation. The objective is to improve soil structure and stability. Conservation tillage encompasses a range of tillage practices up to and including "Zero (No) Tillage".

Conservation Agriculture (CA) is a holistic approach to crop production, which encompasses Conservation Tillage and also seeks to preserve biodiversity in terms of both flora and fauna. Activities such as integrated crop, weed, and pest management form part of Conservation Agriculture. The concept of "as little as possible, as much as is needed" will be the guiding principle when it comes to chemical usage for SOWAP crop production.

Generally it can be said that CA is an important tool in those regions of the world where soil erosion is a major problem and where the retention of soil moisture is an important goal. Keeping water in the soil is equally important if floods and droughts are to be avoided.

Conservation agriculture is beneficial for the landscape. The positive effects apply to the landscape as a whole and to the landscape forming factors. It is very difficult to characterize the effects on the totality of the landscape in an exact form. The present paper presents the influences on several landscape forming factors.

Conservation agriculture is beneficial for the soil. The main benefit of conservation agriculture is that the soil will be preserved more or less in seminatural conditions as soil disturbance by cultivation is minimized and physical and chemical depletions are reduced. Soil structure remains very good with enhanced drainage, porosity, adsorption capacity and structural stability (Lavier, B. *et al.* 1997). Compaction and loss of soil structure can be reduced or stopped by applying CA since there is less traffic on the field and crop residues are not buried in the soil. It is good for soil organic matter, too.

As it is well known, organic matter influences soil structure, soil stability, buffering capacity, water retention, biological activity and nutrient balance, all of which also affect erosion risk (Holland, J.M. 2004). Erosion losses can lead to catastrophic diminishment of organic matter (Szűcs, P. *et al.* 2006). The organic matter content of the soil decreases under conventional cultivation rather quickly. Kinsella, J. (1995) estimated that most agricultural soils loose 50% of initial soil C. When conservation agriculture is applied crop residues remain on the soil surface offering very good protection against erosion.

The environmental benefits of conservation agriculture include on-site and off-site effects, the latter having local, regional or global importance. From global aspects, carbon dioxide and other greenhouse gases have to be mentioned first. Conservation agriculture means the reduction of energy consumption and mechanical work, reducing the emissions of CO_2 and CO gases. CA promotes carbon sequestration in soils. Reduced mechanical activity means less SO_2 emissions from motors mitigating acidification of the atmosphere. As a consequence of conservation agriculture, air pollution is also reduced.

Concerning global biodiversity, conservation agriculture offers better nesting sites and better food supplies (Belmonte, J. 1993). Conservation agriculture fields host higher bird, small mammal and game populations (Guedez, P-Y. 2001). The benefits for soil biodiversity are self-evident. Excellent food and habitat are provided for micro-organisms, earthworms and insects, promoting bioactivity and biodiversity of the soil.

As mentioned above, soil moisture conditions are much better, than under conventional agriculture. An improvement of water management of the soil is manifested in reduced runoff by 15–89% (Holland, J.M. 2004).

In addition to the positive influence of conservation agriculture on infiltration, runoff and leaching, conservation agriculture helps to reduce the risk of pollutants to reach surface and groundwater. There is an indirect positive affect on aquatic ecosystems, too.

The SOWAP project

Recognizing the benefits of conservation agriculture, a demonstration project (SOWAP, Soil and Surface Water Protection Using Conservation Tillage in Northern and Central Europe, 2003–2006, EU LIFE Project, ID. Number: LIFE03

ENV/UK/000617) was launched in 2003 supported by the EU LIFE Programme, involving several organizations[2]. This three-year, 4 million EUR project is co-funded (50:50) by EU LIFE and Syngenta. The project ended in 2006 but the measurements in Hungary are ongoing, financed by Syngenta.

The objective of the SOWAP project is to assess the viability of a more "conservation-oriented" agriculture, where fewer tillage practices replace different ways of cultivation carried out under more "conventional" arable farming systems.

The main study topics of the project include soil erosion, aquatic ecology, biodiversity, soil microbiology, agronomy and economics.

In Hungary two sites were selected near Lake Balaton *(Figure 1).* The first site, Szentgyörgyvár is for soil erosion studies. Four large plots (120 m^2 each) were established on a slope with 10% gradient. The parent material of the soil is sandy loess, the soil type is Luvisol. Mean annual precipitation is 700 mm. An automatic weather station is installed, too.

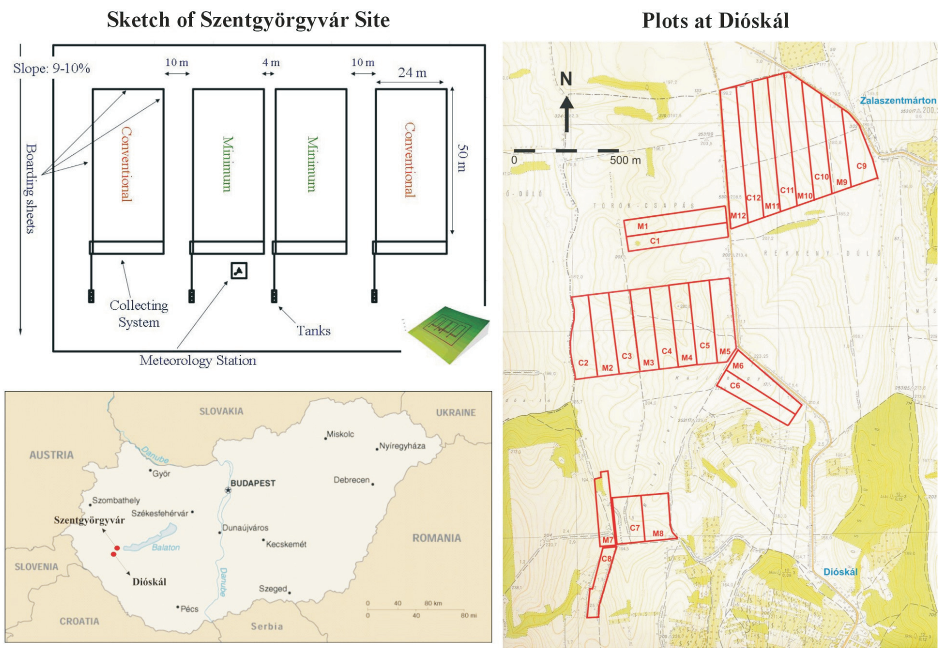


Fig. 1. Location of study sites

[2] Agronomica, U.K.; Cwi Technical Ltd, U.K.; FWAG, U.K.; Harper Adams University College, U.K.; Geographical Research Institute of Hungarian Academy of Sciences, HU; National Trust, U.K.; Cranfield University – NSRI, U.K.; RSPB, U.K.; Syngenta, U.K./HU; The Allerton Trust, U.K.; The Ponds Conservation Trust, U.K.; University of Leuven, Belgium; Vaderstad, U.K./HU; WOCAT, The Netherlands; Yara (UK) Ltd, U.K.

The second site, Dióskál (*Figure 1)* is for farm scale demonstration and for ecological studies. It is a farm of 107 ha situated on a gently sloping, hilly area with similar environmental conditions as the first site.

Methods

a) Erosion plots. Runoff amount is determined after each event. Runoff and soil loss are measured after each tank emptying, followed by sampling. The samples will undergo the following analyses. Runoff: pH, soluted N, P, K, total suspended sediment, TOC, total salt content, herbicide content; eroded soil: dry mass, particle size distribution, N, P, K and organic matter content. Crop quality, quantity and biomass are also investigated. Economic viability of the practices employed (e.g. production costs) will be calculated whenever applicable.

b) Ecological plots. For the terrestrial ecology survey 24 plots were identified at *Dióskál* (12 conventionally tilled and 12 minimum tilled). The ecology experiment includes the survey of weeds, soil micro-organisms, birds and earthworms-insects-seeds as important food sources for birds. Conservation tillage was direct drilling and, if soil conditions were not appropriate, direct drilling was preceded by a shallow discing.

Results

Runoff, soil loss and soil moisture

The main results concerning runoff and soil loss are presented in *Figure 2*. The results show that there was a remarkable difference between the two tillage types. Runoff and soil loss on the conservation plots were always less than on the conventional plots.

Average runoff on conservation plots was only 33.2% of that on conventional plots and the percentage of soil loss was only 1.7% *(Figure 2).* These results support the positive environmental effect of conservation tillage, especially with regard to soil loss.

The average soil loss per year was 2.44 t ha^{-1} versus 0.08 t ha^{-1} *(Figure 3),* and the average runoff volume per year was 453.8 m^3 ha^{-1} versus 172.6 m^3 ha^{-1} *(Figure 4).*

The difference between the two treatments is less in case of runoff. This can be explained by the characteristics of surface cover and soil structure under the two treatments. If a high intensity rainfall hits the soil surface the minimum tilled soil may not offer the best structure for infiltration.

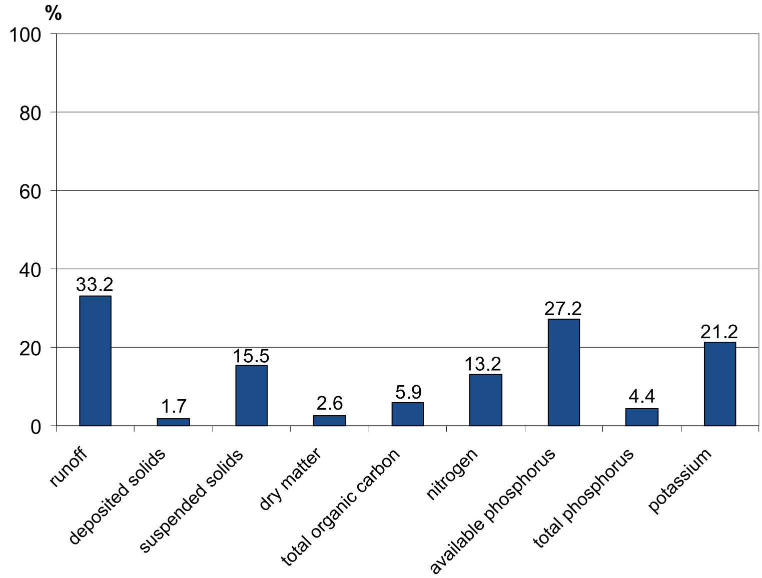


Fig. 2. Average runoff, soil loss, TOC and nutrient loss on conservation plots as a percentage of that on conventional plots (2004–2006)

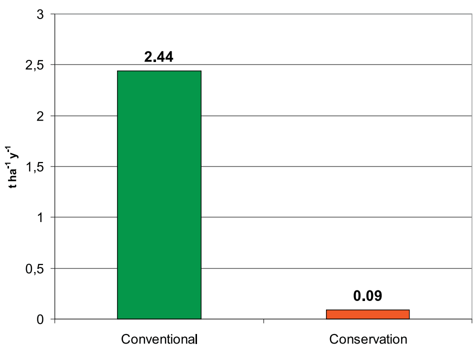


Fig. 3. Soil loss on conventional and conservation plots

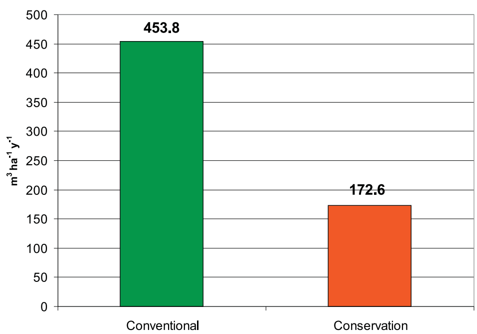
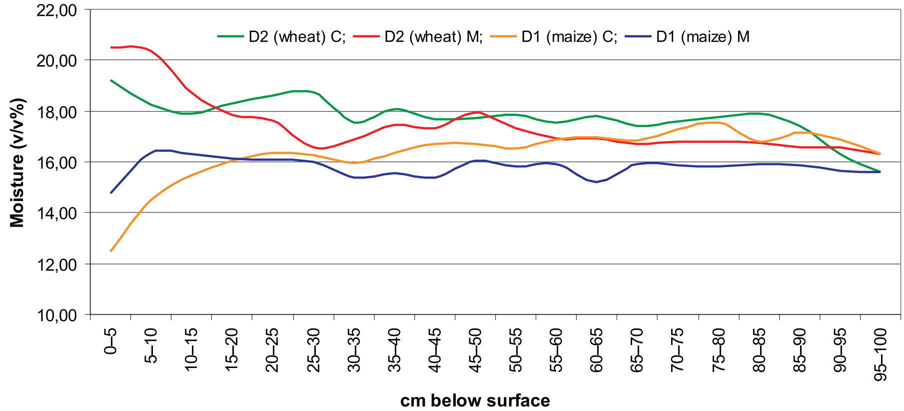


Fig. 4. Runoff on conventional and conservation plots

Gravimetric soil moisture measurements were carried out at Dióskál *(Figure 5)*. The upper 20 cm of the conservation plots had higher soil moisture content values (8.8% on the average). Below 20 cm the difference between conservation and conventional plots diminishes and conventional plots have slightly better conditions (on the average 1.77% higher moisture content). As soil moisture in the upper 20 cm is more important for plants and the difference below this level is negligible, conservation tillage appears to provide better soil moisture conditions.

a) Spring 2005



b) Autumn 2005

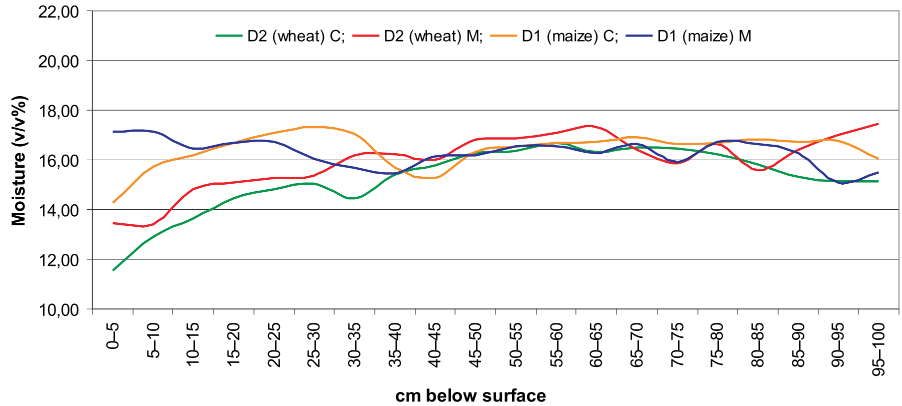


Fig. 5. Soil moisture content curves representing conventional (C) and conservation (M) fields at Dióskál 1 (D1) and Dióskál 2 (D2). Samples were taken at 3 points along the slope profiles and the data shown are mean values of these for each curve

Organic matter and nutrient contents of runoff

Figure 2 shows that not only soil loss and runoff values are lower on the conservation plots but nutrient loss is much less, too.

TOC, nitrogen, phosphorus and potassium concentrations of sediments were affected by tillage remarkably. In the case of conservation tillage these values are higher than with conventional tillage, which shows the better nutrient status and higher TOC content of the topsoil. Presumably the difference in the nutrient concentrations of the sediment from the two plot types is also due to the higher humus and nutrient content on the conservation plots.

Rill erosion

A rill erosion survey was performed on the Dióskál 1 experimental field (plots C4 and M3, see Figure 1) in early June 2005 and. Rill widths and depths were measured on 120 m long and 10 m wide plots. In 2005 the plots were covered with maize sown in early May. The amount of precipitation during the preceding two months was 105.2 mm. There was a striking difference between conventional and conservation tillage fields. On the conventionally tilled fields, rills occurred almost in every row while there were hardly any rills on the conservation plot.

The total volume of rills on conventional tillage was 13 m^3, versus 0.5 m^3 on conservation till. Soil loss due to rill erosion was 141.7 t ha^{-1} on conventional plot, versus 5.4 t ha^{-1} on conservation plot. There is a slight difference in bulk density values (1.3 g cm^{-3} versus 1.36 g cm^{-3}). The soil of the conventional plot was less compacted because of the effect of plowing.

The explanation of much better conditions on the conservation plot is due to the protection of plant residues from the previous year and the remnants of the winter cover crop (rasp) which was disced into the soil after the harvest. After plowing, the soil surface of the conventional plot was bare, without any protection against erosion.

Ecological survey

Conservation agriculture offers better conditions for the activity of earthworms. The number of earthworms on the conservation plots was significantly higher than on the traditional plots. This was the case during the whole monitoring period of two years under two different crop rotations *(Figure 6).*

Altogether 37 bird species were registered during two winter seasons including 28 protected species (76% of total). One third of these species are significant from European perspective indicating that agricultural areas are also important from the aspect of nature conservation.

Seeds play a key role in the nutrition of 22 species (60%) and, as a consequence of this, an important function of agricultural fields is to provide food during the critical winter period *(Figure 7).*

Conservation agriculture plots proved to be more favourable for birds, first of all for small warblers like skylark (*Alauda arvensis*), goldfinch (*Carduelis carduelis*), yellowhammer (*Emberiza citrinella*), greenfinch (*Carduelis chloris*) and tree sparrow (*Passer montanus*), than traditional plots did in both of the winter seasons investigated. Conservation agriculture provides a better food supply and improves winter survival reducing the negative effect of agriculture on bird fauna.

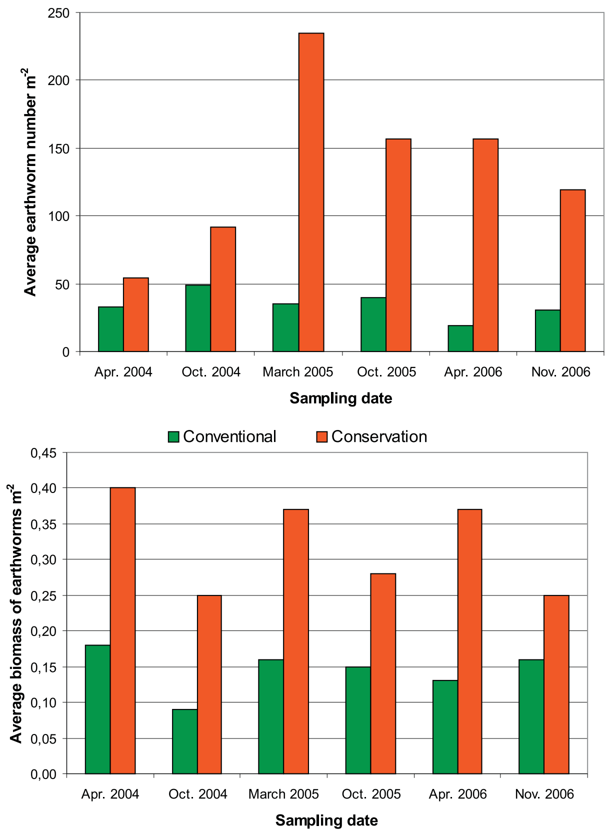


Fig. 6. Average earthworm number and average biomass per square meter at Dióskál

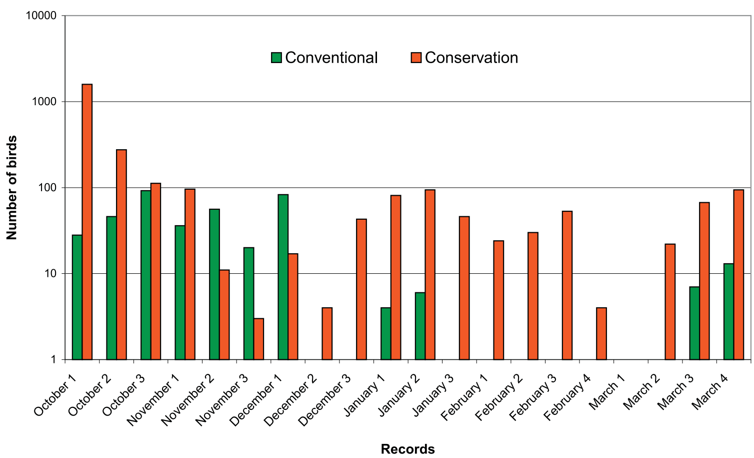


Fig. 7. Total number of birds recorded at Dióskál between October 2004 and March 2005

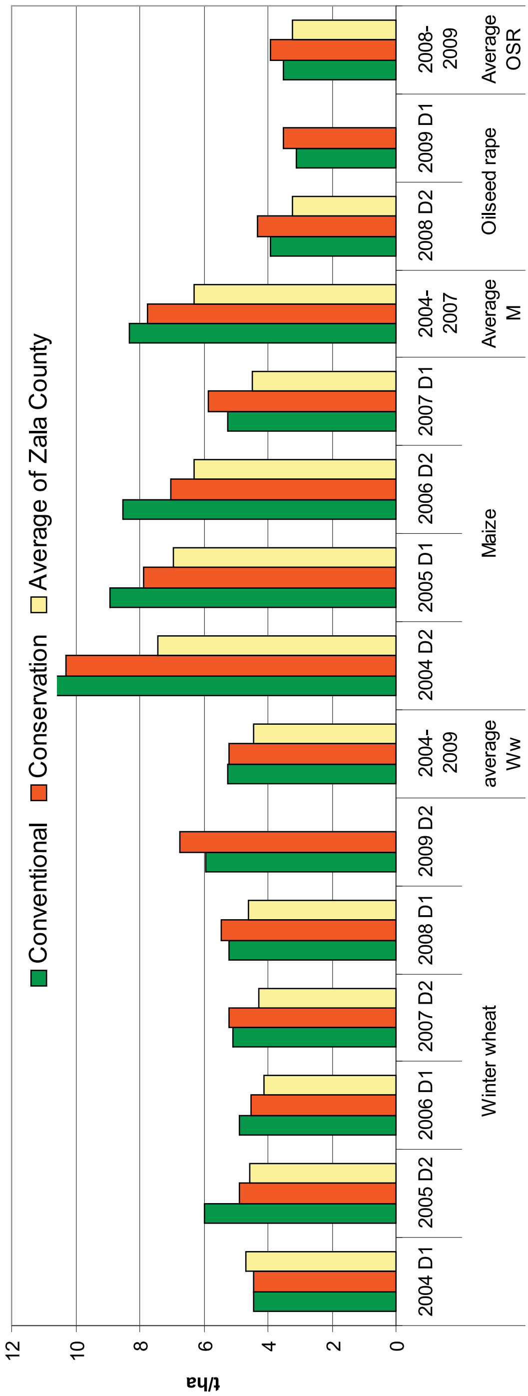


Fig. 8. Crop yields at Dióskál (2004–2009) and the average values for Zala county

Crop yield and production costs

Crop yield on the Dióskál plots was practically the same under the different tillage systems *(Figure 8).* The same is valid for the production costs *(Figure 9).*

Conclusions

Agricultural activities have an important impact on the landscape. Conservation agriculture is a sustainable way of farming with favourable effects on the landscape. The results of the SOWAP project support this statement. Conservation tillage techniques have reduced soil loss and water runoff from fields compared to conventional plowing. According to the statistical analysis under conservation tillage runoff was reduced by 66.8%, soil loss by 98.3%, TOC loss by 94.1%, nitrogen loss by 86.8%, phosphorus loss by 95.6% and potassium loss by 78.8% relative to quantities measured on the conventional plots. Soil moisture conditions were better in the upper 20 cm under conservation tillage. Rainfall simulation experiments indicated the protection of plant residues under conservation tillage. The number and volume of rills diminished un-

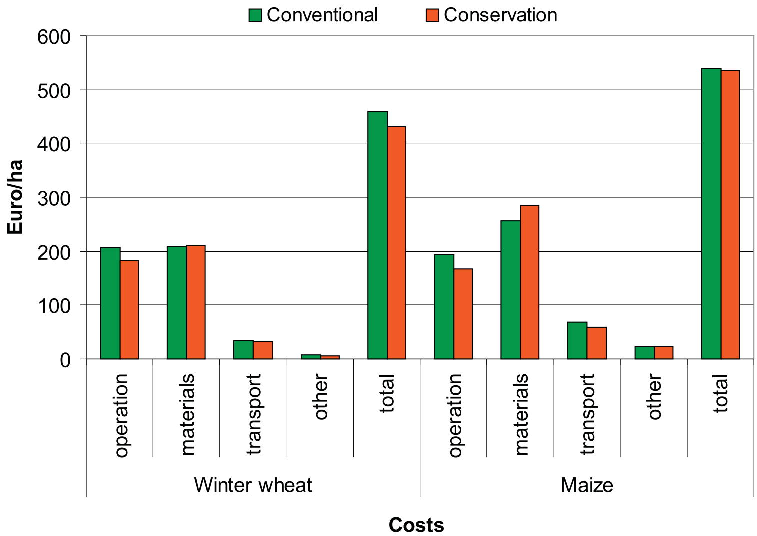


Fig. 9. Average values of production costs at Dióskál (2004–2006)

der conservation tillage. Yields of winter wheat, winter oilseed rape, sugar beet and maize were similar from both plowed and conservation-tilled fields. Biodiversity conditions were also much more adequate on the conservation plots. Conservation tillage has significant advantages for the soil itself and the environment alike.

Acknowledgement: The SOWAP project was funded by the EU LIFE programme and by Syngenta Ltd. This support is gratefully acknowledged.

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A quantitative procedure for building physiographic units supporting a global SOTER database

Endre Dobos[1]–Joël Daroussin[2] and Luca Montanarella[3]

Abstract

Until recently, manual methods were used for delineating SOILSCAPE. The use of digital data sources, such as digital elevation models (DEM) and satellite data can speed up the completion of digital soil databases and improve the overall quality, consistency, and reliability of the database. Our approach uses DEMs for SOILSCAPE delineation based on the terrain classification system of "traditional manual" and Edwin Hammond's landform classification methods, published in 1954.

In this study, the goal was to use quantitative methods to derive terrain classes that match the criteria of the "Georeferenced Soil Database for Europe" Manual of procedure and to create a DEM-derived polygon (soilscape) system for Europe. Four terrain attributes were used to define the SOILSCAPE: hypsometry (~elevation and relief intensity), slope percentage (SP), relief intensity (RI), and dissection (PDD). The SRTM30 (Shuttle Radar Topographic Mission) database was used as a base DEM and for the derivation of the SP, RI, and PDD layers.

We concluded that no major modification is required for the procedures to incorporate information that is derived quantitatively from digital data sources. The resulting database will have all the advantages of quantitatively derived databases, including consistency, homogeneity, and reduced data generalization and edge-matching problems.

Keywords: digital soil mapping, SRTM, digital terrain modelling, small scale soil database, DEM, morphometric terrain analysis

Introduction

Soil database is needed for global scale yield forecasting, modelling and research. However the only available soil map with a global coverage is the 1:5

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million scale FAO (Food and Agriculture Organization, United Nations) soil map of the world, which has been compiled from data collected up to the late seventies. Since the completion of the FAO soil map much new data have been documented and new approaches of mapping and database development have been developed. The lack of a standardized, compatible, reliable soils database at appropriate scale is a major constraint to global environmental and agricultural modelling. Therefore, the SOTER (World SOil and TERrain Digital Database) project was initiated by the International Society of Soil Science (ISSS) in 1986 (ISSS, 1986). Initially SOTER was intended to have a global coverage at 1:1 million scale (Batjes, N.H. 1990; ISRIC, 1993), which goal was later degraded to 1:5M due to the lack of financial means. Other international organizations, such as the United Nations Environmental Programme (UNEP), FAO of the United Nations and the International Soil Reference and Information Centre (ISRIC) joined this project and supported the idea of having a global scale soil and terrain database useful for a series of applications. An international committee was appointed to develop a "universal map legend system" and to define a minimum necessary set of soil and terrain attributes suitable for compilation of a small-scale soil resources map. The database can provide information for a wide range of applications such as "crop suitability, soil degradation, forest productivity, global soil change, irrigation suitability, agro-ecological zonation, and risk of drought" (ISRIC, 1993). It is not feasible to delineate soil polygons on regional-to-global scale soil databases. Only homogeneous terrain units defined by their physiographic and parent material information can be defined to represent homogeneous units of the soil forming environment. Soil information appears only on the attribute level as assigned soil associations.

The central and eastern part of Europe is completed based on the SOVEUR project (Batjes, N.H. and Bridges, E.M. 1997). The database is currently operational and has been used for assessing different land and soil degradation processes acting in the area. However, it still shows the most typical limitations of data inconsistency listed below. The database was compiled from national databases provided and translated to the "SOTER language" by the national soil survey institutions. Differences in the interpretation of soil parameters are evident from the acidification map *(Figure 1).* Almost all political borders are visible on the thematic map. Besides the variation in resolution and quality of the incorporated data, this artefact is most likely due to the differences in interpretation of numerous soil terms, and to the misplacement of the national soil variability on the global variability range. More appropriate quantification procedure for soil property characterization is needed to solve this problem.

The work has been started to prepare the SOTER database for the western part of Europe as well. The European Commission has agreed to

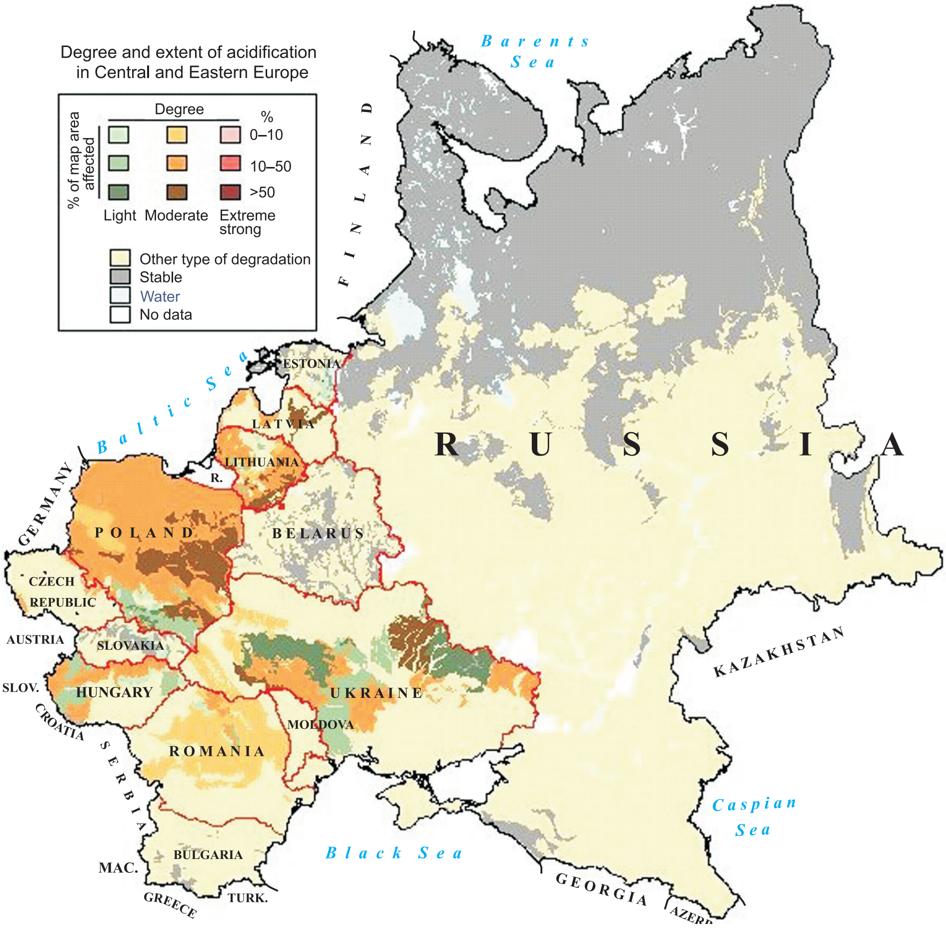

Fig. 1. Degree and extent of acidification risk in Central and Eastern Europe derived from the SOVEUR database

complete the SOTER database for the EU countries at a scale of 1:5M. The soil information for the EU SOTER map is taken from the SGDBE1M with an expert knowledge and decision rule controlled procedure developed by INRA Orleans (KING, D. *et al.* 2002). A preliminary version of the database has been completed by aggregating the existing SGDBE1M polygons. Unfortunately, the SGDBE1M polygon delineation does not follow the SOTER methodology. Thus the SOTER Unit delineation based on the aggregation of SGDBE1M polygons does not necessarily match SOTER criteria.

Emerging digital technology and high resolution digital terrain information, such as the digital elevation model (DEM) obtained by the Shuttle

Radar Topography Mission (SRTM) (Farr, T. G. and Kolbrick, M. 2000), represent a great resource and potential for developing a quantitative procedure to replace the existing SOTER procedure. The main advantage of a quantitative procedure lies in the spatial and thematic consistency of the final product.

The existing SOTER procedure needs to be modified slightly, partly due to its natural evolution and partly because of the quantification of the criteria that were originally defined qualitatively. Dobos, E. and Montanarella, L. (2004) conducted preliminary studies on the use of digital terrain and remotely sensed data for the SOTER unit delineation. The results were promising and a program was launched to update and modify the SOTER procedure to incorporate digital elevation data in the delineation of the Terrain Units. This work is done jointly by the European Commission Joint Research Centre (EC JRC) – Soil and Waste Unit, ISRIC and FAO. A SOTER Procedure Modification (SPM) workshop was organized in Ispra, Italy, 21–22 of October 2004, to implement the changes that were agreed upon since the last published version of the Manual and define the needs for future research to update the procedure and incorporate the newly emerging tools and data sources such as DEM data. The decision was taken that Europe would be the first pilot area for the global soil database with EU SOTER as the database to test the new procedure.

This paper focuses on the development of the quantitative DEM-based procedure to delineate SOTER Terrain Units at both 1:1M and 1:5M scales. Up to now, no accepted procedure on the characterization of terrain units has been developed. This work has aimed to set up a DEM based procedure to delineate homogeneous terrain units that match the ones derived by following the traditional SOTER manual. In other words, the original SOTER procedure was translated to the digital manner using DEM as a major input for the terrain unit delineation.

Materials and methods

The study area

The study area covers the countries of the European Union. However, in this paper as well as for the procedure development, a smaller pilot area was selected, namely the eastern half of the Carpathian basin *(Figure 2).*

The data

The Shuttle Radar Topography Mission (SRTM) global elevation data covers almost 80 percent of the globe, almost all terrestrial land surfaces. Its cover-

Fig. 2. The study areas. The big window (1) comprises the full extent of pilot area, while the windows (1) (Bükk Mountains) and No. 3 (Great Hungarian Plain, Alföld) are the smaller areas to show specific characteristics of the procedure.

age extends between 60° north and 56° south latitudes. SRTM is a joint project between the National Aeronautics and Space Administration (NASA) and the Department of Defence's National Geospatial-Intelligence Agency (NGA) to produce a near global digital elevation data coverage at a relatively high spatial resolution. Farr, T. G. and Kolbrick, M. (2000) describe the data capturing and processing procedure. The data is handled and distributed by the United States Geological Survey and can be downloaded from their website [1].

Before the SRTM data could be used, the input DEM had to be hydrologically corrected. Sinks that are due to errors in the data and the micro-scale natural sinks, such as the sinkholes –which appear as noise at that scale – had to be filled, while the meso- and macro-scale natural variability of the area were kept. According to our experience in using SRTM data, a limit of 20 meters has to be set as a maximum sink depth to be filled. This limit is suggested in this study as well.

Methods

The classifications for the four terrain layers are described in the four sections below. *Figure 3* shows the flowchart of the analysis. ArcInfo® geographical information system software and its GRID raster analysis module were used to achieve the work.

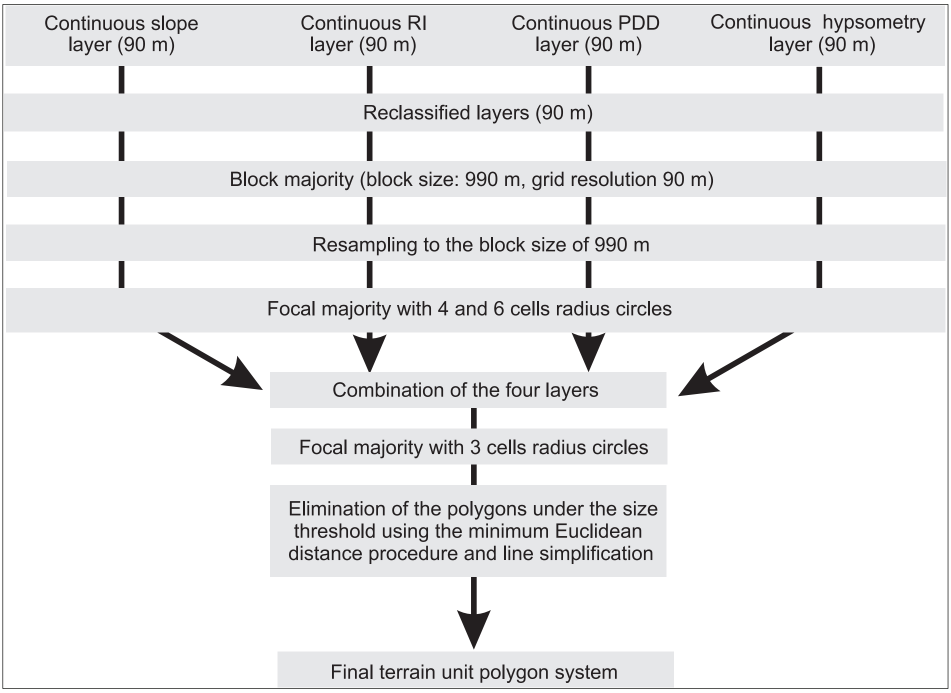

Fig. 3. Flowchart of the Terrain Unit delineation. RI stands for relief intensity while PDD means potential drainage density

SOTER Terrain Unit delineation

SOTER Unit delineation is based on two primary soil formation phenomena: terrain and lithology. Each SOTER Unit represents a unique combination of terrain and soil characteristics. The two major differentiating criteria are applied in a step-by-step manner, leading to a more detailed identification of the land area under consideration. Physiography is the first differentiating criterion to be used to characterize a SOTER Unit. The term physiography is used in this context as the description of the landforms on the Earth's surface. It can be best described as identifying and quantifying the major landforms, on the basis of the dominant gradient of their slopes and their relief intensity. The use of these variables, in combination with a hypsometric (absolute altitude above sea level) classification and a factor characterizing the degree of dissection, can make for a broad subdivision of an area and delineate it on the map. (Dobos, E. and Daroussin, J. (2007) gives more information on the role of dissection on the terrain parameterization.) Further subdivision of the SOTER Unit according to the lithology (parent material) needs to be done to complete the delineation procedure.

Until recently, manual methods were used to delineate SOTER Units, the geometric objects of the SOTER database. The availability of DEM makes it feasible to use a quantitative approach. Worstell, B. (2000) has proposed an approach using DEM for SOTER Terrain Unit delineation based on Edwin Hammond's (1954) landform classification methods. Worstell, B. has adapted and modified his methods to create a quantitative procedure to classify landforms on a regional scale.

A new, quantitative method for creating a SOTER database has been suggested by Dobos, E. and Montanarella, L. (2004) using the 1 km resolution SRTM30 data as the base DEM. Although the procedures were promising, they suggested more research and quality check on the results.

The aim of the present study was to develop a quantitative method to derive terrain classes that match the criteria of the SOTER Manual of Procedure (ISRIC, 1993).

According to the manual, four terrain attributes are used to define the SOTER Terrain Unit: hypsometry (elevation), slope percentage, relief intensity and dissection. The GIS layers of these attributes were derived from the digital elevation model by translating and reformatting the terrain class characteristics given by the SOTER Manual.

These four layers are combined to produce the complex landform classification. This combined layer was then vectorized, and finally generalized to achieve the polygon size limit appropriate for the 1:1M and 1:5M scales of the database to be produced.

The class limits of these attributes are defined more or less quantitatively in the Manual, ("Attribute coding"), except for the dissection for which only qualitative definitions are given. Changes in the class borders were implemented as well: they have been proposed and agreed upon in the SOTER Procedure Modification workshop. The dissection class limits were derived from the Potential Drainage Density (PDD) layers (Dobos, E. *et al*. 2000) via empirical approach.

Coarse resolution DEM tends to generalize the land surface and eliminate the micro- and meso-scale features of the surface, drastically decreasing the slope and relief values of the area. Therefore, a relatively fine resolution DEM (SRTM) was used to maintain the higher scale landscape elements and to derive the terrain descriptor values for the area. The resulting variables show much more detail than what the targeted scales are capable of handling. Thus, a generalization and aggregation procedure was used to obtain the appropriate resolution.

Slope

The slope layer was derived from the SRTM data using the slope function available from the ArcInfo® GRID module. This function uses the average maximum technique (Burrough, P.A. 1986).

The SOTER modified classification scheme for the slopes is shown in *Table 1.* The use of SLOPE function resulted in a continuous slope layer, which was reclassified according to the SOTER classes in (*Table 1*). This kind of classification rarely results in distinct borders between the classes, necessary for defining polygons of practical size. It gives too much spatial detail, which cannot be represented at the target scale ("salt and pepper" effect). Therefore, adequate filters have to be used to derive the slope layer with homogeneous pattern of slope classes and the resolution has to be degraded to reach the spatial detail needed for the targeted 1:1M and 1:5M scales.

Table 1. The SOTER modified slope classification scheme

Slope class	Range of slope percentages
1	0–2
2	2–5
3	5–10
4	10–15
5	15–30
6	30–45
7	above 45

Raster-based generalization procedure

The main steps of the generalization procedure are shown in *figures 3* and *4*. The appropriate spatial resolution of the grid for a 1:1M scale target database is around 1x1 km. Two options were considered for degrading the resolution, *(i)* averaging the cell values within 1 km^2 area or, *(ii)* taking the majority class and assigning it to the spatially degraded cell (blocks). The majority class of the area characterizes the landscape better than the average value. Therefore, the blocking approach was applied to define the majority class within a square shape area with the size of 11 by 11 cells (990x990 m). The resulting grid remains with the original 90 m resolution. Therefore it was then resampled to the target resolution of 990 meters, which was decided by the authors to be appropriate for the target 1:1M scale.

The resulting grid still had some salt and pepper effect, having a mixture of stand-alone cells or small contiguous areas, especially on the transition zones between the classes *(Figure 4C)*. This phenomenon represents a significant problem when representative polygons are to be drawn with a minimum polygon-size requirement. To overcome this problem, a filter was applied to that grid layer by using a majority value function with a 4 cells radius circle *(Figure 4D)*. The function takes the most frequently occurring class within the specified neighbour-

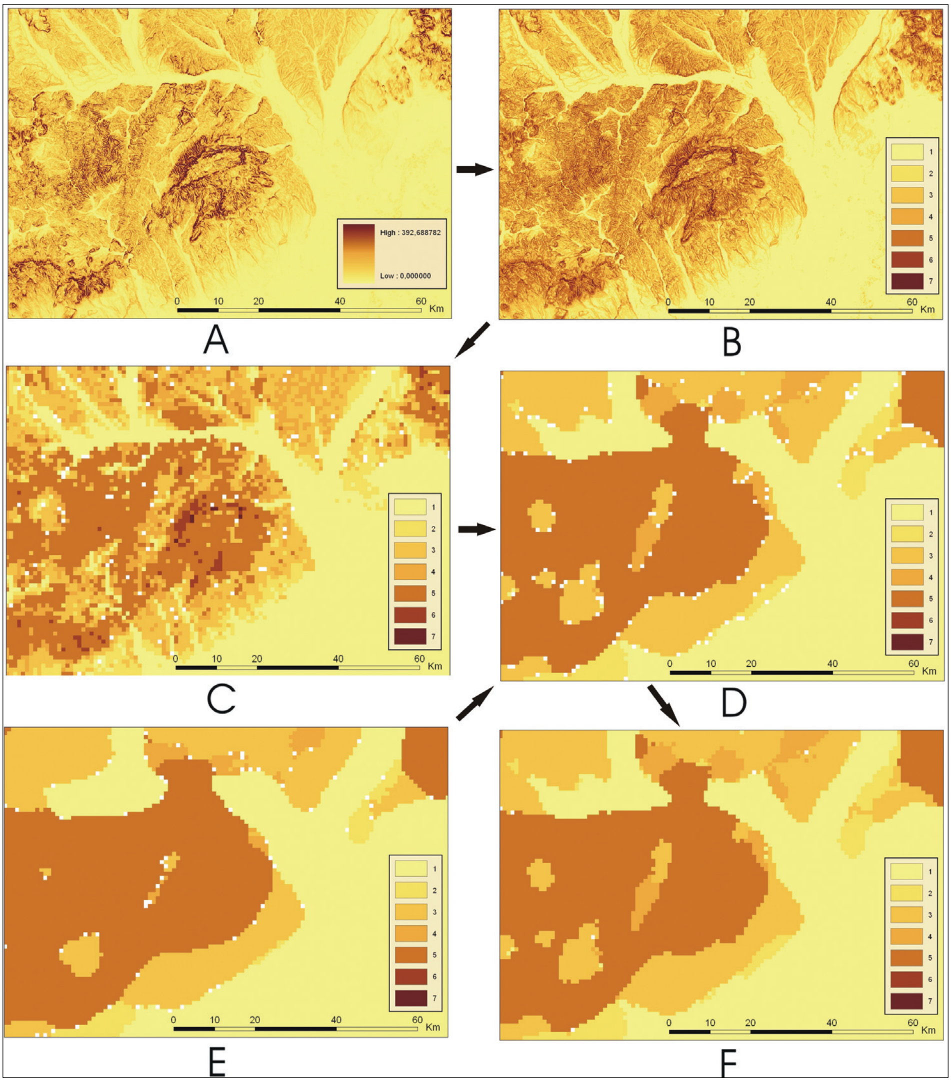

Fig. 4. Flowchart explaining the creation of the slope grid illustrated with an example from the Bükk Mountains, pilot area No. 2. *Table 1.* provides the corresponding slope classes. – A = Continuous slope layer; B = Classified slope layer; C = Resampled; classified slope layer; D = Filtered with majority filter; 4 cells radius; E = Filtered with majority filters; 6 cells radius; F = The final slope layer

hood and assigns it to the centre cell of the moving window. This relatively small neighbourhood of 4 cells was chosen not to over-generalize the landscape, while having enough area to smooth the grid to the required level. In case of equal representation of two or more classes within the specified neighbourhood, a "*no* *data*" value is given to the centre cell, which has to be filled to achieve complete/continuous coverage. To achieve this, the same filter was used again but with a bigger, 6 cells radius *(Figure 4E)*, circle, and the "*no data*" cells in the previous step were replaced with values from this grid layer. Applying these two steps creates patches having sizes appropriate to that target scale *(Figure 4F).*

Relief Intensity (RI)

Relief Intensity (RI) is one of the most significant discriminating terrain factors in the SOTER Procedure. RI is defined as the difference in altitude between the highest and lowest points within a specified distance. It is used in three different places in the procedure: (1) in the major landform description, (2) in the hypsometry characterization and finally, (3) in the dissection characterization. A simplified classification has been suggested by the SPM workshop *(Table 2)* and introduced a new unit for measuring RI, which is now expressed in *m/[area of a 1 km diameter circle]*. For practical reasons in the implementation of the method, the 1 km diameter is approximated with a 990 m diameter because, when using 90 m resolution projected SRTM data, it can thus be expressed simply with a 5 cells radius circle (5 cells radius = 11 cells diameter = 990 metres diameter circle).

The algorithm defines a circle shape neighbourhood with a radius of 5 cells and identifies the highest and the lowest points within that area. The difference between these two points is assigned to the centre cell of the moving processing window as an RI value.

The rest of the procedure was basically the same as in the one used for deriving the slope layer. High resolution, 90 m SRTM data was used to create the original RI layer, which was later classified according to the classes listed in *(Table 2)*. Then this classified image was generalized following the generalization procedure described above.

Table 2. The Relief Intensity classification as proposed by the SOTER Procedure Modification workshop

Relief Intensity class	Elevation range in meters within a 990 m diameter circle
1	0–50
2	50–100
3	100–300
4	above 300

Dissection (PDD)

The degree of dissection is difficult to quantify with traditional methods (ISRIC, 1993). The use of DEM makes it feasible to derive an artificial drainage/valley network, which characterizes the landscape dissection. Dobos, E. *et al*. (2000) developed an index called the Potential Drainage Density (PDD) and a function to compute the PDD. The function derives a drainage network from the DEM and measures the network's density within a predefined sized neighbourhood. The nature of (and the procedure for creating) the PDD layer are described by Dobos, E. and Daroussin, J. (2007).

The data was processed in two steps in this study. In the first step, a DEM-based drainage network was derived by thresholding flow-accumulation values. Cells having a flow-accumulation value higher than this threshold were considered as drainage ways. These drainage cells were assigned a value of 1, while all other cells were set to "*no data*". In the second step, a size for a moving window was selected, and a count of the drainage-way cells within the window was assigned to the centre cell. The result is the PDD value. The higher is the PDD value, the more dissected is the terrain.

The procedure suggested here requires three parameters to be set: (1) the flow accumulation threshold for the drainage network derivation, (2) the radius of the circle for the counting window and (3) the class limits for the reclassification of the continuous PDD image.

Choosing a flow accumulation threshold to build the drainage network

The threshold value was set to 100. In the case of the SRTM data, it translates to approximately a 1 km^2 catchment's area for a drainage line to start. Lower values create a very dense network with too many details, while higher thresholds decrease the pattern density, thus disguising some necessary details.

Choosing a radius for the circle to count drainage cells

The radius was set to 20 pixels/cells. Previously several radii were tested. The rule of thumb is that a too small radius is not able to deliver meaningful information about the general landscape. The resulting images show buffer-like zones along the drainage lines with relatively big portions of the image having "*no data*". Choosing a radius that is too large tends to over-generalize the image, there again masking general landscape characteristics. The optimal choice is the smallest circle, which is still big enough to pick up at least one drainage cell. After several trials and errors, the radius value of 20 was found to be appropriate for the drainage network derived from the SRTM data using the flow-accumulation threshold value of 100.

Choosing class limits for the reclassification of the continuous PDD image

The dissection measurement unit as defined in the "Manual of Procedure" (ISRIC, 1993) is the length of permanent and seasonal streams and rivers within a

1 km^2 neighbourhood. Three dissection classes are distinguished: 0–10, 10–25, and above 25 km/km^2. In this study, using these class limits would have been meaningless because the approach is different in a sense that we use "potential" drainage lines *versus* actual ones. In the digital procedure, only two classes were defined with value ranges as given in *Table 3.*

Table 3. The PDD class ranges

Class	PDD value range
1: less dissected areas, convex surfaces	0–90
2: more dissected areas or depressions, concave surfaces	above 90

The procedure then followed the same line as for the other data/model/map layers by applying the generalization and filtering procedure described above for slope in order to derive the final image.

Hypsometry (elevation)

The original SOTER Procedure Manual suggests a two steps procedure for elevation classification. The first step divides the area into three general relief types, namely *(i)* the level lands, *(ii)* the sloping lands and *(iii)* the steep sloping lands. The second step further divides each of these three types into elevation subclasses but using a different classification scheme for each type. This two steps classification system was simplified by the SPM workshop and a new one was introduced which was used here as well.

After the SRTM image was reclassified using the classes in *Table 4*, it followed the same generalization and filtering procedure as the other layers to derive the final hypsometry image *(Figure 6D).*

Table 4. The Hypsometry classes suggested by the SPM workshop.

Table 4. The Hypsometry classes suggested by the SPM workshop

Hypsometry class	Altitude ranges (meters above sea level)
1	Up to 10
2	10–50
3	50–100
4	100–200
5	200–300
6	300–600
7	600–1500
8	1500–3000
9	3000–5000
10	above 5000

Removing PDD as differentiating criterion from the terrain parameters list on the high relief areas

Previous tests of the Dobos, E. *et al.* (2005) procedure have indicated some need for modification. By nature, the quantitative procedure interprets the landscape based on four different stand-alone terrain parameters: relief intensity, slope, elevation and dissection. These four were found to be the most significant factors to identify natural landscape units. However, when the geomorphologic unit delineation is manually done, the interpreter has a complex view on the landscape and units are formed in his mind, not necessarily taking the quantitative thresholds into consideration. The interpreter aims to find the best-corresponding complex units as one, while the quantitative procedure creates four sets of delineations and combines them to form a final polygon system. This latter approach produces several analogue, but not perfectly matching lines, almost similar, but often not the identical delineations of the same units, resulting parallel, redundant approaches in the procedure, and a lot of extra work for aggregating the slave polygons. That was the case for the PDD, where it was used on a high relief area. On the mountainous and hilly regions, slope, relief and elevation do a perfect job for differentiating between the geomorphological units. Involving PDD just means to overcomplicate the procedure, while no additional information is produced. Contrary to the high relief areas, PDD is one of the most significant parameters for the terrain differentiation on a low relief area, where the slope, relief and the elevation have only slight variations. Therefore a decision has been made to pre-stratify the mapped area into high and low relief. Threshold of 100 m/km^2 was chosen to classify the area into the two groups. Elevation, slope and relief were used for the high relief areas, while these three were completed with PDD and all four were used together for the low relief areas. This approach significantly decreased the number of slave polygons top handle.

Database compilation

The next step in the database development was to combine the information from the above four SRTM-derived terrain thematic layers (slope, RI, PDD and hypsometry) into a single grid constituted of Terrain Units. Expectedly this grid had many small and meaningless patterns. It was therefore filtered using a majority function with a 3 cells radius circle shape neighbourhood to create a more homogeneous appearance of the Terrain Units. This grid was then vectorized to create polygon coverage.

Vector-based generalization of the raw SOTER Terrain Units polygon system

Figure 5 shows a close view on part of the raw SOTER Terrain Units polygon system (black thick lines and red thin lines). It is evident that even after the many steps of filtering, there are still a lot of small polygons, which are below the size limit specified in the SOTER Procedure Manual (ISRIC, 1993) (hatched polygons on *Figure 5*). According to the Manual, the minimum area of a polygon

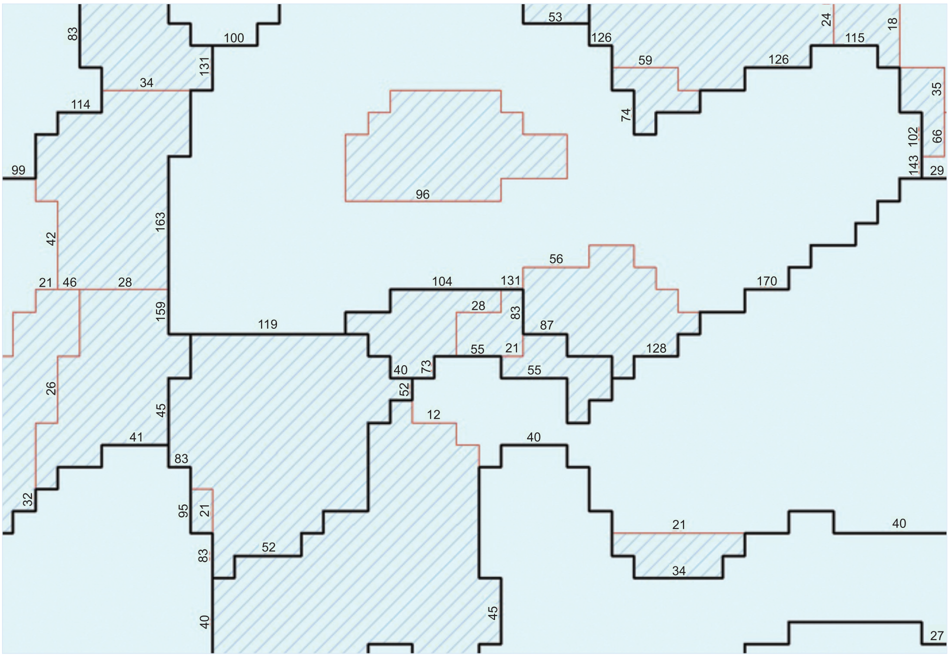

Fig. 5. The minimum Euclidean distance-based aggregation procedure. The red numbers are the Euclidean distances calculated between one polygon and its neighbour. The hatched polygons are those that have a surface area below the threshold (to be aggregated to one of their neighbours). The red thin lines are the polygon borders removed by the algorithm for aggregating

must be 25 km^2 if represented on a 1:1M map and 625 km^2 at a 1:5M scale. Any polygon smaller than these thresholds, depending on the target scale, has to be aggregated with one of its neighbouring polygons, preferably with the one that has the most similar terrain characteristics. To evaluate this similarity in a quantitative manner, the Euclidean distance between each polygon pair is calculated using the same four thematic terrain layers as produced above. These distances (red numbers on *Figure 5*) are then used to select the neighbouring polygon that has the minimum Euclidean distance from the polygon to aggregate.

In the first step, the four continuous landform parameter grids (slope, RI, PDD and hypsometry) are normalized to a range of 0 to 1,000 using equation (1). This step is important to give equal weights to all the four landform parameters.

$$X_{norm} = \frac{X - X_{\min}}{X_{range}} * 1000 \qquad (1)$$

where *Xnorm* is the normalized value for parameter X in the processing cell,*X* is the original value for parameter X in the processing cell, *Xmin* is the minimum value of parameter X calculated from all cells in the grid layer,and *Xrange* is the value range of parameter X (*Xmax* – *Xmin*) calculated from all cells in the grid layer.

At this stage, each cell is characterized by the four normalized values $SLOPE_{norm}$, RI_{norm}, PDD_{norm} and $HYPSO_{norm}$. In the second step, the mean values of these four normalized landform parameters are computed for and assigned to each polygon. Thus, each polygon is characterized by the four normalized mean values $SLOPE_{Poly}$, RI_{Poly}, PDD_{Poly} and $HYPSO_{Poly}$. In the third step, the Euclidean distance (*Ed*) is calculated as a measure of similarity for each neighbouring polygon pair using equation (2) and assigned to the arc that divides that pair.

$$Ed = \sqrt{D_1^2 + D_2^2 + D_3^2 + D_4^2} \qquad (2)$$

where $D_1 = SLOPE_{PolyLeft} - SLOPE_{PolyRight}$

$D_2 = RI_{PolyLeft} - RI_{PolyRight}$

$D_3 = PDD_{PolyLeft} - PDD_{PolyRight}$

$D_4 = HYPSO_{PolyLeft} - HYPSO_{PolyRight}$

and where $SLOPE_{PolyLeft}$ is the mean normalized slope value of the polygon standing to the left of the arc

$SLOPE_{PolyRight}$ is the mean normalized slope value of the polygon standing to the right of the arc and so forth for each of the four parameters.

At this stage, each arc holds a quantitative estimation of the similarity between the two polygons that it separates in terms of landform characteristics (red numbers on *Figure 5*).

In the fourth and final step, the algorithm can now select – for each of the polygons that are candidate for aggregation – the arc to delete that has the lowest Euclidean distance value of all arcs making up the polygon. Deleting that arc results in aggregating the small polygon to its most similar neighbour.

Aggregating several small polygons together may result in a new polygon that still has an area below the specified threshold. Therefore, the procedure is iterative. It starts again from the second step, i.e. calculating the mean values of the 4 normalized landform parameters for each newly aggregated polygon, calculating the Euclidean distances between the pairs and eliminating the arc with the smallest Euclidean distance value. The procedure is repeated until the resulting polygon system remains stable.

The procedure was implemented as a standalone AML tool, which can either be downloaded from the JRC's Soil and Waste Unit homepage or provided by the authors on request.

Results and Discussion

Figure 6 shows the four terrain variables derived from the SRTM DEM grid for the eastern half of the Carpathian basin. The resulting data sets were found to be realistically characterizing the terrain. Although, the centre and south-west-

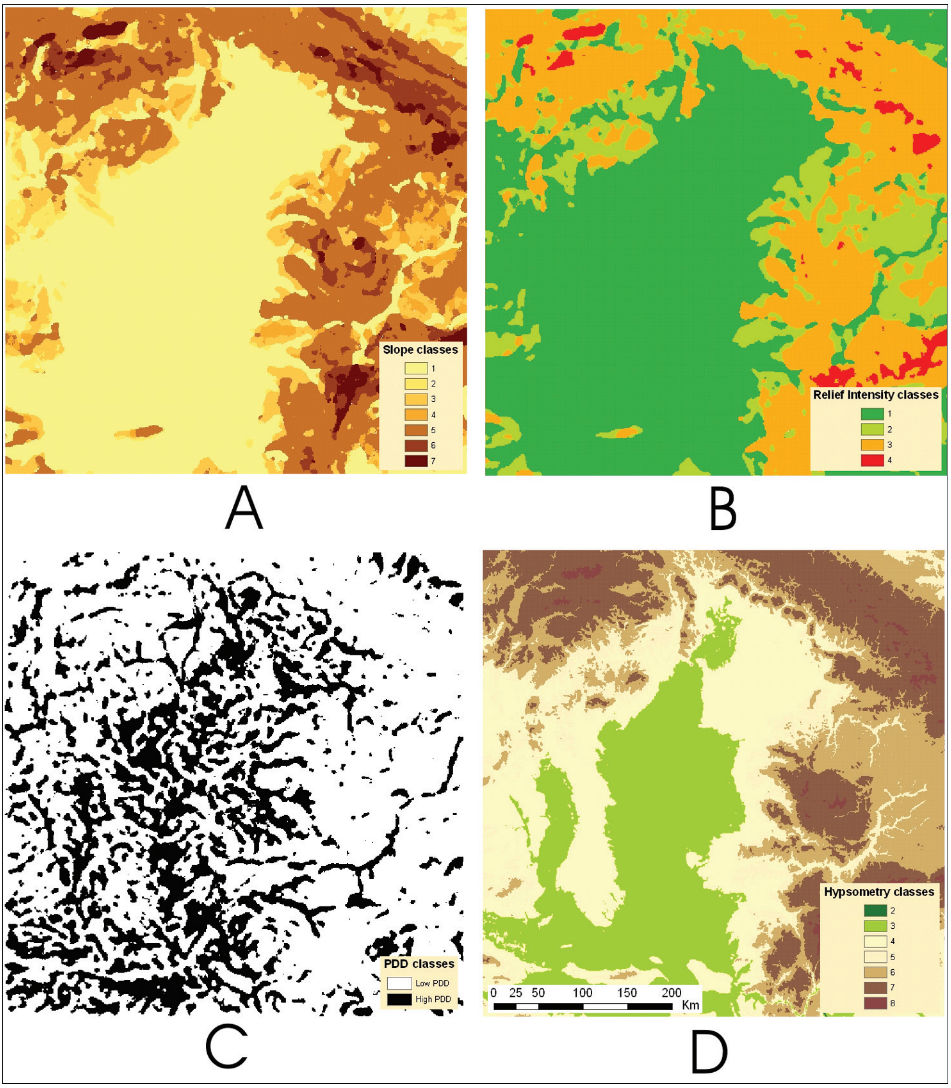

Fig. 6. Maps of the four classified landform parameters in the pilot area. Please refer to the method section for the class meanings. –A = Slope classes; B = Relief Intensity classes; C = PDD classes; D = Hypsometry

ern part is a low relief area (Alföld) with little terrain variability, expressed as only a few meters range in elevation, yet this variability is the most important factor controlling the soil formation processes. In contrast, it is evident from all four derived terrain variable images that the ring of the Carpathians surrounding the plain shows strong variations in the terrain. The challenge of this study was to capture all the significant natural physiographic variation on both plain and hilly areas by applying a quantitative, consistent procedure using the 3 arc second resolution SRTM DEM.

Dobos, E. *et al.* (2004) used a coarser resolution 30 arc seconds SRTM DEM (~1 km) for delineating SOTER Terrain Units. They concluded that the spatial detail needed for deriving a 1:1M scale database is well achieved with such a 1 by 1 km resolution dataset. However, a coarse spatial resolution DEM tends to "overgeneralize" the terrain features by decreasing their value ranges.

The approach developed here is an attempt to take advantage of the availability of a fine spatial resolution DEM. The thematic terrain variable layers were derived from the 90 m resolution DEM to keep as much details of the landscape information as possible. These resulting images were classified based on the SOTER criteria. The classification was followed by the generalization procedure. In the first stage of the generalization procedure, the parameter grids were resampled to coarser resolution. This could have been done by averaging the fine resolution (non-classified) cell values to the coarser resolution one and then classify this spatially degraded grid. But doing so would have taken us back to producing unrealistic classes, which may not even exist in the area. Instead, a "blocking" approach was chosen to achieve this step of the generalization procedure. Blocking consists in assigning the most frequently occurring class value within a block of cells to the entire block. Doing so has several advantages over averaging: 1) it maintains the "most important" information within a block, 2) it maintains the variability inherent to the entire dataset, and 3) it is a valid operation on class values (non-numerical). The first step of the generalization procedure for the 90 by 90 m cell images thus consisted in majority blocking to 11 by 11 cells blocks (990 by 990 m) followed by simply resampling the blocked images to 990 by 990 m cell size images. The method is illustrated on *Figure 4* was applied to the four landform parameter images. As it can be seen from *the Figure 4C*, the method keeps the original classes within the area, showing no trend to shift them downward. Further filtering the image (*Figure 4D*) however shows a tendency to enlarge solid, homogeneous patterns and extend their area over the neighbouring, more heterogeneous areas. This is why filtering must use a relatively small moving window size to minimize this effect.

Both the BLOCKMAJORITY and the FOCALMAJORITY functions have a negative side effect. When more than one majority class occurs within a block or focal neighbourhood (two or more classes are found in the same number of cells within the processing window), the function cannot decide among them and assigns "*no data*" to either all cells within that block (BLOCKMAJORITY case) or to the centre cell of the focal processing window (FOCALMAJORITY case) (see the white spots in *Figure 4D*). Introducing a second filtering step with a larger window is a turnaround "trick" to get rid of almost all these "*no data*" cells by simply picking up for them a value that is found within a larger neighbourhood. The insignificant portion of "*no data*" cells that still remain even after applying this method is treated in the later stages of the generalization procedure, namely with using the polygon aggregation algorithm. It is a more "intelligent" and target oriented procedure and it uses the cell properties directly, instead of estimating the cell class based on its neighbourhood characteristics. However, running the algorithm on a database having a lot of tiny neighbouring polygons with often missing bigger, dominant adjacent polygons to join, the product of the aggregation would be influenced much more by order of polygon processing than by the semantic characteristics of the polygon and would result in a random like aggregation of these polygons. That is why filtering was necessary first to decrease the number of polygons to an acceptable level. The polygon aggregation function was then used to deal with the rest of the "*no data*" polygons. Thus, a raster based filtering and a vector based aggregation was found to be the optimal combination for generalization.

New classification schemes were introduced by the SPM workshop for the four landform parameters derived from DEM data. This paper does not aim to discuss their benefits and impacts. The only conclusion made from the visual interpretation of the polygon system is that the new scheme follows well the geomorphologic units of the landscape and creates meaningful delineation. The changes in the class limits for slope and hypsometry were found to be a great improvement in this study. The new slope classes make a smoother and better discrimination of the land. The classes are grouped around the most frequently occurring values, therefore making a more balanced distribution among them. This phenomenon is even more evident with the hypsometry classes. New classes were introduced to improve differentiation among the landscape units on the low-lying plain areas, where the elevation above the sea level is almost the only significant terrain factor besides the PDD.

Three of the four terrain variables, namely the slope, RI and hypsometry, have not any contribution to the plain area characterization *(Figure 6).* The hypsometry classes contribute a little, but just "accidentally" here because the Great Hungarian Plain lies along the 100 m altitude class limit. The only parameter, which contributes to the landscape unit delineation on a plain area is the PDD. The slope and RI parameters, complemented with the hypsometry, are very efficient in characterizing the landscape of the hilly and mountainous lands. The combination of these three elements creates a very detailed physiographic characterization even without considering the PDD parameter. A large portion of the information provided by the PDD for these higher relief regions is already delivered by the other three parameters. However it is evident that the PDD carries much additional information over the other three parameters, but this appears mainly on a higher scale, not appropriate to the target scales of this project. As opposed to the high relief areas, only the PDD can provide meaningful information for unit delineation within the plain areas by highlighting the depressions and low lying areas where wetness potentially occurs. Using the three dissection classes suggested in the Manual (ISRIC, 1993) would result in a lot of details and small patterns not adequate at the target scales. Instead, only two classes were created and adjusted to delineate both the low lying areas and valley bottoms in hilly and mountainous regions, and the depressions in plain areas. The class boundaries were defined empirically by testing different setups and matching them to real physiographic features.

The pilot area selected for the study was quite challenging due to its very complex natural and anthropogenic geomorphologic patterns. Starting from the second half of the nineteenth century an extensive dike system was built along the major rivers of the Great Hungarian Plain to prevent a huge area from annual floods and to expand agricultural land. At that time, it was often difficult to identify the major watercourse because huge areas were completely covered by inundation or flooding water appearing as temporal lakes. Nowadays the geomorphologic setup of the Plain still resembles to the one from before the dike system. Huge low lying areas, depressions, narrow sand barriers, sand dunes, loess plateaus and old, abandoned river beds create a mosaic of geomorphologic patterns *(Figure 7).* This picture was further diversified by the man made dike and channel structure. Dikes along the Tisza River are captured in the SRTM DEM data and are visible on the DEM image as well (see the brown linear pattern along the Tisza River, pointed with two arrows in *Figure 7).* This of course has a significant impact on the drainage network determination necessary for deriving the PDD. The PDD is generally successful at detecting depressions and local heights. However, the area along the Tisza River is quite problematic. Dikes, especially where the surrounding area is relatively high as well are often taken as heights, preventing the water from flowing through to the river and are thus classified as local elevated areas. This phenomenon extends the area of the natural heights over the low lying ones (see the polygon peninsula extending along the Tisza and pointed by the two arrows). In other cases, where the low lying character of the surrounding area is strongly expressed, thus collecting a lot of drainage lines, these lines are trapped along the dikes on both sides of the river. This creates a high drainage density for those areas, despite the existence of the dikes (see the lower left

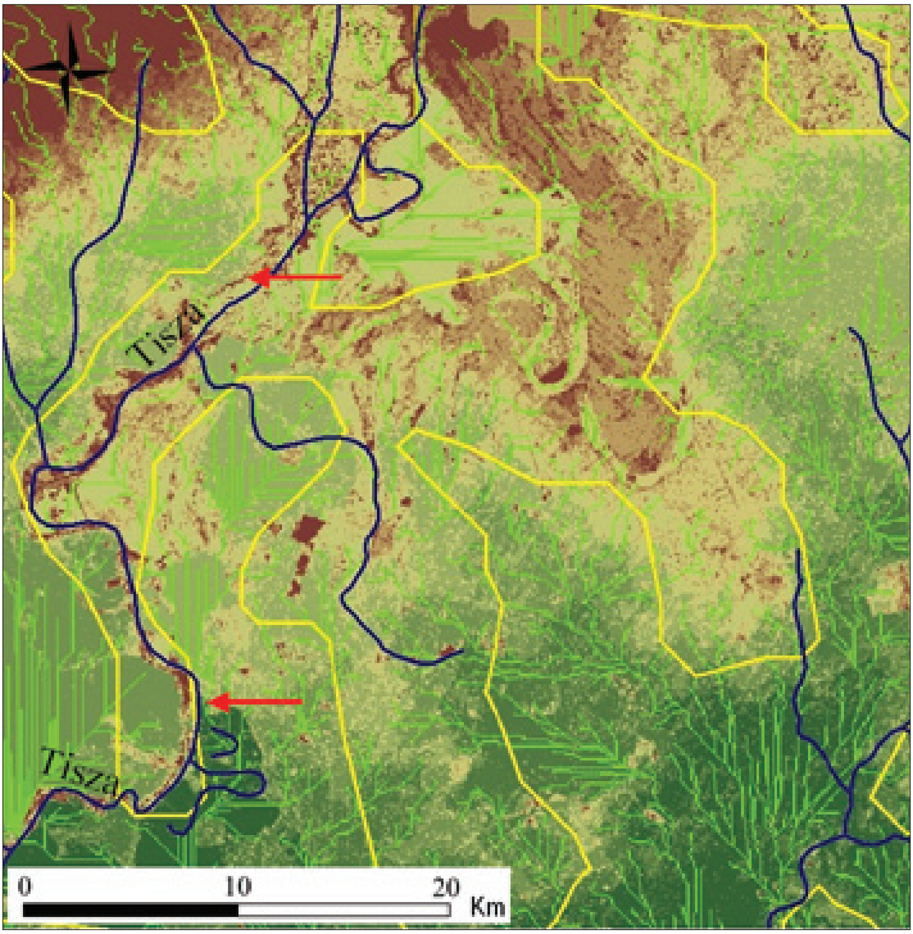

Fig. 7. A 50 by 50 km zoom into the Tisza Valley on the Great Hungarian Plain. The 15 m elevation range (81 to 96 m above sea level) is represented with green to brown colours. Yellow lines show the resulting 1:5 million SOTER polygon system borders. Blue lines show the actual drainage system (rivers, streams and channels) whereas the green ones show the drainage system derived from the SRTM DEM as part of the PDD procedure. The red arrows highlight some of the dikes along the Tisza River

corner of *Figure 7*). In contrast, these are classified as low lying areas. Although this effect hampers the continuous delineation of the Tisza River channel and shifts the balance towards the low PDD area over the high one, it is not as erroneous decision as it may appear. Indeed, dikes have a great impact on the surface water flow, which impact is reflected on the image as well.

The RI classification has changed a lot after the SPM workshop, but mainly in a formal way. The various RI units that were used in different contexts within the previous methodology were replaced with one common unit: *m/[area of a 1 km diameter circle]*. This new unit still maintains a link to the original SOTER RI units while it is easier to handle within a GIS and meets the definition used by geographers for that measure.

The final step in the procedure aims at generalizing the polygon system so that it meets the requirements of the SOTER Manual regarding the target scales: polygons that are below the minimum size limits of 25 and 625 km² at the 1:1 and 1:5 million scales, respectively, must be eliminated and

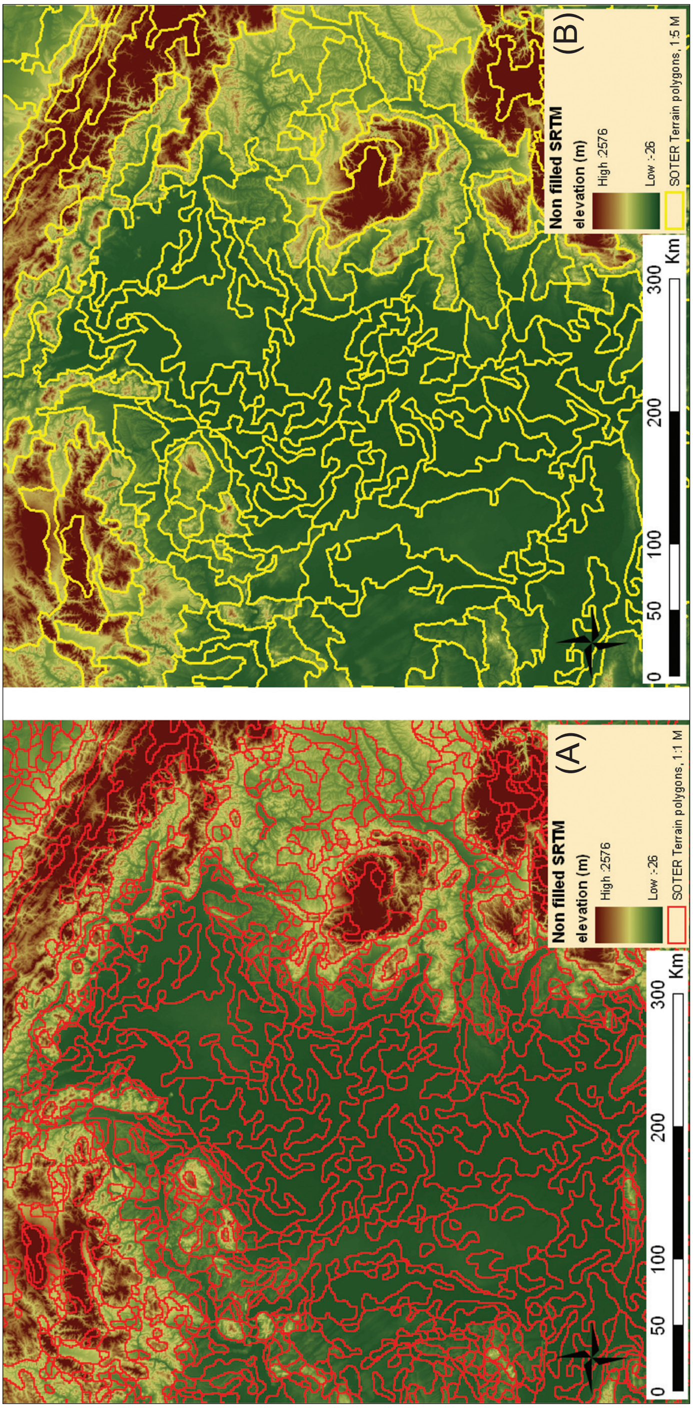

Fig. 8. The generalized polygon system derived from SRTM DEM data to produce the 1:1M (A) and 1:5M (B) scales SOTER Terrain Units for the Alföld and for part of the Carpathians

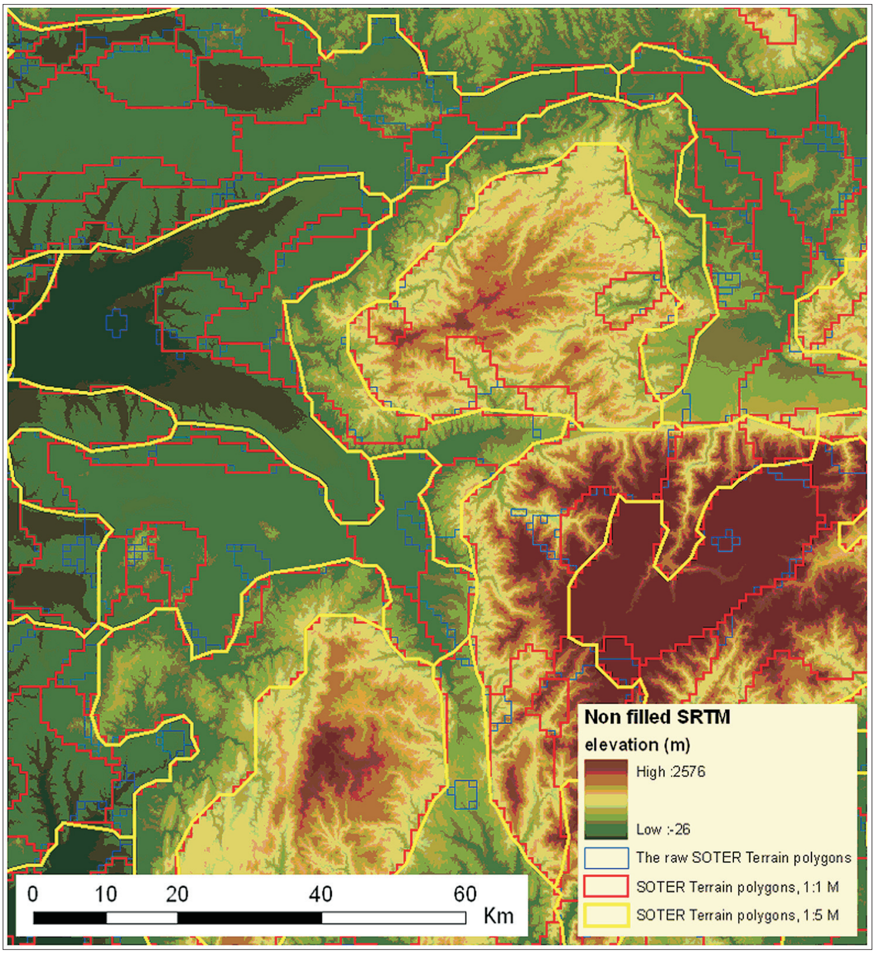

Fig. 9. The SOTER Terrain Unit structure aggregated to 1:1M and 1:5M scales

polygon borders must be simplified. Within the pilot area *(Figure 8)* the lower right corner was zoomed into *(Figure 9)*. It shows all three polygon systems together to give an idea of the effect of the procedure: the raw polygon system as derived directly from the grids (blue lines), the polygon systems produced for the 1:1 million (red lines) and 1:5 million (yellow lines) target scales are displayed.

The procedure eliminates small polygons by aggregating each of them with its most similar neighbour. Similarity between a small polygon and its neighbours is measured by considering the Euclidean distance between their respective landform characteristics. The most similar neighbour, namely the one that is at the smallest Euclidean distance, is selected for aggregation.

On our dataset, despite reducing the number of polygons by 82% at a scale of 1:1M aggregation still moderately altered the original polygon system. Only small, few cell-sized polygons were eliminated, while the overall look of the polygon system was well-kept. At that scale, most of the landscape units that are visible on the SRTM image have been successfully delineated. With hardly any exception, all the blue polygons in *Figure 9* that were aggregated to form the red ones were correctly assigned, followed the landform units of the area.

As expected, aggregation to the 1:5M scale resulted in a more drastic change of the polygon system, reducing the number of polygons by 98%. Characteristic andsometimes very different landscape units had to be combined in a meaningful way. This required a lot of compromise, especially when a small intrusion had to be eliminated but none of its neighbours was really similar. Nevertheless, the algorithm was generally performed successfully and no major problem was identified on the resulting polygon system. Many of the linear features such as bottoms of the valleys were kept in the output and representative (to the geomorphologic units) Terrain Units were formed, appropriate for the target scale.

Generalizing polygons means also generalizing the borders of the polygons that remain after aggregation so that their resolution meets the target scale. The corresponding tolerances (200 and 1000 m, respectively) were chosen according to cartographic common sense (0.2 mm on a map at both scales). Generalizing the arcs is achieved through line simplification. Among the two algorithms provided within the ArcInfo® GENERALIZE command, in our case and only by visual inspection of the results, the Douglas, D.H. and Peucker, T.K. algorithm (1973) appeared to perform better than the pattern recognition one. A "cosmetic" side effect of the line simplification is that the stair-like appearance of the arcs due to the vectorization of the original 990 by 990 m grid cells is smoothed out. Applying both polygon aggregation and line simplification reduced the number of vertices (coordinate pairs) in our dataset by 53 and 89% at the 1:1M and 1:5M scales, respectively, thus dramatically reducing the database volume. Regardless of the scales, the aggregation method produces more or less homogeneous Terrain Units giving satisfying results.

Conclusions

The development of a quantitative procedure for compiling a harmonized, consistent database is seen as a promising way to speed up the completion process of the global SOil and TERrain project. Many segments of the digital soil mapping technology have been made available since the late 1990s. Numerous studies were carried out to test the usefulness of digital elevation data for soil survey and characterization and much knowledge has been accumulated on this topic. The Shuttle Radar Topography Mission (SRTM) project developed global digital elevation model coverage, which is now freely available and easily accessible for use. This emerging set of data and technology can help creating a common platform for the global SOTER database development.

The authors used this opportunity to develop a procedure and test it in the context of the SOTER project for the European Union. This pilot study aimed at making a step forward on this road by creating a methodology for incorporating DEM into the SOTER procedure.

This paper describes this new quantitative method for creating a SOTER Terrain Unit polygon system. The method is designed for mapping large areas of the world quickly and cost effectively. The resulting SOTER database will have the advantages of quantitatively derived databases, namely consistency, homogeneity, limited data generalization problems, and it will avoid edge-matching and harmonization problems. The procedure is based on the SOTER Manual specifications and is meant to be compatible with the datasets formally developed using the traditional way. But it also incorporates the procedural changes, which have occurred since 1995, when the last revision of the Manual was published.

The procedure has been tested on a representative pilot area covering the eastern half of the Carpathian Basin. The delineation of the terrain features is appropriate to the targeted scales. Meaningful and homogeneous geomorphologic units were identified at the 1:1M scale in the test area. More complex but still uniform units were identified at the 1:5M scale as well.

The method is used to develop the SOTER database for the Member States of the European Union. Further refinement and characterization of the Terrain Units will be done using the Soil Geographical Database of Eurasia at 1:1M scale (King, D. *et al*., 2002).

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Dust accumulation and loess formation under the oceanic semiarid climate of Tenerife, Canary Islands

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Abstract

Sediments formed by mixing dust of Saharan origin with local weathered pyroclastic rocks were investigated using granulometric analyses for environmental reconstruction. For this purpose traditional sedimentological parameters were applied together with indices such as FG (fineness grade) and K_d (degree of weathering). It could be established that surface deposits are loess or loess-like sediments reworked by colluvial processes. It was also concluded that soils formed on alkalic basalt lava are semipedolites i.e. sediments that have undergone pedogenesis of limited extent, whereas on the phonolite genuine paleosols formed. The stratification of sediments show half-year variation instead of annual one due to the alternating dry and wet seasons (parent material being transported by north-eastern and Sahara trade winds). With the exception of the soil developed on the phonolite lava all the deposits studied are younger than 1 Ma.

Keywords: Saharan dust, pyroclastic rocks, grain size analysis, sedimentological indices, trade winds

Introduction

In the section at Bandas del Sur, on the south-eastern part of Tenerife (*photos 1* and *2*), Canary Islands (*Figure 1*) loess-like deposits and sediments affected by pedogenesis were investigated using grain size parameters. Based on the parameter values this method is aimed to characterize these deposits and to identify the environmental conditions that prevailed during their formation.

The deposits have developed on volcanic pyroclastic rocks as a result of the weathering of the latter and a concurrent admixture of the falling dust of African origin. Dust accumulation and formation of loess-like deposits is going on even nowadays (*Photo 3*). Nevertheless this so-called African dust is not uniform either; partly it was blown out from sand deserts of Sahara and from the western areas of Atlas Mountains, partly derives from "perisaharan loess" of Africa. On the Western Canary Islands airborne material of sand

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Photo 1. The island of Tenerife, with the highest peak of the stratovolcano (Pico del Teide, 3718 m). (http://upload.wikimedia.org/wikipedia/commons/8/8c/Tenerife_LANDSAT-Canary_Islands.png)

Photo 2. Volcanic rocks and sediments building up Tenerife (Photo by Schweitzer, F.)

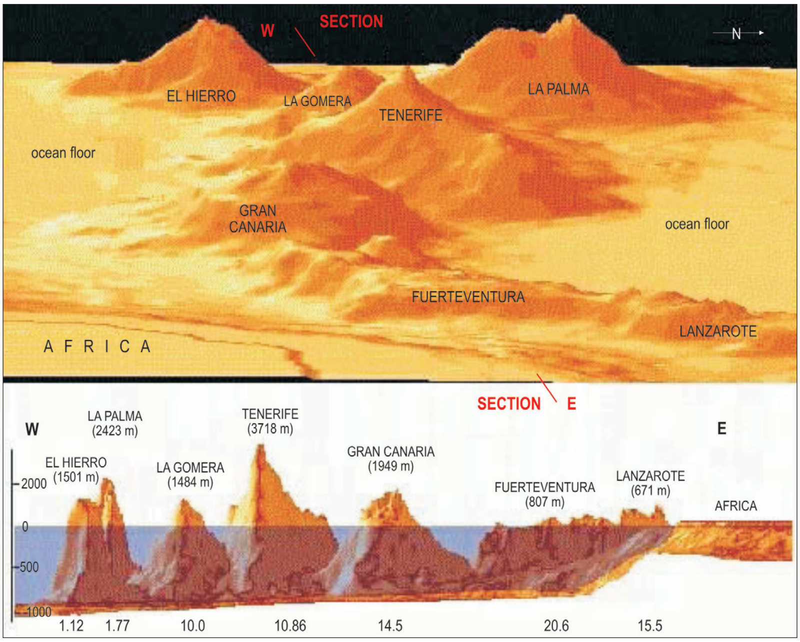

Fig. 1. The Canary Islands hot spot. Carracedo, J.C. *et al*. 2002.
http://www.mantleplumes.org/Canary.html

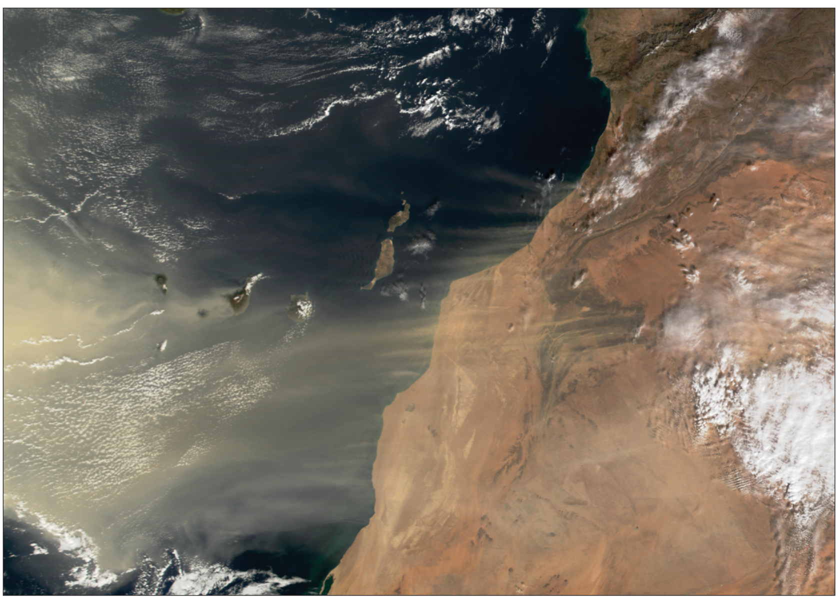

Photo 3. Satellite image showing African dust blown towards the Canary Islands (http://earthobservatory.nasa.gov/IOTD/view.php?id=1169)

dunes and loessial sediments redeposited from the Eastern Canary Islands (Lanzarote, Fuerteventura) to Tenerife or Gran Canaria, sometimes reworked several times was also added.

The climate on Tenerife is oceanic semiarid, thus periodicity i.e. alternating dry and humid half-years are reflected by the stratification of geological sequences. Half-year periods stem from the differences in warming of the ocean and land and expressed by dry trade winds of north-eastern direction in summer and humid trade winds blowing from the Sahara in winter. Half-year periods of deposition are manifest on Canary Islands similar to China, where they are the consequence of summer and winter monsoons due to differences of warming.

Von Suchodoletz, H. *et al.* (2009) described and analysed reddish clays and loess-like yellowish sediments on the Isle of Lanzarote. He identified paleosols, loessial colluvial layers and sediments/colluvia with traces of pedogenesis.

Fluvio-lacustric loessial sediment was described on Gran Canaria by Menéndez, I. *et al.* (2009). Fluvial action was responsible here for the redeposition of sediments. In his opinion calcareous sheets were formed in the humid seasons, whereas desiccation and formation of "dry" soils (with carbonate precipitation) characterized the arid phases.

The method applied

A unified method of comparative grain size analysis has been elaborated for the analysis of Quaternary sediments and there were laid foundations of an exact characterization and comparability of these deposits by the classification of loess regions. This method was tested in Hungary and applied exclusively by our research team for the investigation into Quaternary deposits (loess and loess-like sequences).

Through the evaluation of the results an opportunity has opened to acquire much more information in a rapid way about the history of evolution of the studied area:

- palaeoenvironmental conditions during the deposition of the loess material;
- changes taking place in the geographical environment;
- climate fluctuations during the past 2 million years, including the ice ages;
- warming maxima and cooling minima of temperature during the Quaternary;
- differences between the profiles of various loess regions based on the above research methods.

Values of each parameter (index) as environmental indicator are gained by the application of analogous methods, so they are to be considered a highly correct and reliable source for a comparative analysis of profiles within a given region and between different regions, and for drawing conclusions on their palaeogeography.

Quaternary sediments are characterized using the above method and an attempt is made to draw conclusions about changes of the dynamics of rate of sedimentation and to establish local correlation between horizons with similar characteristics. Traditional sedimentological parameters (So, K, S_k, M_d) were applied together with two indices introduced in Hungary recently: FG (fineness grade) and K_d (degree of weathering), and with $CaCO_3$ content and percentage share of clay, silt, loess and sand fractions.

The role of parameters as environmental indicators could be established. Their values point to changes in granulometry and in turn can also be instrumental in demarcation of basic lithological units and identification of phases of sedimentation and gaps in the process. Variations can be recognized inside seemingly homogeneous horizons as differences might be detected as well between layers of apparently identical genesis in order to make comparisons, correlations, to draw conclusions about palaeogeography of the given region.

Table 1 contains two new indices. Fineness grade (FG) serves for an exact separation of horizons from each other, reconstruction of palaeotopography. Increasing or decreasing values of FG are indicative about the source area of the parent material of loess, about wind direction and velocity during transport. K_d index can be used to determine the degree of weathering, to point out extreme warming and cooling events. Traditional parameters provide additional information such as sorting (So) on the origin of the sediment material, kurtosis (K) is instructive for the sharp separation between loess and sand, asymmetry (S_k) gives orientation to separate between regions of accumulation and denudation.

Of the newly adopted indices fineness grade shows maximum values in soils and minima in sands. Knowing these values soil horizons become recognizable while those finer than the average represent young loesses and considerably finer ones indicate old loesses. Minimum values indicate sands, while somewhat higher ones represent silt interbeddings. FG values are used for an exact denomination of sediments, delimitation of the boundary of layers, their trend to increase or decrease refer to grain size to refine or coarsen so it can be used for distinguishing between old and young loesses, revealing alterations within paleosols, correlation between loess and paleosol horizons.

K_d index is represented by minimum values in soils and maxima in loesses (and by figures slightly above minimum in sands). Apart from being useful for the identification and demarcation of sediments, its maxima is suitable for pointing out extreme cooling within loess sequences (their exact depth can be identified within a given loess layer) and minimum values refer to warming maxima inside

Table 1. Values of FG, K_d, M_d, So, K and S_k in the section at Bandas del Sur

Denomination	FG (fineness grade)	K_d (degree of weathering)	M_d mm (median)	So (sorting)	K (kurtosis)	S_k (asymmetry)
Paleosol (formed on phonolite lava)	73.12–85.84	1.14–1.17	0.016–0.023	3.16–3.72	0.15–0.23	0.24–0.27
Sediment (formed on alkali basalt) affected by pedogenesis	64.28–70.23	1.74–1.83	0.041–0.140	6.73–6.84	0.46–0.51	0.81–1.37
Loess sediment (formed on a sequence affected by pedogenesis)	56.21–64.89	1.12–4.49	0.023–0.057	2.26–3.15	0.23–0.28	0.12–0.18
Loess-like deposit I (on weathered pumice stone as parent rock)	58.09–60.02	2.45–4.47	0.027–0.187	5.66–5.82	0.36–0.38	0.42–0.47
Loess-like deposit II (on weathered lapilli as parent rock, with an admixture of Saharan dust)	60.02–62.40	2.72–3.15	0.027–0.028	2.59–2.78	0.39–0.42	0.17–0.22 0.41–0.49
Loess-like deposit III (on weathered breccia as parent rock, with an admixture of Saharan dust)	57.13–63.09	2.49–3.33	0.027–0.085	1.37–1.48	0.36–0.43	0.32–0.57
Sediment (formed on upper alkali basalt) affected by pedogenesis	63.32–71.14	1.68–1.73	0.04–0.06	6.01–6.11	0.49–0.55	0.34–0.38

soils (exact depth within the soil horizon).

Sorting (So) has its peaks of maximum in soils, minima in sands and average values are typical of loesses. According to Trask, P.D. (1932) So index values less than around 2.5 represent poorly sorted sediments, normal sorting is around 3 and well sorted deposits are above 4.5. In the sequences the highest figures represent loess sand, stratified sand, clays and incipient soils. Minimum values appear in unstratified sand, fine grained sand loess and in young loess. By this classification most of the deposits are poorly or normally sorted sediment.

S_k indicates *asymmetry* of sediments. They allow to distinguish between sands and loess on the one hand and clays and silt on the other, and to separate areas of accumulation from those of denudation. Using this parameter more phases of sedimentation can be identified than using other methods.

Kurtosis (K) values are low in soils, with minimum peaks in sands and medium figures in loesses. Its extremes indicate mixing loess with soil, referring to boundaries of loess and soils sharply.

Geographical setting

Canary Islands are situated between 27°37′ and 29°23′ of northern latitude and 13°20′ és 18°16′ of western longitude. The largest isles are Tenerife, Fuerteventura, Gran Canaria, Lanzarote, La Palma, Gomera and Hierro (*Figure 1*) and there are numerous islets. The archipelago is located along the margin of the African litosphere plate. Tenerife is in the central part of Canary Islands (*photos 1* and *2*), 300 km off the coasts of mainland Africa. It is ca 97 km long, and 16 to 48 km wide. Pico del Teide is the highest mountain on Tenerife ("snow covered mountain") and on the islands, raising to 3,718 m.

Origin of the islands

The latest results of investigations confirm basalt rocks becoming younger from the west to the east. Figures of absolute dating seem to fit in the theory by Hess, P.C. (1992) based on Schmincke, H.-U. (1976) that the islands emerged from the plate formed by sea-floor spreading from the Mid-Atlantic Ridge.

Along the boundary of continental/oceanic plates sediments have accumulated in a thickness of ca 10 km, and "oceanized" subsequently. There is a considerable difference between the age of oceanic crust (ca 180 Ma, Jurassic) and that of the majority of the volcanites (ca 20 Ma, Miocene). Transversal faults run perpendicular to the ridge and might continue on the continental plate. Canary volcanism is presumably the continuation of the fault running from South Atlas. The emergence of the islands is due to the Canary hotspot, associated with convection upwelling of melted rock from great depth of the mantle (intraplate volcanism).

According to Viñuela, J.M. (http://www.mantleplumes.org/Canary.html) Canary Islands formed at the margin of Jurassic oceanic plate and of African continental plate. Material of the mountain chain on the rise originated from the upper mantle and *settled in a vertical sequence*.

The first alkali magmatic activity of this *hotspot* started with the emergence of the isle of Fuerteventura in Upper Cretaceous (~70 Ma), and continued with submarine volcanism through Eocene and Oligocene (~39 Ma) into surface volcanism in Miocene (~20.6 Ma).

The development of submarine and surface volcanism associated with hotspots include the following phases (Walker, G.P.L. 1990).

Submarine volcanism

Volcanism on the Canary Islands has included submarine stages and emergent stages. The latter are shield building stage, declining stage, erosional stage, and rejuvenated stage. Four isles: Fuerteventura, Lanzarote, Gran Canaria and Tenerife are currently in the stage of rejuvenation, La Gomera is in erosional stage, La Palma and El Hierro are in declining stage. It is widely accepted that the material of oceanic "hotspot" volcanism is molten rock upwelling from the mantle. The age of volcanism on the Canary Islands (Carracedo, J.C. *et al.* 2002): Fuerteventura 20.6 Ma (rejuvenated stage), Lanzarote 15.5 Ma (rejuvenated stage), Tenerife 11.6 Ma (rejuvenated stage), Gran Canaria 14.5 Ma (rejuvenated stage), La Gomera 12.0 Ma (erosional stage), El Hierro 1.12 Ma (shield building stage) és La Palma 1.77 (shield building stage).

Surface volcanism

According to Ancochea, E. *et al.* (1990) surface volcanism on the Canary Islands can be classed into four main groups: 1. *"old basalt sequence" (11.6–3.3 Ma),* presumably separated volcanic ensembles: Teno in the north-west, Anaga in the north-east, and Roque del Conde in the south, have K/Ar age of Late Miocene and Early Pliocene; 2. interruption of volcanic activity until *1.9 Ma* with the dissection of the initial structure of the central Cañadas Volcano, emergence of Cañada sequence I and II as a result of trachyte, phonolite and basalt extrusions between *1.89* and *0.13 Ma*; 3. minor eruptions of basalt *from 0.9 Ma to historic times*, minor basaltic eruptions on the ridge between Cañadas és Anaga stretching in south-west–north-east direction; 4. emergence of the caldera and disappearance of part of Cañadas Volcano between *0.17* and *0.13 Ma;* subsequent building up of a volcano with the centre at Teide–Pico Viejo (basalt, trachyte, phonolite).

According to the actually accepted geochronological data *in the vicinity of Cañadas,* i.e. within the study area, *four pyroclastic phases* could be distinguished *during the past 2 million years:* 1. *San Juan de la Rambla phase (~2 Ma*) towards North Tenerife (Ancochea, E. *et al.* 1990); 2. *Adeje phase* (*1.5–1.8 Ma*); 3. *Las Amérocas phase* (*1.1–0.9 Ma*) with all the pyroclastic clays between La Bentrana and Arico ignimbrites; 4. *Bandas del Sur phase (0.7–0.15 Ma)* in the south-east of Tenerife.

Relief

Landforms on the Canary Islands are characterized by heterogeneity within a small area. Surface features are the result of volcanism, wind and fluvial erosion and marine abrasion. The main rocks to build up the islands are the *basalts, phonolites* and *rhyolites.* Volcanism is still active on Tenerife, Lanzarote and La Palma. The most typical landforms of volcanic origin are the cones with calderas of different size, the lava fields and basaltic plateaus. A basic type of *valleys* is represented by deeply cut *barranco*s running partly on a radial pattern. Also there are wide troughs (*walle*s) and trench-like valleys dissected by a dense network of gullies.

Sea coasts are mostly high. In the west of the island 100 m high coasts are not exceptions. In contrast, low coasts are infrequent, they rather occur in the south.

The most ancient regions on Tenerife are the mountains of *Teno, Anaga* and (partly) those of *Adeje–Lorenzo.* There are walls built of basalt with a length of several hundred metres. Due to heavy rainfalls and a long erosional period lasting since the Tertiary barrancos are the most characteristic landforms. The considerable relief intensity between Teide peak and the sea coast strengthens the *impact of erosion*.

Mountains of Anaga

In the lack of plateaus, volcanic cones and walls of craters several elongated ridges stretching northwards and southwards were formed by barrancos cutting in deeply. Part of them resembles alpine relief.

Teide and Las Cañadas

Pico de Teide elevates to 3717 m, over timber line and is visible from all over the Canary Islands. In winter time the summit remains snow covered for weeks. This is a regular cone of a stratovolcano descending northward abruptly. On its south-western side Pico Viejo rises to 3,102 m. Pico de Teide is half-circled at 20 km length by a curious piedmont called Las Cañadas del Teide. The landscape is dominated by extensive lava fields.

At *Bandas del Sur* erosional gaps could be recognized which separate three cycles of landform evolution (Bryan, S.E. *et al.* 1998; Brown, R.J. *et al.* 2003). Altogether they make up 15 pyroclastic units (paleosols, other sediments, erosional gaps and "fallout" deposits originated from volcanic ash clouds).

The ignimbrite of Arico is a product of Plinian eruptions of limited scale composed of falling dust and ash flows. The former deposited within a small area. The material of deposited pyroclastic flows can easily be separated. In this area no lava flows occur, only pyroclastic sediments can be found. The latter are of phonolite or trachyphonolite (Rodehorst, U. *et al.* 1998) and originate from the volcano Las Cañadas, active for 3.3 million years (Bryan, S.E. *et al.* 1998). The ignimbrite of Arico is labelled as "welded" one by Fritsch, K.

and Reiss, W. (1868). It was them who recognized that this type of ignimbrites unites the features of tuffs and lava flows. The ignimbrite was also investigated by Schmincke, H.-U. and Swanson, D.A. (1967), Ridley, W.I. (1971) and Alonso, J.J. *et al.* (1988). This viewpoint was opposed by Brown, J.R. *et al.* (2003).

The studied section

In the exposure (*Photo 4*, *Figure 2*) soils formed on phonolites and alkalic basalt, loess interbeddings, and loess-like deposits formed by the mixture of weathered pyroclastic matter with an admixture of dust from Sahara were studied in the south-eastern part of Tenerife, in the surroundings of Arico. The oldest deposit is the lowermost phonolite with an age of 3.3–2 Ma (Martí, J. *et al.* 1994), followed upward by Arico ignimbrite: by K/Ar dating it is 0.65±0.03 Ma (Ancochea, E. *et al.* 1999) and by $^{40}Ar/^{39}Ar$: 0.61±0.09 (Bryan, S.E. *et al.* 1998). The oldest ignimbrite in the environs is La Brentana with $^{40}Ar/^{39}Ar$: 1.44±0.12 Ma and isochron age: 1.50±0.17 Ma (Alonso, J.J. 1989). Most of the layers in the section goes back to Bandas del Sur phase (0.7–0.15 Ma) and are associated with pyroclastic processes of Las Cañadas volcano (Huertas, M.J. *et al.* 2002).

Photo 4. The studied section in the environs of Bandas del Sur (Photo by Kis, É.)

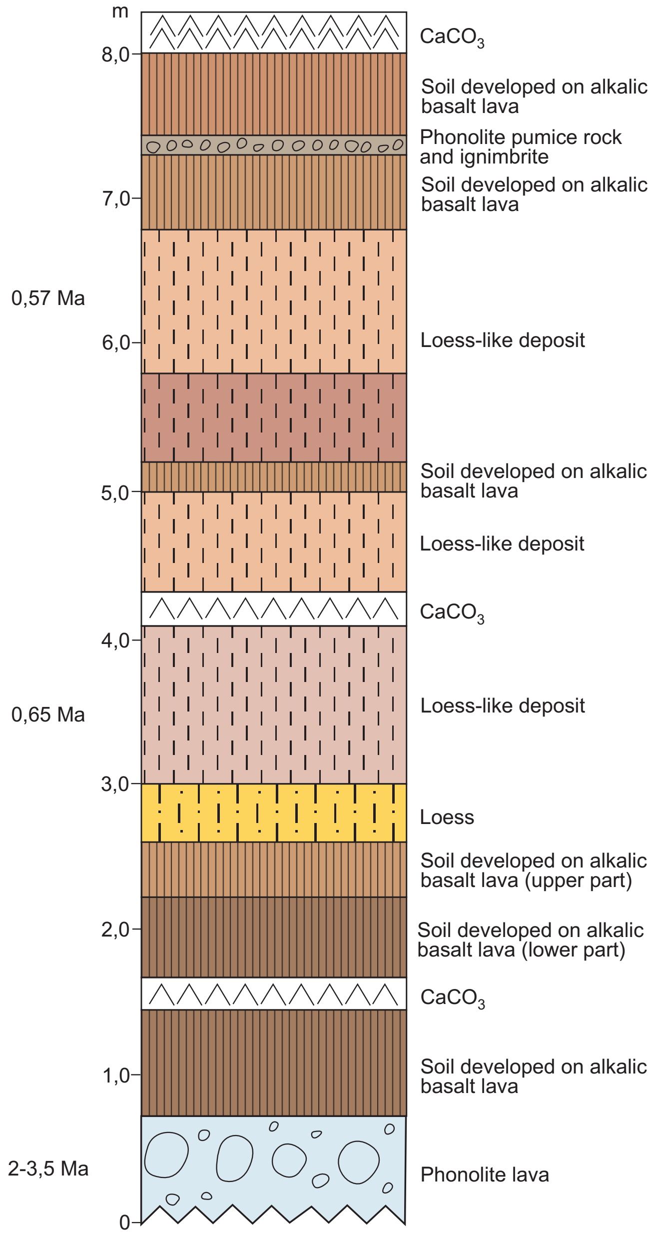

Fig. 2. The section at Bandas del Sur (Schweitzer, F. and Kis, É. 2010)

In the lowermost part of the section the phonolite lava of Las Cañadas volcano is found dated 3.5–2 Ma (Martí, J. *et al.* 1994, *Photo 4*, *Figure 2*). There is an erosional hiatus above it overlain by a paleosol (*Photo 5*), which is separated from the superimposing layer formed on alkalic basalt undergoing double soil formation by two tuff horizons (*photos 6* and *7*, one of them is a phonolite pumice lapilli). Upwards the profile there is a loess horizon *(Photo 8).*

Further up above the loess and a layer with the traces of pedogenesis the *first loess-like sediment sequence* contain two well-sorted ash layers and two weathered pumice horizons originated from fallout deposits (i.e. from ash clouds) with an admixture of Sahara dust (*Photo 9*). There is a strong erosional hiatus above this layer.

Parent material of the *second loess-like sediment sequence* with yellowish sandy colour is lapilli. Its characteristic feature is the occurrence of light green pumice rock pieces that could reach 40 cm

Photo 5. The lowermost soil developed on phonolite (Photo by Poór, I.)

Photo 6. Soil developed on alkalic basalt lava (Photo by Poór, I.)

Photo 7. Upper soil with the underlying tuff and breccia (Photo by Schweitzer, F.)

Photo 8. Loess-like deposit upon alkalic basalt affected by pedogenesis (Photo by Poór, I.)

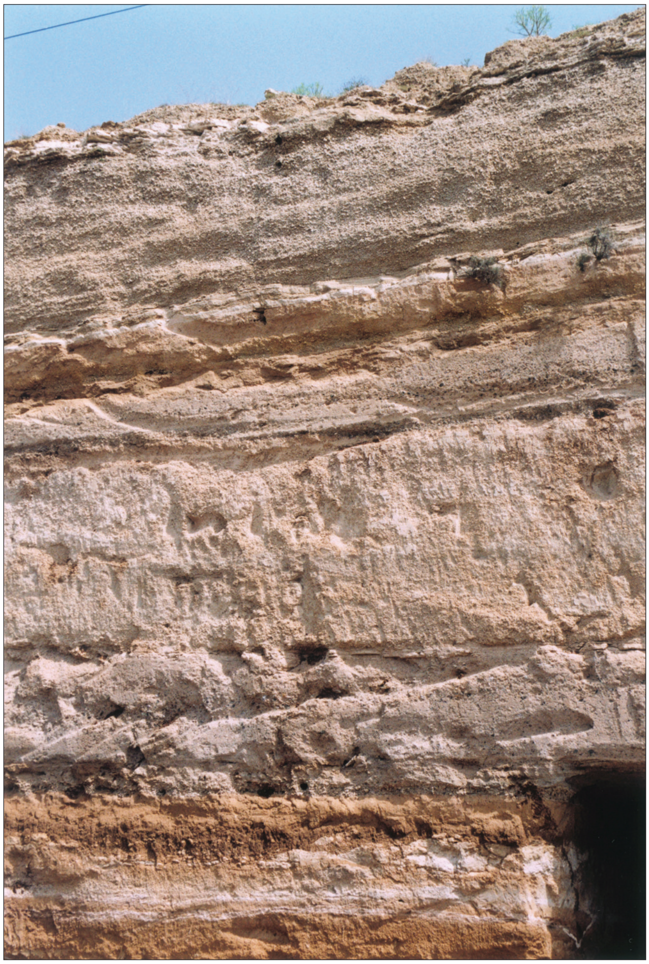

Photo 9. Loess-like deposit formed by weathering of pumice rock and its mixing with Saharan dust above the lower double soil (Photo by Schweitzer, F.)

in size. The smaller they are the more they are zeolitized. There are voids i.e. places of large pumices having fallen out. This layer of zeolitized lapilli has been eroded intensely by the overlying breccia. Here at the boundary of two phases of sedimentation a long gap can be recognized (*Photo 10*).

The *third loess-like sediment sequence* starts with breccia composed by black and green pumice stones above layers containing water (*Photo 9*: sediments over lapilli). Upon this ash layer there is an embryonic soil developed on a pyroclastic flow. Further up a layer containing pumice follows and an embryonic soil developed on a pyroclastic flow can be detected that is overlain by two ash layers, with a thickness of ca 30 cm each (*photos 8* and *9*).

Photo 10. Loess-like deposit formed by weathering of lapilli and its mixing with Saharan dust in the lower part of the photo (Photo by Kɪs, É.)

Climate

The climate on the Canary Islands is determined by their position within the strip separating North- and South Atlantic with temperate and tropical climate, respectively and where the Sahara and the longitudinal Atlantic climatic zone meet. Decisive role belongs to three types of air currents: 1. oceanic tropical, 2. oceanic polar and 3. Saharan continental. The climate is rhythmic with alternating half-year periods (summer and winter half-years). Oceanic tropical climate dominates the summer half-year, whereas Sahara and oceanic polar prevail in the winter one. North-west off the island is situated the area of high pressure all year long (Azores high/anticyclon). Its position is varied during the year but basically remains within the Azores–Madeira–Canary strip. In the summer this Azores high is predominant with north-estern trade winds. In the winter however its position and strength change and oceanic polar or humid tropical air masses intrude and the latter cause intense rainfalls. If Azores high moves eastbound the Canary Islands would fall under the influence of African continental climate.

Climate on the islands shows periodicity, under the influence of monsoon. *In the dry summer half-year* Azores high dominates up to 30° of northern latitude with north-eastern trade winds of a 90–95% frequency. Trade winds generally are dry and do not bring rains. However, they do to the islands, because they take up moisture over the ocean and near-surface air is lifted upwards by mountains which in turn condense water vapour in the rising and cooling air, and clouding over starts. During the humid winter half-year polar oceanic or humid tropical air masses might invade. At this time monsoon is less significant and winds blowing from the Sahara and transporting humid subtropical air masses turn northward along the western margin of the African continent (Ortiz, J.E. *et al.* 2006 based on Nicolson, S.E. 1996 and Moreno, A. *et al.* 2001).

Half-year climate periods similar to the Canary Islands can be identified in China as well (summer and winter Asian monsoon). Consequently, in both areas, e.g. on the Loess Plateau too stratification of sediments displays half-year variations.

Climate change, the amount of dust transported from Africa and the character of transport bear importance in our case because dust as parent material of loess and loess-like deposits at Tenerife have been blown out (and still are) by north-eastern trade winds, polar oceanic and continental Saharan winds.

Dust blown out from the Sahara can reach places several thousand kilometres away, e.g. coral reefs of the Caribbean *(Photo 11)*. Saharan dust accumulates on the oceanic floor and it is detectable in deep cores. Part of the deposited dust might be redeposited repeatedly, because due to the sea level subsidence during the glacial epochs it appears on the surface of the shelf surrounding the isles. This is why we should have some idea about the past sea level oscillations.

Dust transport

In the summer Saharan dust is transported by north-eastern trade winds (*Photo 11*) and in winter this is done by the Saharan air masses. *In the summer* the northern portion of Saharan air masses flows north of the Canary Island *at a height of 1,500–5,500 m*. The material is moving horizontally in the lower part of the troposphere towards the islands (Koopmann, B. 1981; Bozzano, G. *et al.* 2002). Eventually dust is deposited upon dry or wet surface (Criado, C. and Dorta, P. 2003; Menéndez, I. *et al.* 2007). In winter dust is transported at *0–1500 m height* during Calima event. Calima winds are continental African trade winds (*harmattan*) deflecting Atlantic cyclons westward, to Canary Islands (Criado, C. and Dorta, P. 2003).

As dust is being deposited both on the ocean floor and land surface, particles sedimented over three years in deep sea were studied at European

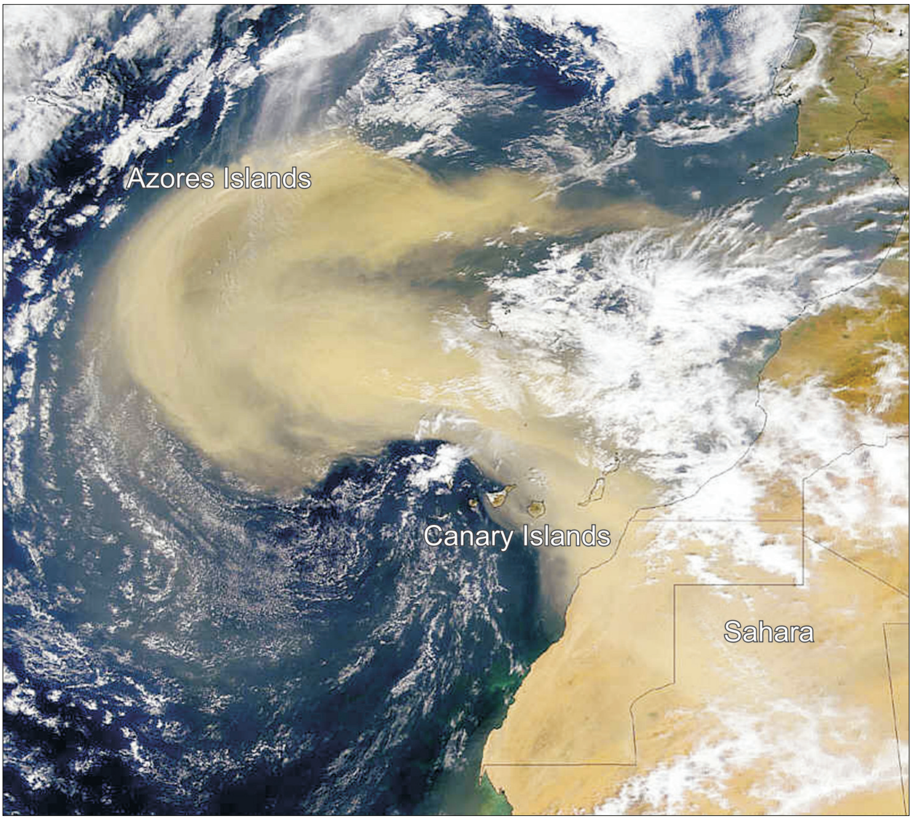

Photo 11. North-eastern trade winds transporting Saharan dust (http://www.phys.unsw.edu.au/~jbailey/planets/dust.html)

Station for Time-series in the Ocean, off Canary Island. By Neuer, S. *et al.* 1997 sedimentation has a highly seasonal character, its maximum falls to late winter, early spring. Most of the particles consist of basalt, various minerals and carbonates and a large amount of organic matter. Minerals make up *eolian deposits of African origin*. Comparing sediment at depths of 1 and 3 km it was found that the amount of sedimented particles increases gradually with depth. Annual deposition of organic carbon was 0.6 gm^{-2} at 1 km and raised up to 0.8 gm^{-2} at 3 km depth.

On the Canary Islands in the warm and *wet time intervals* marine terraces and fossil soils (with warm fauna) developed, whereas in dry intervals calcareous crusts and poligonal evaporite soils and eolian deposits (including dunes) (Petit, J.R. *et al.* 1999) formed. Of the sediment studied those having undergone pedogenesis formed in humid periods and loess and loess-like sediments formed during dry intervals.

Photo 12. Traces of sea level oscillations in the northern part of the Mountains of Anaga (Photo by Schweitzer, F.)

Sea level oscillations and the age of marine terraces

Dating of terraces is a serious challenge for researchers as the islands are situated in a highly tectonic area with a sizeable annual uplift. Zazo, C. *et al.* (2003) compared the highest sea levels during interglacials and interstadials with marine isotope stages (OIS 5a [5c, 5e, 7, 11 or older]). During OIS 5e (135–117 ka) three sea level maxima occurred. At the highest of them sediments contained the so called Senegal Fauna. The rate of uplift was 0.011 mm/yr, which suggests 2 m sea level rising during OIS 5e. Terrace formation was triggered by intense tectonic movement. Most of the terraces emerged in the Middle and Late Pleistocene. *Strombus bubonius* warm fauna found in a layer of *Cladocora caespitosa* coral has OIS 7 age; Hillaire-Marcel, C. *et al.* 1986; Goy, J.L. *et al*. 1986; Zazo, C. and Goy, J.L. 1989; Chappell, J. and Shackleton, N.J. 1986 established 15 m rise in sea level, whereas Roy, P.S. and Boyd, R. (1996) came to 2–4 m in stable South Australia. This oscillation was determined by Hearty, P.J. and Kindler, P. (1995) in 2.5 m (OIS 7a) and ≤ 0 m (OIS 7c) on the Bahamas.

The following warm faunas of high sea level stages dated OIS 9 or OIS 11. OIS 11 was the longest (420–360 ka) and warmest interglacial over the past half of a million years (Droxler, A.W. and Farrell, J.W. 2000). Its warm fauna was described in Chile (Ortlieb, L. *et al.*, 1996). During this interval sea level rising presumably was 17 m in South Australia with tectonic stability (Murray-Wallace, C.V. *et al.* 2001) and on the Bahamas (Hearty, P.J. *et al.* 1999)

On Tenerife (Igueste, 97–13 m a.s.l.) warm marine fauna (*Strombus bubonius*) is dated OIS 5e (Zazo, C. *et al.*, 2003, change in sea level: 0 m).

In the Mountains of Anaga the fossil sea coast has an age of OIS 5e (≈130 ka), at Igueste de San Andrés OIS 5e (~131 ka). On the Canary Islands *Strombus bubonius* was dated last interglacial i.e. OIS 5e (Meco, J. *et al.* 2002). Talavera, F.G. *et al*. 1989; Zazo, C. *et al.* 2003 describe fossil coasts as of OIS 5 age and indicate sea level rise of 1–2 m (e.g. Poque de las Bodegas).

The degree of uplift (sea level curve compared with present-day values): El Medano 1.5 m, North Anaga 10.5 m (*Photo 12*, OIS 5e), Igueste de San Andrés 2.8 m, Playa de Gordejuela 18.5 m (540–690 ka), Montana Pelada 35 m, <778 ka.

Results

In the sections studied and their surroundings there were investigated sediments formed by a mixture of weathered surface pyroclastic deposits with Saharan dust. The analyses were aimed to determine the character of these sediments and the circumstances of their formation. For sediment analysis (*Table 1, Photo 3, Figure 3*) a new method was applied by our research team with the involvement of the values of sedimentological parameters for the indication of environmental conditions for the first time in Europe.

With the applied method of environmental evaluation loessial materials and layers affected by pedogenesis were identified in the studied surroundings, hitherto largely neglected by researchers.

Similar loessial sediments had not been described on Tenerife. There were determined parameter values for the sediments identified as weathered pyroclastic surface deposits formed in the course of colluvial processes and subsequently mixed with Saharan dust. Environmental conditions, past climate change and character of sea level oscillations had also been studied.

Along with the traditional parameter values fineness grade (FG) were determined used so far only in American and German literature, and K_d, applied by Chinese researchers. This way the deposits on Tenerife became characterized and new denominations for the layers were introduced. Of the other isles fluvio-lacustric deposits have been identified on Gran Canaria and colluvial loess on Lanzarote.

Parameter values were used to characterize: a paleosol developed upon phonolite lava dated 2–3.5 Ma, the overlying ignimbrite sequence, upward

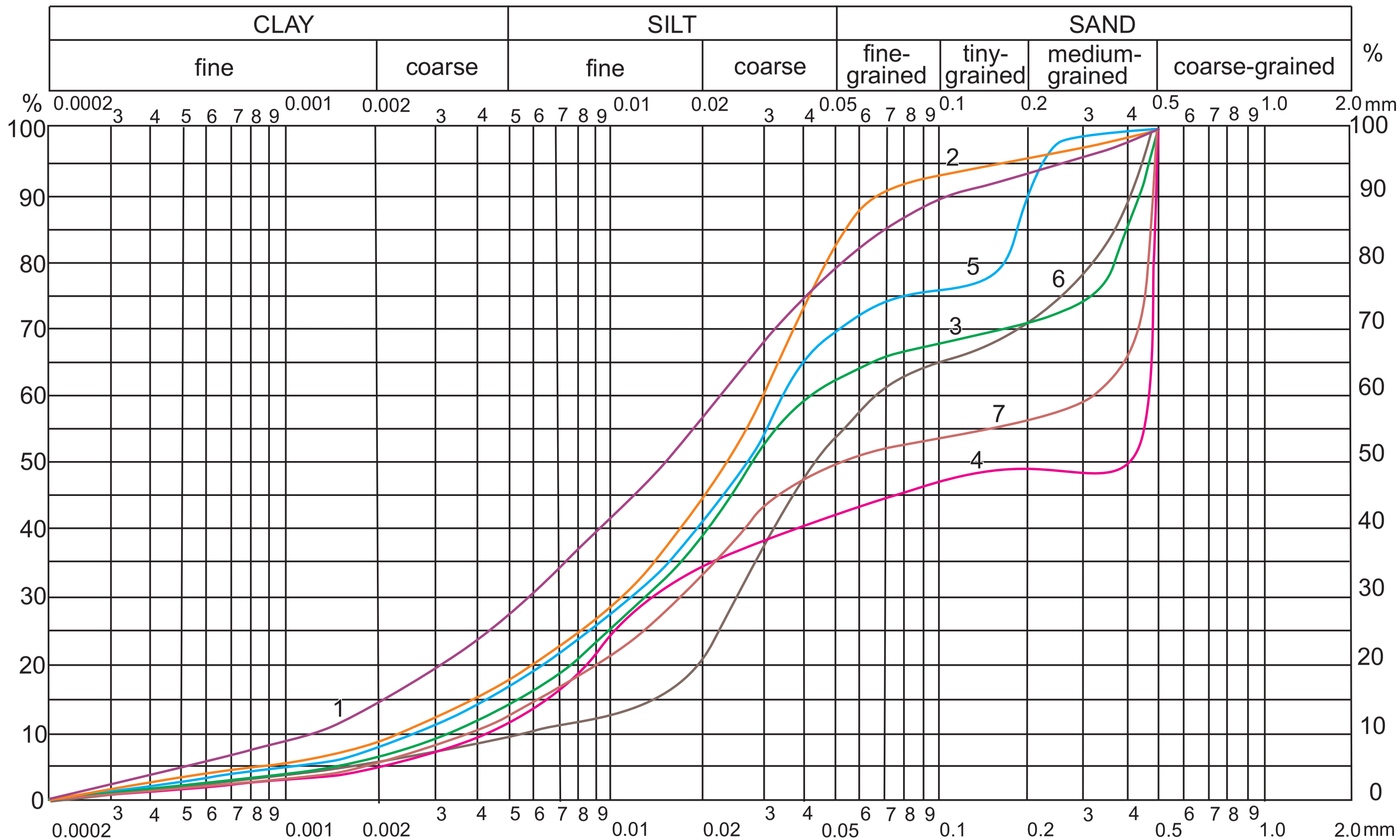

Fig. 3. Grain size curve of the section at Bandas del Sur on the basic of nine sediment size classes (Kis, É., Schweitzer, F. and di Gléria, M. 2010)

sediments affected by pedogenesis upon alkalic basalt lava, a series of sediments formed upon parent rock formed on three ignimbrites and cover sediments containing two alkalic basalt lavas affected by pedogenesis with tuff and breccia interbeddings.

Apart from the soil and sediments there is a loess horizon superimposing the deposit affected by pedogenesis over the lowermost alkalic basalt and three loessified sediments on weathered surfaces with an admixture of Saharan dust. Sediment upon pumice stone as its parent material above the loess was described as the first loessified layer, that overlying lapilli as the second and the sediment affected by pedogenesis situated upon breccia parent rock as the third deposit. It was established that most of the loessial sediments are slope deposits, affected by colluvial processes, so their appropriate denomination is colluvial loess-like sediments. A marked erosional gap could be identified above the lower phonolite lava (*Photo 4*), above the loess horizon, first loessial sediment and sediment formed on the upper alkalic basalt and affected by pedogenesis. Also there is a sharp boundary between the two fine tuff layers within the first loess-like sediment. Calcareous crusts and dry poligonal soils formed during interglacials, and terraces and paleosols were described. Of the calcareous crusts formed during arid stages the thickest are those underlying second and third loess-like deposits. The sequence above the paleosol is younger than 1 Ma.

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LITERATURE

Hungarian Geographical Bulletin 59 (2) (2010) pp. 231–233.

Kenneth J. Gregory: The Earth's Land Surface. SAGE Publications, London, 2010. 348 p.

There has been a marked specialization in geomorphological book publishing in recent decades. The contents of university text-books are increasingly different from those of handbooks and monographs. The former tend to focus on evolutionary concepts, systems operation and interaction rules, methodology (primarily interdisciplinary approaches) in an easily digestable form, while the latter remain to be the sources of facts, descriptive data on geomorphic processes and landforms. Ken Gregory's text-book for undergaduates is a reference book of a particular kind. In the Preface author explains the paucity of illustrations, which is obvious from the first sight (in spite of some interesting colour plates towards the end). He claims that most of the figures, charts and maps necessary to understand the basics of geomorphology are now available for students through 'googling' on the world-wide web. Consequently, there is no need to publish all of them as a hardcopy any more and, thus, more space can be devoted to the verbal explanation of regularities which are not always clear and coherent enough in the entries of Wikipedia or other common electronic sources of knowledge. (It may be remarked, however, that other authors feel the opposite way and do their best to block verbalism for the sake of a wealth of illustrations in our age of visual culture.) It is remarkable that author does not even refrain himself to refer to Wikipedia for additional information, a practice often criticized. However, there would have been even more opportunities to direct readers to web sources giving URL references. After each chapter thought-provoking questions offer topics for discussion.

Anyhow, in Chapter 1, a historical review of the discipline entitled "Visualizing the land surface", nobody lacks figures but one finds several tables, a mode of transmitting information particularly favoured by Professor Gregory. The total number of tables, which in other books are applied to provide quantitative information, amounts to 81 here but not more than 24 of them serves the above purpose, the overwhelming majority are for summarizing, sytemizing and comparing theories (e.g. the historical evolution of geomorphological thought), methods (like dating techniques), views as well as environments, geomorphic processes, landforms and everything else. They are often not really tables but information boxes – although in the present book this category is reserved for the presentation of major figures in geomorphology and the related disciplines. (The inclusion of some great scientists outside geomorphology, like Charles Darwin, is certainly justified. His microgeomorphological field experiments, however, should have been mentioned.) In an undergraduate textbook the concepts central to the discipline have to be formulated clearly. The present volume also excels in this respect. The distinction between erosion and denudation, however, is not expressed successfully. The systems theory and the ecological approach is manifest in every chapter (for instance, in the treatment of fluvial processes referring to the river continuum, serial discontinuity and other concepts). One of the most important tables, number 2.5, is a very useful summary of author's views on paradigm shifts. The debate on the significance of extreme events is presented through meaningful case studies. On other occasions the tabulated data, however, are not absolutely correct. For instance, the list of leading geomorphological journals does not show the year when the Zeitschrift für Geomorphologie started (new series in 1957) and the French Géomorphologie: relief, processus et environnement appears under its old name, Revue de Géomorphologie Dynamique.

In subsequent chapters it is evidenced again that geomorphology is not only a science of space but also of time – and the latter aspect raises the really serious problems (e.g. dating various processes). Later on it is emphasized that a crucial property of environmental change is its rate as it controls human adaptation. The treatment of geomorphic environments and processes is balanced – although author is slightly biassed towards fluvial and anthropogeomorphology. (A remark on the use of the adjective 'anthropogenic': it had been used by German scientists before it spread in the Russian literature.) In the section on karst processes minor misspellings occur (Kweilin instead of Guilin, lapis instead of lapiés). Table 5.9 is a brave attempt to present most recent directions in environmental modelling – treated with criticism.

In Part III landscape evolution is introduced in a state-of-the-art systems theory approach. A novel appreciation of the impacts of the last glaciation arouses the readers' interest. With a strong focus on authors from the English-speaking world, an intention to give credit to scentists from other regions, also to Russians and even to Eastern Europeans (e.g. the Polish school of periglacial geomorphology) is traceable here. When permafrost sensitivity to climate change is investigated, the use of internet sources is encouraged. The palimpsest analogy of Olav Slaymaker is borrowed to shed light on the complexity and paradoxical nature of periglacial studies. The inheritance of Pleistocene landforms, vegetation sequences as well as human impact are also described systematically. Dealing with arid environments, it is emphasized that dust transport is much more important in geomorphology than previously thought.

Part IV is on the geographical zonality of geomorphic processes in a historical perspective. (Unfortunately, the pioneer of vertical zonation studies, Alexander von Humboldt, is left without mention.) The treatment of geomorphic processes by climatic belts instead of their origins indicates that author turns away from rigid process geomorphology. The description of geomorphic processes in the various belts begins with polar regions. (Vatnajökull in Iceland mentioned on p. 167 is not a valley glacier but an ice cap – as it appears correctly some pages later.) Some results of latest research are also included, e.g. on the subglacial drainage systems of Antarctica. Less convincing is the chapter on temperate environments but this is explained by their transitional character. (The Vistula River is not typically a river of the maritime province.) In the humid tropics weathering processes are highlighted. Table 10.2 is a comprehensive summary of all terms related to the savanna landscape.

It must have been a demanding task for Professor Gregory to present the urban landscapes in the slightly more than 20 pages of Chapter 11. However, he manages at least to define the most important terms as well as to present the problems of cities in a broad perspective within this limited space. The perception of the urban environment and the processes shaping it are different from those in all other landscapes. A special attention is paid to urban hydrology, the creation of impervious surfaces, stream channelization, and their ecological consequences. The opportunities for urban water management are also presented in a well-constructed table. Chapter 12 is on the future of the discipline and highlights basics in environmental auditing, Environmental Impact Assessment, land evaluation and geomorphological design (soft engineering). This is an appropriate end to a book which is comprehensive in its topics, logical in explanations but at the same time easy to read for both undergraduates and the interested public. A true reflection of Prof Gregory's professional enthusiasm and rich experience.

Dénes Lóczy

Márton Veress: Karst Environments: Karren Formation in High Mountains. Springer Verlag, Dordrecht–Heidelberg, 2010. 230 p.

In mountains of higher elevation the characteristic environmental properties (lower temperature values and higher precipitation amounts, the proximity of glaciers, enduring snow cover or simply the frequent occurrence of bare rock surfaces) modify the karstification process and produce particular assemblages of karst features.

Author's investigations on karren (lapiés) in high-mountain environments date back to almost two decades. His findings were published in Hungarian in 2007. The book, used widely as a university text-book, is now made available in author's translation into English for the international public.

Following a brief historical overview of geomorphological research in high-mountain karst regions, the major characteristics of high-mountain karstification are briefly presented and illustrated with a general figure showing the distribution pattern of landforms. This figure is a good "appetizer" for a long series of carefully designed and drawn block diagrams and profiles, which are closely integrated into the text. Further chapters deal with the nature and rate of karren formation and classify the contributing factors (water runoff and rock structure) distinguishing altitudinal zones according to the presence or lack of vegetation (the pine zone, dwarf pine zone and bare rock zone). The diversity of forms is illustrated with examples from author's study areas: the Julian Alps in Slovenia, the Totes Gebirge and the Dachstein in Austria and the Asiago Plateau in the southern range of the Italian Alps. The variable densities of feature occurrence challenge interesting explanations.

Veress typically favours minute classification as the basic approach to the description of individual features: the morphological properties of rillenkarren, trittkarren, and particularly rinnenkarren are all meticuluously characterized and typified. Equally great attention is devoted to karst features originated by seepage. Soe subtypes are identified and denominated in the English language for the first time. For exactly this reason their name may not be perfectly selected but the illustrations (cross-sections, block diagrams and colour photographs) help the reader recognize them and find their equivalent in their own study areas.

Although s good proportion of karren are of complex origin, such features are often neglected in karst literature. Naturally, their classification involves the greatest difficulties. Author handles this problem in combination with another typical property of karren features: that they often do not occur individually but join in assemblages. Such assemblages can be particularly well studied on glacially eroded surfaces: in glacier valleys and on slopes. The latter topic, karren formation on high-mountain slopes provides an excellent opportunity for the presentation of the local zonality of features. Veress describes in detail how karstification processes influence general slope development.

Another major issue treated in the book is the combination of karren features, how they coalesce to form complex morphological units. The causes which lead to establishing connections between karren features are diverse. The findings of their detailed analyses are shown in clearly drawn profiles and map representations. Finally, a comprehensive holistic approach, the karren cell concept, is put forward to provide a common framework for the ideas initiated by author and elaborated by his students on the dynamics of karren formation and on the zonation of features.

This succintly but precisely written monograph should appear on the reading list of all geomorphologists involved in the research of high-mountain karst regions. It is also useful for any geographer who guides field trips of students to the karst mountains of Central Europe.

Dénes Lóczy

CHRONICLE

Hungarian Geographical Bulletin 59 (2) (2010) pp. 234–237.

Symposium in Professor József Tóth's honour

Pécs, 17–18. March 2010

In this March a renowned scholar of Hungarian geography, Professor József Tóth turned 70. Professor Tóth, rector emeritus, earned acclaim for his remarkable professional career. Back to the 1970s he contributed significantly to the formation of the core of the community of Hungarian geographers what is currently representing the field of science and did it from the scientific workshops of Szeged and Békéscsaba. As a result of his tenacious work in Pécs, the Institute of Geography at the UP has grown four times greater and the university has incorporated a 15-year-old Doctoral School of Earth Sciences. His scientific interest has been focused on half a dozen key topics, while his investigations and findings were published in about 500 articles and 13 books. At the beginning of Tóth's career his main interest was the Great Hungarian Plain, the features of its settlement network and the possible directions of its development. Since the 1980s he has become interested in the problem of defining the terms settlement and region, and of identifying their specific features. He has also been interested in finding the place and role of geography among sciences. He developed the tetrahedron model that defines spatial nodes according to four basic dimensions. On the other hand he was carrying out investigations concerning the geographical space since the end of the 1970s. Since the mid-1990s he began to focus on cultural geography as a new direction of his discipline.

On the occasion of the jubilee and as a token of their respect, the staff of the Institute of Geography, University of Pécs (UP) organized a symposium. As an additional factor of organizing the symposium the institute could also celebrate the 15th anniversary of the establishment of the UP's Doctoral School of Earth Sciences – founded by Professor József Tóth.

The symposium was held on March 17 and 18, 2010 at the University of Pécs and its aim was to celebrate professor József Tóth together with the geographical public of Hungary. The two-day event was hosted by Zoltán Dövényi, director of the Institute of Geography at UP, who also opened the symposium. Róbert Gábriel, rector of UP greeted professor Tóth as a former rector and as a school founder. On behalf of the Faculty of Sciences István Geresdi, dean, acknowledged his efforts for building and strengthening the institute and the doctoral school. Professor Tóth has played a prominent role not only in scientific activities but in the public life as well. Among his many roles and functions he is the head of the Pécs-Baranya section of TIT (National Association for the Dissemination of Scientific Knowledge) so Erzsébet Schmidt, director, also congratulated him on his birthday. A laudation on behalf of the PhD students was presented by Bertalan Radvánszky. Three books were dedicated to Professor Tóth as gifts. First, he received the first volume of Tér, Tálentum, Tanítványok (Space, Talent, Disciples), which contains publications written by the members of the institution's departments and the leaders of partner institutions. It was delivered by István Péter Kovács, assistant lecturer, who also expressed his appreciation of the professor's hard and productive work. The second volume of Tér, Tálentum, Tanítványok was handed over by Noémi Lívia Görcs, PhD student. This book contains important contributions of present and former PhD students of the Doctoral School of Earth Sciences. The third book, which is about Nepal, was presented by Zoltán Wilhelm, the director of the Institute's Asia Centre.

Concerning the professional programmes; leaders, members and representatives of the most important Hungarian geographical research centres gave presentations (and forwarded greetings), on themes relating to the professor's research topics. Tamás Csapó from University of West Hungary (NYME TTMK) gave a lecture on Hungarian small, medium and large towns and cities. Árpád Hanusz, on behalf of the Institute of Geography of the College of Nyíregyháza, summarized cross-border tourist destination management cooperation and its possibilities, focusing on the border area along the Upper Tisza. Károly Kocsis, director of Geographical Research Institute HAS (MTA FKI), professor of Miskolc University gave a brief introduction of the geographical research and higher education centres of the Carpathian Basin. Zoltán Kovács, head of department at the University of Szeged, introduced the relationship between cities and the creative economy focusing on the interaction of them in the past decades. Gábor Nagy, director of the Alföld Department of Centre for Regional Studies at Békéscsaba, characterized the current conditions of cities of the Great Plain. Aquincum, a former settlement and its connection with the landscape was analysed by Ferenc Schweitzer, professor emeritus, retired director of MTA FKI. Hungarian lingual relative roots were observed by a cultural geographical approach of István Süli-Zakar, head of department at University of Debrecen. Mária Szabó director, Gergely Horváth and Gábor Csüllög as representatives of the Institute of Geography and Earth Sciences of ELTE gave a presentation on the reclamation and revitalization of former industrial areas and rust belts of Hungary by introducing some case studies. Finally, on behalf of the host institution and the organizers András Trócsányi, associate professor, head of a geography department at UP, gave a presentation with the title "Our geography" on the scientific and academic work of professor Tóth and its impact on research activities by his colleagues.

An exhibition entitled 'Homo Ludens' on the main corridor of the institution was also prepared as part of the symposium. It was opened by Zoltán Dövényi, who emphasized the colourful and multi-faceted character of the celebrated scholar. After the presentations of the symposium, a reception was awaiting the guests at Tettye Restaurant, where professor Tóth was knighted and became a member of Pécs Wine Order.

On the second day, as a continuation of the professional programme, those who were interested could participate on a local urban field trip. It was led by András Trócsányi who introduced the "another face" of Pécs. First they visited the Central Mecsek, where they had the occasion to take a look at former zones of recreation and entertaining areas, and visited the closed mining areas and those ghettos of the periphery. The city's industrial park where the two major enterprises of the city: Elcoteq (a subsidiary of the Finnish firm in consumer electronics and communications technology industries) and Alexandra (the largest publishing house in Hungary), are situated was also visited by the participants. They have also been guided to the possible south-eastern expansion of the city, by taking a look the airport of Pogány, the new M60 motorway junction and those huge shopping centres that are to be built by the entrances of the motorway.

Visiting Pécs in 2010, the year when the city holds the title of the Capital of European Culture it is important to observe the works on high investment projects; therefore the participants got a short overview of the Zsolnay Porcelain Manufacture, to be transferred to a Cultural Quarter, he city's new conference and concert centre named OPUS, the Regional Library and Knowledge Centre, often referred to as the Beehive. These huge investments are elements of the city's rehabilitation processes and Eastern expansion of the downtown areas. All these changes play an important role in the settling and flourishing of the Quaternary sector that is supposed to rely on knowledge economy and culture.

Judit Gyüre–Szilvia Kékesi and Klára Stefán

József Tóth (left) at the 2nd British-Hungarian Geographical Seminar, Szeged, 1977 (Photo by L. Bassa)

Professor Tóth with his wife at the symposium (Photo by Gy. Mánfai)

Róbert Gábriel addressing the audience (from left to right: István Péter Kovács, Noémi Lívia Görcs, Zoltán Wilhelm, István Geresdi, Zoltán Dövényi, Erzsébet Schmidt, Bertalan Radvánszky) (Photo by Gy. Mánfai)

Professor Tóth as a newly elected member of Pécs Wine Order (Photo by Gy. Mánfai)

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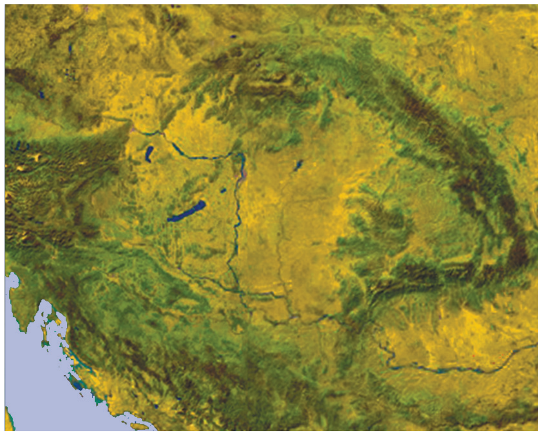

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