

FOCUS ON TERROIR STUDIES IN THE EGER WINE REGION OF HUNGARY

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Abstract

In 2001, the Hungarian Ministry of Agriculture and Rural Development designated the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) to elaborate a Geographic Information System (GIS) supported Vineyard Register (VINGIS) in Hungary. The basis of this work was a qualification methodology (vineyard and wine cellar cadastre system) dating back to several decades, however, in the 1980s and 1990s the available geographical maps and information technology did not provide enough accuracy for an overall evaluation of viticultural areas. The reason for the VINGIS elaboration and development was an obligation resulting from the EU membership to ensure the agricultural subsidies for the wine–viticulture sector. The aim of our study from 2008 was to use the most advanced methodology available to create a geo-referenced *model database* describing production sites in the Eger wine region. The database includes geo-referenced information of geomorphology (slope, exposition, and elevation), lithology, soil type, depth of water table and pH of soil water. Special dataset was introduced in the database of 9 production sites cultivating *Vitis vinifera* L. cv. ‘Kékfrankos’ (Blaufränkisch), the most abundant red grape cultivar of the region and of Hungary. The vines on the selected sites were of similar age, plant and row distance, all vertically shoot positioned. Soil and canopy management were performed similarly, as well. Meteorological data were collected from automatic weather stations nearby the examined sites, physical and chemical soil properties were analyzed, phenological stages, yield quantity and quality, as well as wine analytical data and the results of organoleptic evaluation were registered for 3 years. Orthophotos of the investigated sites and hyperspectral NDVI pictures of three special sites were also added to the database. This study serves as the first model for Hungary, how GIS can aid the classification and characterization of different terroirs and may promote the elaboration of a precise viti-vinicultural practice and appellation origin control system.

Keywords: *Geographic Information System, Digital Terrain Model, geology, soil types, Eger wine region, ‘Egri Bikavér’*

1 INTRODUCTION

According to the resolution of the Organisation International de la Vigne et du Vin in 2010 (OIV, 2010) ‘Vitivinicultural “terroir” is a concept which refers to an area in which collective knowledge of the interactions between the identifiable physical and biological environment and applied viti-vinicultural practices develops, providing distinctive characteristics for the products originating from this area. “Terroir” includes specific soil, topography, climate, landscape characteristics and biodiversity features’.

Terroir is composed of material elements /i.e. soil, topography, weather, grape variety/ and immaterial ones /i.e. history, culture, tradition, reputation, etc./ (Tomasi et al., 2013). The aim of our study was to use the most advanced methodology available in Hungary to create a geo-referenced *model database* describing production sites in the Eger wine region. Our study is partly based on the work of the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) in Hungary, which elaborated a Geographic Information System (GIS) supporting Vineyard Register (VINGIS) in the country and our research was partly carried out on soil, meteorological, plant physiological survey and collection data sets of harvests and wine quality for several years.

The Bull’s Blood of Eger (‘Egri Bikavér’) is one of the most reputed red wines in Hungary and abroad, produced in the North-Eastern part of the country. It is known as a ruby blended, full bodied wine with fruity and aged character. A similar name is used for Bull’s Blood of Szekszárd (Szekszárdi Bikavér), produced in South-West of Hungary. This blended wine is characterized also by full body, smooth structure, friendly tannins. ‘Egri Bikavér’ is sold in the biggest quantity in Hungary (~80.000 hl/year) compared to wines with similar name (Gál,

2006). Three quality classes for this brand have been elaborated: 'Egri Bikavér' Classisus, Superior and Grand Superior. A product description was ratified in 2011 for the protection of origin.

A leaf fossil of *Vitis hungarica* - 30 million years old - was recovered in the area of Eger wine district ('Kis-Eged-hegy'). Archeological traits and historical records prove that in the 11th century wine production had already been carried out in this area. In the 13th century, after the Mongol invasion of Hungary ('Passing of the Tatars') more advanced viticultural practice was imported into the region with Walloon, Italian, French and later Serb population. Vine growing and wine trade flourished in the 15-16th centuries, nevertheless the Ottoman-Hungarian war destroyed many vineyards in the country and in this wine growing area as well. In 1552, the Ottoman troops laid a siege on the Castle of Eger but the defenders repelled the attacks and defended the castle. The siege has become an emblem of national defense and patriotic heroism in Hungary (Liptai, 1985). Historical records state that the strength of Hungarian soldiers was fortified with wine of the region. The renaissance of the Eger wine region took place in the 18th century. The first classification of the Eger vine growing area occurred in 1760, when vineyards were classified into 3 categories according to their soil type, slope angle and sun exposition conditions. In 1789 a new category occurred in the region: vineyards appropriate for 'asszú' wine production. The first description of '*Bikavér*' dates back to 1851 (Sugár, 1981). Until the end of the 19th century white and red grape varieties were planted in the same vineyard, harvested and processed together. The result was a strong spicy red wine, the spicy flavor was acknowledged as the grape variety 'Kadarka' sub-variety 'Lúdtalpi'. In the 20th century Jenő Gröber planted first the vineyards with only one variety and made great efforts to put '*Egri Bikavér*' on the map both within the country and internationally as well. Between the 1960s and 1980s the mass production destroyed the quality of 'Egri Bikavér' and only after the 1990s' privatization new, Hungarian owned wineries appeared on the market with high wine quality. Due to continuous excavations of the last century, 643 vine cellars have been discovered so far with a total length of 147 km.

The Hungarian vineyard cadastre system was elaborated in the 1980s (Kecskés and Botos, 1990). The 0 to 400 points evaluation system describes 18 factors (soil characteristics, slope, exposition, ground water, winter frost, precipitation, road conditions, etc.). The EU accession of Hungary required to reform the regulations of the viticulture and wine-growing. Recent development of geo-informatics promoted this registration. In 2001 the Hungarian Ministry of Agriculture and Rural Development designated the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) to elaborate a Geographic Information System (GIS) supported Vineyard Register (VINGIS) in Hungary. The basis of this work was a qualification methodology (vineyard and wine cellar cadastre system) dating back to several decades, however, in the 1980s and 1990s the available geographical maps and information technology did not provide enough accuracy for an overall evaluation of viticultural areas. (Martinovich et al.; 2005, Katona and Molnár, 2005, Szenteleki, et al. 2012;).

2 MATERIALS AND METHODS

The total surface of Hungarian vineyards is 69.725 ha. 5.511 ha of this is situated in the Eger vine region, which is the fourth biggest one, after Kunsági, Mátrai, Tokaji regions (Figure 1). The wine region expands between 47°46'- 47°59' N latitudes and 20°10'- 20°36' E longitudes. The highest parcel is located at 505 m above sea level. In 2013, the 4.892 ha productive vineyards gave 31.565 ton grapes, the average yield was 6,6 t/ha. The main cultivated white varieties are: Olasz rizling (Welschriesling), Leányka, Királyleányka, Hárslevelű, Muscat Ottonel, Müller Thurgau, Riesling, Traminer and those for red cultivars: Kékfrankos (Blaufränkisch), Zweigelt, Blauburger, Pinot noir, Portugieser, Cabernet franc, Cabernet sauvignon, Merlot, Syrah Kadarka Menoire.

The Eger wine region's digital maps were generated with the help of the VINGIS program from a topographic map (Agrotopo, created by the Institute for Soil Sciences and Agricultural Chemistry, Hungarian Academy of Sciences) based on Digital Terrain Model (DTM) used by the Institute of Geodesy Cartography and Remote Sensing /http://www.fomi.hu/portal_en/index.php/products-and-services/vingis/ (Martinovich et al., 2009). The analysis was carried out on a spatial scale of 1:10.000 for DTM (20 m by 20 m real time spatial resolution) maps and 1:100.000 for lithological and soil maps. The ArcGIS 9.3 program (ESRI, 2004) was used to create a data base incorporating special dataset in the database of 9 production sites (Figure 2) cultivating *Vitis vinifera* L. cv. 'Kékfrankos' (Blaufränkisch), the most abundant red grape cultivar of the region and of Hungary. The vines on the selected sites were of similar age, plant and row distance, all vertically shoot positioned. Soil and canopy management were performed similarly, as well. Meteorological data were collected from 7 automatic weather stations (BOREAS, <http://www.boreas.hu/>) nearby the examined sites between 2004-2013. A 10 years long meteorological data base was used for calculation indexes characterizing mesoclimatic conditions in 7 vineyard plots, i.e. Heliothermal (Huglin) index (Huglin, 1978), Winkler index (Winkler et al., 1974) and Cool Night Index (Tonietto and Carbonneau, 2004). Physical and chemical soil properties were analyzed (Stefanovits et al., 2005), phenological stages, yield quantity and quality, as well as wine analytical data and the results of organoleptic evaluation were registered for 3 years (2006-2008). Missing data in some years are due to technical problems of the weather stations.

Detailed presentation of geo-informatic maps and meteorological data with calculation of different bioclimatic indexes will be submitted in this paper.

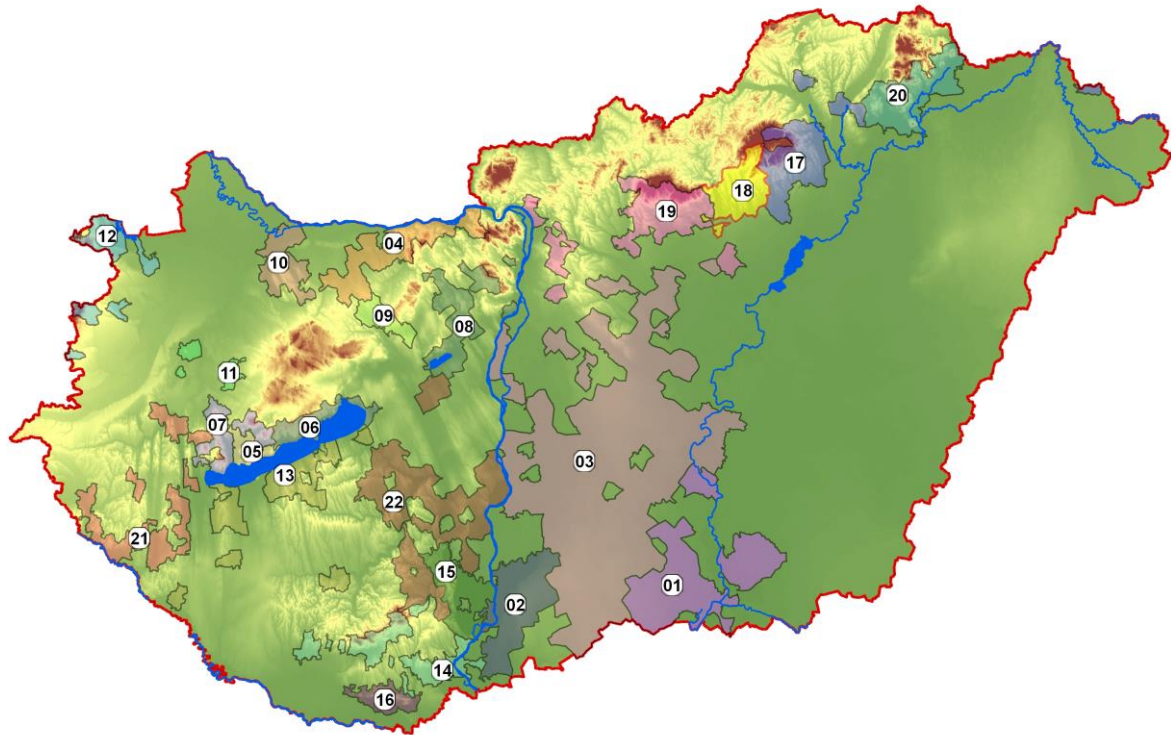
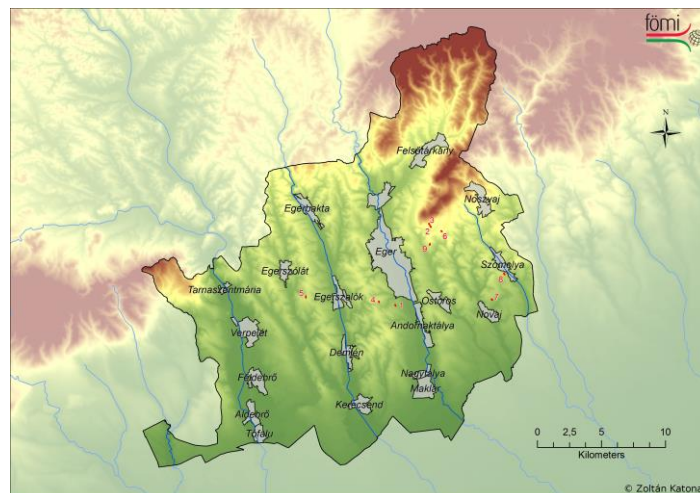


Figure 1: Wine regions of Hungary :01-Csongrádi borvidék; 02-Hajós-Bajai borvidék, 03-Kunsági borvidék; 04-Neszmélyi borvidék; 05-Badacsonyi borvidék; 06-Balatonfüred-Csopaki borvidék; 07-Balaton-felvidéki borvidék; 08-Etyek-Budai borvidék; 09-Móri borvidék; 10-Pannonhalmi borvidék; 11-Nagy-Somlói borvidék; 12-Soproni borvidék; 13-Balatonboglári borvidék; 14-Pécsi borvidék; 15-Szekszárdi borvidék; 16-Villányi borvidék, 17-Bükki borvidék; 18-Egri borvidék; 19-Mátrai borvidék; 20-Tokaji borvidék; 21-Zalai borvidék; 22-Tolnai borvidék.



**Figure 2: Location of experimental vineyards in Egervine region with the name of settlements:
1. Kőlyuk-tető (Eger), 2. Nagy-Eged-hegy lower (Eger), 3. Nagy-Eged-hegy upper (Eger), 4. Nagy-galagonyás (Eger), 5. Tó-bérc (Egerszólát), 6. Sík-hegy (Eger), 7. Ipánberki (Szomolya), 8. Juhszalag (Novaj), 9. Vidra (Eger)**

3 RESULTS AND DISCUSSION

Figures 3-7. present the Digital Terrain Model (DTM) with elevation, slopes and aspects of the vineyards in the Eger wine region. Vineyards are located between 126 and 504 m above sea level. The highest elevation of vineyards is on the emblematic 'Nagy-Eged-hegy' (hill) at 504 m. The slope degree of inclination varies between 0 and 54,5°, the average value of the cultivated area is 5,7°. On the steepest slopes this inclination can cause

serious erosion problems specially for young plantations. The vineyards are mostly SW, E, SE, S-facing (Table 1.).

Most of the cultivating area was formed on paleogen, neogen and earlier deposit of sediments (Figure 6.). The geology of the wine region is rather variable. In the area Mesozoic lime stones, Tertiary sand and clay sediments, volcanic stones are equally present. Rhyolite tuff of the volcanic rocks is of great significance in the region, since it has a wide occurrence supplying redundant minerals for the vineyards, nevertheless most of the vine cellars were grooved in these rocks. On the foothills young sedimentary deposits are representative.

Due to the variable geological conditions, soil types are rich as well (Figure 7). Variations of brown forest soils are dominant in the area. These soil types contain clay minerals in high quantity, therefore waterholding capacity of the soils is outstanding and rich in very different mineral elements. On steep slopes however vineyards have shallow fertile soil layers due to erosion problems.

Table 1: The distribution of the slope aspects of the cultivated area in the Eger wine region

Aspect	%
Flat	0,3
North	4,1
North-East	11,7
East	18,0
South-East	16,0
South	15,9
South-West	18,9
West	10,8
North-West	4,4

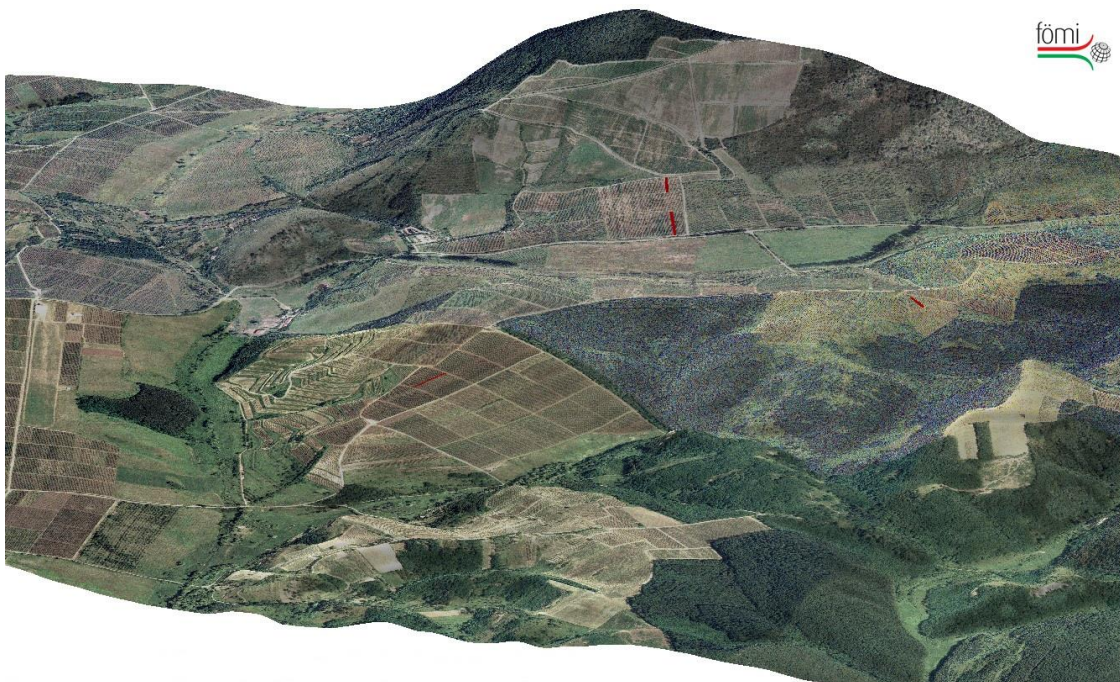


Figure 3: Perspective picture with orthophoto of the emblematic Nagy-Eged-hegy (hill)

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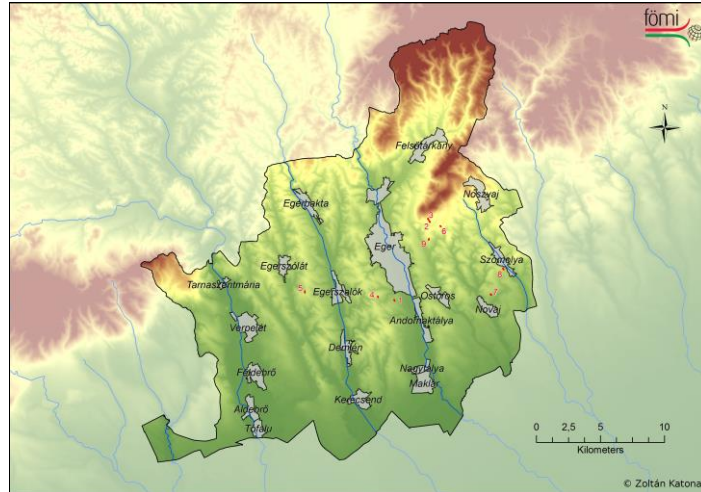


Figure 4: Location of experimental vineyards in Eger wine region.

1. Kőlyuk-tető (Eger), 2. Nagy-Eged-hegy lower (Eger), 3. Nagy-Eged-hegy upper (Eger), 4. Nagygalagonyás (Eger), 5. Tó-bérc (Egerszólát), 6. Sík-hegy (Eger), 7. Ipánberki (Szomolya), 8. Juhszalagos (Novaj), 9.

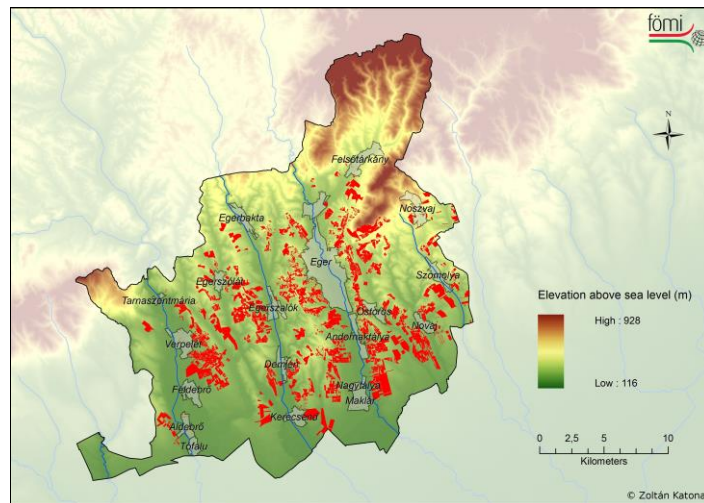


Figure 5: Vineyard plots of the Eger vine region on DTM

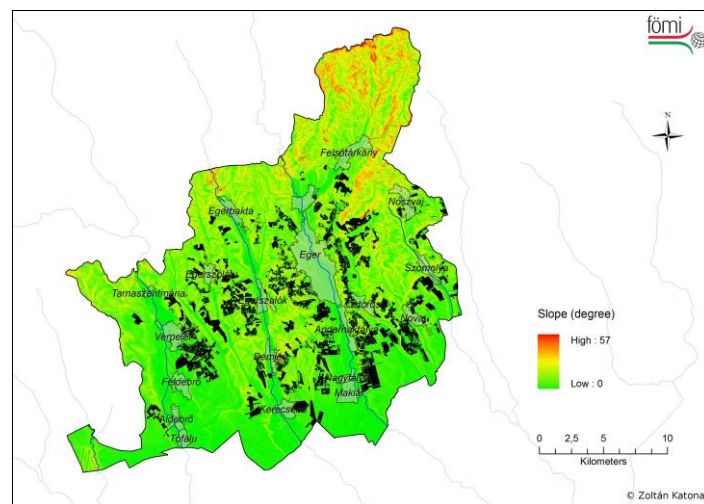


Figure 6: Vineyard plots of Eger wine region on digital slope map

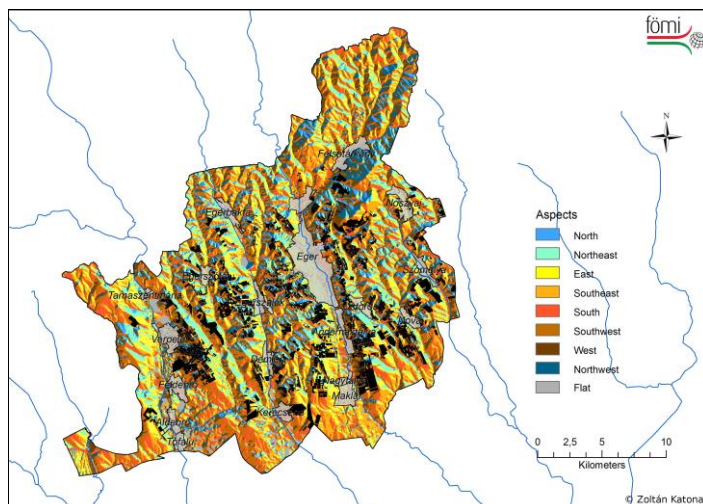


Figure 7: Vineyard plots of Eger wine region on aspect map

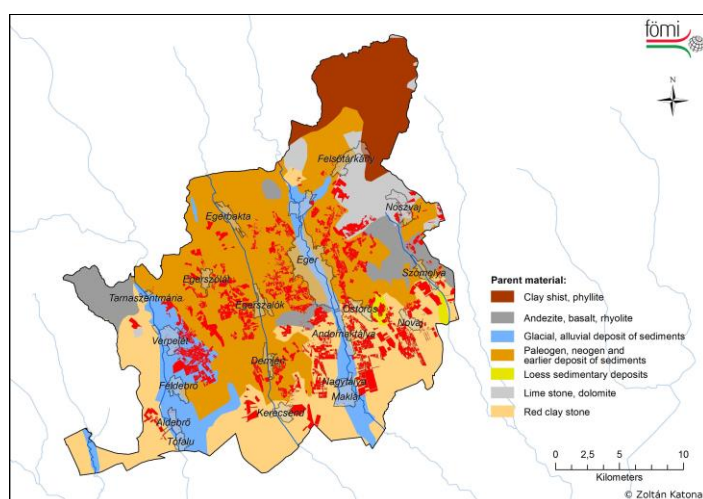


Figure 8: Vineyard plots of Eger wine region on lithological map

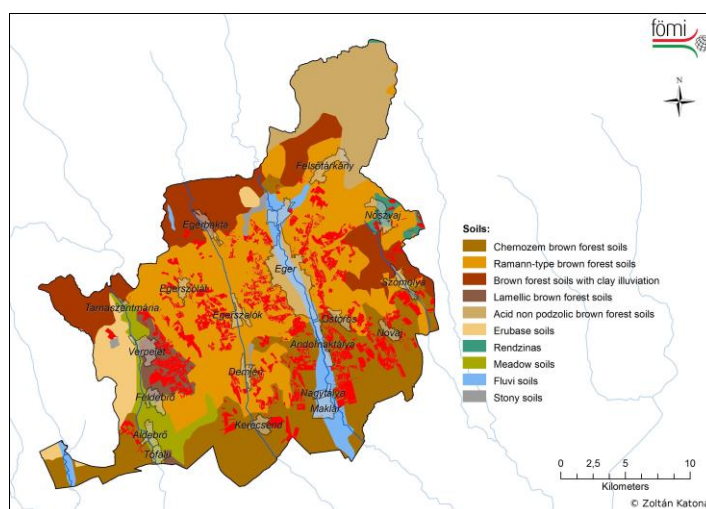


Figure 9: Vineyard plots of Eger wine region on digital soil map

According to the classification of Tonietto and Carbonneau (2004) the Eger wine region belongs to HI – 1 Temperate and HI +1 Temperate warm growing areas concerning the Huglin index (Table 2.). This bioclimatic

index reflect a slow warming effect in the Eger wine region during the past 10 years, although this time scale is rather short yet. Further study is planned to complete missing data by using ex.the E-OBS dataset (ENSEMBLES Observational Gridded Dataset) is freely available from ECA&D website (<http://www.ecad.eu>) operated by the Royal Netherlands Meteorological Institute (KNMI). Our data reflect warmer growing conditions in Nagy-Eged-hegy lower and upper, Juhszalagos and Istvánberki sites. In most cases Tó-bérc insured the coolest conditions for vine growing.

Table 2: Huglin index (HI) on different growing sites of the Eger wine region

HI	Year									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Kőlyuk-tető	1878	1940	1980	2253	1999	2235	1820	2245	2403	2189
Nagy-Eged-hegy lower	1847	1902	1968		1991		1863	2270	2377	2150
Nagy-Eged-hegy upper	1814	1963	1802	1767	2049	2286	1850	2247	2338	2125
Sík-hegy	1938		2097	2339		2335	1881	2301	2374	2155
Tó-bérc	1814	1909				1871	1611	1936	2105	1941
Juhszalagos		1868	1933	2163	1922	2139		2321	2445	2205
Ispánberki			1980	2233	1962	2216		2335	2468	2212

Winkler index (Table 3.) install the Eger wine region in Temperate ($1391 < WI \leq 1670$) and Temperate warm ($1671 < WI \leq 1940$) classes. Highest values for Nagy-Eged-hegy lower and upper and Sík-hegy insure elevated heat sum for optimal growing and ripening conditions for red grape cultivars (Kékfrankos, Cabernet franc, Cabernet sauvignon, Syrah).

Table 3: Winkler index (WI) on different growing sites of the Eger wine region

WI	Year									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Kőlyuk-tető	1286	1390	1459	1589	1432	1654	1309	1669	1791	1645
Nagy-Eged-hegy lower	1348	1430	1527		1506		1395	1756	1871	1723
Nagy-Eged-hegy upper	1370	1523	1455	1395	1626	1868	1453	1818	1936	1786
Sík-hegy	1450		1672	1777		1872	1450	1825	1936	1786
Tó-bérc	1285	1378				1437	1212	1446	1608	1468
Juhszalagos		1288	1357	1479	1334	1537		1666	1754	1665
Ispánberki			1502	1642	1436	1716		1794	1944	1762

The classification of Tonietto and Carbonneau for Cool Night index (2004) indicate that growing areas of the Eger wine region (Table 4) have rather variable night conditions between 1-30 September. The values point out that in 2009, 2011, 2012 night conditions during ripening were high ($CI -1$: temperate nights, $14^{\circ}C < CI < 18^{\circ}C$) insuring optimal conditions for ripening processes for red grapes. Nagy-Eged-hegy upper data call the attention to the fact, that this steep slope vineyard's soil contain smaller and bigger lime stones in the soil and on the soil surface that accumulate heat coming from sunshine during the day and reflect it during night time.

Table 3: Cool Night index (CNI) on different growing sites of the Eger wine region

CI	Year									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Kőlyuk-tető	9,9	11,9	11,8	8,8	10,3	12,4	10,5	12,9	12,7	9,3
Nagy-Eged-hegy lower	11,0	12,9	12,9	10,0	11,4		10,8	14,6	14,0	10,7
Nagy-Eged-hegy upper	12,7	14,6	15,2	11,4	12,6	15,9	12,1	16,4	15,7	12,1
Sík-hegy	12,1	13,9	14,3	11,1	12,3	15,4	12,0	15,6	15,2	11,4
Tó-bérc	10,8	12,5	12,6		10,2	12,7	10,5	13,6	13,4	9,5
Juhszalagos		11,1	10,7	8,0	9,7	12,2	10,2	11,8	11,8	9,3
Ispánberki		13,0	13,5	10,4	11,4	14,7	11,4	14,9	14,1	11,2

4 CONCLUSION

Our database set up in the past 10 years includes geo-referenced information of geomorphology (slope, exposition, and elevation), lithology, soil type, depth of water table and pH of soil water. Special dataset was introduced in the database of 9 production sites cultivating *Vitis vinifera* L. cv. 'Kékfrankos' (Blaufränkisch), the most abundant red grape cultivar of the region and of Hungary. Meteorological data were collected from automatic weather stations nearby the examined sites, physical and chemical soil properties were analyzed, phenological stages, yield quantity and quality, as well as wine analytical data and the results of organoleptic evaluation were registered for 3 years. Orthophotos of the investigated sites and hyperspectral NDVI pictures of three special sites were also added to the database. In this paper we only showed geoinformatic maps and three bioclimatic indexes. This study serves as the first model for Hungary, how GIS can aid the classification and characterization of different terroirs and may promote the elaboration of a precise viti-vinicultural practice and appellation origin control system.

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