

THE VINEYARD LANDSCAPES. HISTORY AND TRENDS OF VITICULTURE IN CASE STUDIES FROM SLOVAKIA

Los paisajes de viñedos. Historia y tendencias de la viticultura en casos de estudio de Eslovaquia

Martina Slámová^{1*}, Ingrid Belčáková²

¹ Department of Landscape Planning and Design, Faculty of Ecology and Environmental Sciences, Technical University in Zvolen, 960 01 Zvolen, Slovakia.

² UNESCO Department for Ecological Awareness and Sustainable Development; Faculty of Ecology and Environmental Sciences, Technical University in Zvolen, 960 01 Zvolen, Slovakia.

ORCID badge of authors and e-mail

Martina Slámová: <https://orcid.org/0000-0002-5578-7993>. E-mail: slamova@tuzvo.sk

Ingrid Belčáková: <https://orcid.org/0000-0002-4231-2737>. E-mail: belcakova@tuzvo.sk

* Corresponding author: slamova@tuzvo.sk

Recibido: 19-12-19. **Aceptado:** 13-06-2020. **Fecha de publicación on.line:** xx-xx-2020

Citation / Cómo citar este artículo: Slámová, M., Belčáková, I. (2020). The vineyard landscapes. History and trends of viticulture in case studies from Slovakia. *Pirineos*, 175, e056. <https://doi.org/10.3989/pirineos.2020.175006>

ABSTRACT: In Slovakia, grape has been cultivated since Roman times. Natural settings limit the distribution of vineyards predominantly to its southern parts, mainly to lowlands and foothills of the Carpathians. Based on a SWOT analysis, we selected three case studies in which urbanization, restoration, and abandonment of terraced vineyards were evaluated. These transformations typically change the character of wine-growing landscapes throughout Europe. Quantitative data on vineyards at national level were adopted from the national statistical database DATACube (1996-2018). Geodata and geo-statistics were accessed from national Open Geospatial Consortium Web Map Services using Quantum Geographic Information System (QGIS). Basic statistics for a numerical field of an area size were calculated from the following vector layers: historical vineyards (1952-1957), current vineyards identified the Basic Data Base for the GIS (ZBGIS) (2019) and vineyard plots registered at the Cadastre of Real Estate (2019). In general, the area of vineyards decreased at national level. One case study exhibited decline of vineyards due to urbanization and land abandonment but small-sized parcels remained preserved and currently appear as features of a traditional wine-growing landscape which has great agritourism potential. In the other two case studies, the area of vineyards increased; small wine-growing plots were merged into medium-sized plots and new modern terraces were built-up. However, these terraces were not properly registered at the Cadastre of Real Estate after land consolidation. Nevertheless, well-maintained terraced vineyards, although modern, prevent soil erosion.

KEY WORDS: Terraced vineyard; traditional landscape; the Carpathian Mountains; land consolidation reforms; urbanisation; restoration; land abandonment.

RESUMEN: En Eslovaquia, el cultivo del viñedo se remonta a la época romana. Los entornos naturales limitan la distribución de los viñedos en zonas con orientación sur, principalmente en las tierras bajas y las estribaciones de los Cárpatos. Basándonos en un análisis DAFO, seleccionamos tres zonas de estudio en las que se evaluó la urbanización, restauración y abandono de viñedos en terrazas. Estas transformaciones suelen cambiar el carácter de los paisajes vitivinícolas en toda Europa. Los datos cuantitativos sobre viñedos a nivel nacional se adoptaron de la base de datos estadística nacional DATAcube (1996-2018). Se accedió a los datos geográficos y a las estadísticas geográficas desde los servicios de mapas web del Consorcio Geoespacial nacional utilizando el Sistema de Información Geográfica QGIS. Se calcularon las estadísticas básicas para las diferentes áreas utilizando la información de los viñedos históricos (1952-1957), los viñedos actuales identificados en la base de datos de ZBGIS (2019) y las parcelas de viñedos registradas en el Catastro Real del Estado (2019). Los resultados demuestran que, en general, el área de viñedo disminuyó a nivel nacional. En una de las zonas de estudio se observó una disminución de los viñedos debido a los procesos de urbanización y de abandono de campos de cultivo, pero el viñedo permaneció en parcelas de pequeño tamaño, que aparecen como parcelas características de un paisaje vitícola tradicional con un gran potencial para el desarrollo de agroturismo. En las otras dos zonas de estudio, el área de viñedos aumentó: pequeñas parcelas vitivinícolas se fusionaron en parcelas medianas y se construyeron nuevas terrazas más modernas. Sin embargo, después de la concentración parcelaria, estas terrazas no aparecen registradas en el Catastro Real del Estado. No obstante, estos viñedos en terrazas bien mantenidos, ayudan a conservar el suelo y evitan los procesos de erosión.

PALABRAS CLAVE: Terrazas con viñedo; paisaje tradicional; Cárpatos; reformas de consolidación de tierras; urbanización; restauración; abandono de tierras.

1. Introduction

Terraced vineyards are widespread in hill and mountain landscapes in many countries, mainly in Southern Europe; for instance, in Italy (Agnolletti *et al.*, 2019) or Southern Switzerland (Rusterholz *et al.*, 2020). Italy has confirmed the continuous existence of terraced vineyards since the Neolithic Age (Agnolletti *et al.*, 2019). Interesting archaeological findings on Donačka Gora Mt. confirmed that ancient people settled on terraced platforms during the transition between the Bronze and Iron Ages and terraced slopes can be found in more than 90% of Slovenia's municipalities (Ažman Momirski, 2019a).

In Slovakia, grape has been cultivated since Roman times (Záruba *et al.*, 1985, Hronský, 2001). Wine and beer were the most used liquids during the Middle ages. In the latter half of the 16th century, the wine production reached up to 70,000,000 l of wine per a year taking into consideration a population of about 1 million in our country (Kazimír, 1986). In the 13th and 14th centuries, forests spreading on foothills of the Malé Karpaty Mts. around the capital of Slovakia – the city of Bratislava were grubbed up intending to increase the area of vineyards. These cultivated areas interacted with built-up areas of the city and vineyards became to be referred as urban vineyards. Viticulture as a way of land use management culminated in the 17th century and the winery had a commercial character. Wine was exported abroad in large volumes (Hronský & Pintér, 2009). Since the middle of the 18th century, the gradual stagnation of viticulture has begun. Due to high market tariffs, the wine was overpriced, and the grape production decreased and consequently the vineyards area was reduced. People cultivated grapes only for the private use. The decline in wine production continued during the 19th century, be-

cause of a newly introduced diseases (*Plasmopara viticola*) and pests. Between 1858 and 1862, grape *Phylloxera* caused the wine-growing disaster not only in Slovakia, but throughout the whole Europe (Bernáth, 2008, Olarieta *et al.*, 2008). In the latter half of the 18th century, wine-growing associations were established in Slovakia. The main aim was to protect professional interests of winegrowers (Kazimír, 1986).

Small family farms had been cultivated vineyards for several centuries, but after the Communist reforms in 50-ties of the 20th century, small-scaled parcels were turned into large intensively cultivated vineyards. Generally, the establishment of big agricultural cooperatives dramatically changed the management of vineyards when quantity was preferred over quality. Extensive vineyards were established in areas with natural settings above limits suitable for grapes (Lieskovský *et al.*, 2013). Hoeing was the most common tillage system in the past. Today, only few vineyards are manually hoed. Manual hoeing protected soil against water erosion. Introduction of tractors and heavy machinery into a winery business has initiated erosion processes, mainly in vineyards where downslope tillage was practiced (Lieskovský *et al.*, 2014). Therefore, after the Communist reforms many vineyards were transformed to vineyards on terraces compatible with modern mechanisation (Štefunková & Hanušin, 2019).

European Union (EU) support for agriculture shall disassociate payments for productivity and for recompensating farmers for providing environmental benefits to their land. Interesting fact is that after the collapse of Communism and further reforms in agriculture in the Eastern Bloc Communist countries, bird populations have declined far less than in Western Europe. One of the reasons was extensification of grapes cultivation and abandonment of vineyards in Eastern Europe (Donald *et al.*, 2002). More recent, post-

Communist era after 1989 did not bring any estimated positive changes. Although, a private sector returned to the viticulture, entrepreneurship problems with land restitutions have persisted. Moreover, market-oriented economy and competition pressure from foreign wines emanating from EU member countries and Brussels politics lead to further decay of predominantly small-scaled vineyards (Tarasovičová *et al.*, 2013). After the Velvet Revolution, the total area of vineyards in Slovakia was 30,988 ha. Data from the first phase of the European project CORINE Land Cover (Identification of Land Cover in Slovakia from Satellite Images) indicated further reduction of vineyards up to 27,375.60 ha (Feranec & Oľahel, 2001). Widespread abandonment and extensification of vineyards have been seen in all the post-socialist countries of Central and Eastern Europe (Lieskovský *et al.*, 2013). Situation has slowly begun to change into a positive way since 2004-2005 when the Common Agricultural Policy (CAP) incentives and subsidies have been implemented (Lieskovský *et al.*, 2013). Despite of effort to subsidy wine-growing, vineyards covered only 18,971 ha in 2010 (Lieskovský *et al.*, 2013). Transformation of small-scale vineyard plots to large blocks of vineyards resulted into many environmental problems also in other European countries (Cots-Folch *et al.*, 2006; Rusterholz *et al.*, 2020). Large-block vineyards contributed to the reduction of the landscape diversity (Štefunková & Hanušin, 2019).

Generally, we distinguish two types of vineyard landscapes in Slovakia – rural and urban (Slavkovský, 1998). Fragments of urban vineyards still can be found directly in town or cities. For instance, in the capital of Slovakia - Bratislava, namely in the city districts: Nové Mesto, Rača, Vajnory, Devín, and occasionally in Karlova Ves vineyards exist. These districts which became parts of the city in the first half of the 20th century (1946) had rural character (Horváth, 1990). Both types of the vineyard landscape together with functionally related

cultivated areas create an attractive landscape mosaic (Dobrovodská *et al.*, 2010a). Besides the primary wine production, the ecological, aesthetic, micro-climatic and recreational functions of vineyards are important (Štefunková *et al.*, 2011).

The wine-growing area of Slovakia is divided into 6 vineyard regions: the region of Southern Slovakia (28%), the Small Carpathian region (called according to the Malé Karpaty Mts.) (27%), the Nitra region (19%), the Central Slovakia region (11%), the Eastern Slovakia region (8%) and the Tokaj region (7%) (Supuka *et al.*, 2011). Small vineyards which have remained cultivated in a traditional way can be found locally in few cadastral districts. They are recognised as historical structures of the agricultural landscape (Dobrovodská *et al.*, 2010b). A national geo-spatial database of vineyards was published in the Atlas of the Slovak Republic (Miklós & Hrnčiarová, 2002). Vineyards in cadastral districts were included within specific substructures of the land cover categories. However, the vineyards database does not inform about a total area of vineyards in a certain cadastral district but only about the presence of vineyards here and neither informs about the terraced vineyards.

The main aim of the article was to identify transformations of terraced vineyards and changes of land cover over the last 70 years in Slovakia. A SWOT (strengths, weaknesses, opportunities, and threats) matrix in Table 1 brought an overview of factors and indicators interacting with viticulture transformations in Slovakia.

Similar processes were indicated also in other European countries, irrespectively whether they were observed in the Eastern Bloc Communist countries (Grigorescu *et al.*, 2012; Novák *et al.*, 2014; Toteva & Atasoy, 2014; Prokopová *et al.*, 2018) or in Mediterranean ones where wine growing has long tradition, dating back millennia (Cots-Folch *et al.*, 2006; Olarieta *et al.*, 2008; Salvati & Sabbi, 2011; Narbarte-Hernández *et al.*, 2020).

Table 1: SWOT analysis of viticulture situation in Slovakia.

Tabla 1: Análisis DAFO de la situación de la viticultura en Eslovaquia.

<p>Strengths</p> <ul style="list-style-type: none"> • preserved traditional vineyards - small parcels with high row density; the oldest vineyards have the rare traditional climbing support of wine-stakes (Supuka <i>et al.</i>, 2011) • vineyards formed the landscape scenery and character and have high cultural, historical, and aesthetic-visual values (Supuka <i>et al.</i>, 2011) • historical vineyards with fruit trees contribute to health benefits, aesthetic values, and support biodiversity (Supuka <i>et al.</i>, 2011) • important part of cultural and historical heritage of Slovakia (Pauditšová, 2011; Falťan <i>et al.</i>, 2016) 	<p>Weaknesses</p> <ul style="list-style-type: none"> • real boundaries of vineyards, especially area of terraces does not correspond with the situation on the cadastral map (Matečný, 2014) • inconsistent and not optimal growing settings for viticulture what makes the wine production unprofitable at existing prices (Tarasovičová <i>et al.</i>, 2013) • no interest of youth in viticulture, mainly because it is seen to be unprofitable (Lieskovský <i>et al.</i>, 2013)
<p>Opportunities</p> <ul style="list-style-type: none"> • wine-routes (Bihuňová <i>et al.</i> 2010) • reconstructed wine cellars create opportunities for recreation and leisure (Supuka <i>et al.</i>, 2011) • agri-tourism connected with viticulture -traditional vines, folk architecture, and festivals (Supuka <i>et al.</i>, 2011) • wine producers are aware of the importance of terroir and wines are bounded with a specific locality (Falťan <i>et al.</i>, 2016). 	<p>Threats</p> <ul style="list-style-type: none"> • 41% of vineyards suffer from the lack of suitable management (Lieskovský <i>et al.</i>, 2013) • the abandonment of vineyards could cause the sites more vulnerable to erosion (Papčo, 2011) • urbanisation (Lieskovský <i>et al.</i>, 2013; Šveda <i>et al.</i> 2016; Štefunková & Hanušin, 2019)

The article has an ambition to achieve two objectives:

- The first objective and the main objective was to evaluate land cover changes of terraced vineyards during the last 70 years in the selected case studies. The period of 70 years covers Communist reforms of agricultural land consolidation when small private plots were consolidated to large-scale blocks (1950-1970) and the wine production was intensified (Štefunková & Hanušin, 2019), and further it covers a period after the Velvet revolution until 2020 when many vineyards were urbanised, abandoned or restored (Lieskovský *et al.*, 2013; Tarasovičová *et al.*, 2013). The period of 70 years is enough long to observe different transformations which were referred in a SWOT analysis and in studies from other European countries. Specifically, the first objective intended to document these processes – urbanisation, restoration, and land abandonment in three case studies during the last 70 years and to compare results with vineyards transformation at national level in the last 22 years.
- The second objective was to identify whether a vineyard which actually exists in the landscape is officially registered in the Cadastre of Real Estate; and vice versa, whether an officially registered vineyard plot is actually covered with a vineyard in the landscape or it is covered with other land cover categories like shrubs, forests or even urban areas. This objective was set up to prove legal status of vineyards and in case of inconsistencies to discuss and propose incentives for the land consolidation of vineyards to be in coincidence with the registration in the Cadastre of Real Estate.

2. The Study Area

Slovakia does not have any specific national geo-database about the distribution of terraced vineyards in the country. Figure 1 displays the distribution of vineyards in cadastral districts and geomorphological subsystems, and particularly in the Carpathian Mountains. The highest potential of terraced vineyards occurrence is expected on slopes of the Carpathian Mountains but locally they may also appear on undulated terrains of lowlands. Vineyards in Slovakia underwent several transformations during centuries of their existence like in other European countries (Cots-Folch *et al.*, 2008; Grigorescu *et al.*, 2012; Agnoletti *et al.*, 2019; Narbarte-Hernández *et al.*, 2020).

At national level, we evaluated recent changes of vineyards over last 22 years (1996-2018) in 5 self-governing regions (the region of Bratislava, Nitra, Trnava, Banská Bystrica, Košice). Further, land cover transformations of vineyards over the last 70 years (1950-2020) were evaluated in three case studies of the following cadastral districts: Svätý Jur (the Malé Karpaty Mts.), Hontianske Tesáre (the Krupinská Planina Mts.) and one case study was located on the boundary of Horné Príbelce and

Čebovce (a contact area of the intramountain basin of Juhoslovenská Kotlina and the Krupinská Planina Mts.).

Terraced vineyards are not historically so commonly documented in Slovakia as it is in Italy, for example (Agnoletti *et al.*, 2015). The presence of a terraced vineyard was a crucial factor in the selection of the case study. In the case study of Svätý Jur, terraced vineyards have persisted from pre-Communist land consolidation reforms (50-ties of the 20th century) in the cadastral district. In Hontianske Tesáre and Príbelce / Čebovce, terraced vineyards were established recently when new heavy machines were introduced into viticulture practices and they became new features of vineyard landscapes.

A case study area was set up to 100 ha. The investigated transformations of vineyards – urbanization, restoration, and land abandonment were specified further, in detail in relation to three case studies:

- Urbanisation is often related with abandonment of vineyards but not always. Sometimes the pressure of investment groups is very high and cultivated vineyards may be turned into built-up areas. Urban sprawl is typical for areas in the vicinity of metropolitan cities and this is also case of a study presented in the article, located in the cadastral district of Svätý Jur, in the vicinity of the Slovak capital of Bratislava (Figure 2a). Similar urban sprawl is evident also in other Post-Communist countries of Eastern Europe. For instance, Iași Metropolitan Area in Romania underwent extremely dynamic urbanisation and related land use changes affected almost all the land use categories. Arable land, pastures and vineyards were transformed mainly to discontinuous urban fabric areas (Grigorescu *et al.*, 2012). In Mediterranean city regions “growth” phase (1960–1990) caused urbanisation of extensive areas of arable land, annual crops, vineyards, and pastures (Salvati & Sabbi, 2011).
- Restoration resulted into land consolidation of plots and cultivation with new, often heavy machines; a case study in the Hontianske Tesáre cadastral district documents new vineyards established on smoothly undulating uplands of the Krupinská Planina Mts. (Figure 2b). From economic point of view, this process is positive. The restructuring of vineyards can be carried out in various ways. EU regulation policy for vineyards’ restructuring supports this activity and subsidized up to 50% of the land terracing costs. However, the establishment of new terraces adopted with their parameters to modern mechanization resulted in high negative environmental and landscape impacts (Cots-Folch *et al.*, 2006). From the other aspect, the vineyards which were reconstructed in sites surrounded with nature valuable farmland and with biodiversity rich areas were successfully restored with the characteristic plant species composition of overgrown terraced vineyards and grasslands 10–15 years after restoration (Rusterholz *et al.*, 2020).

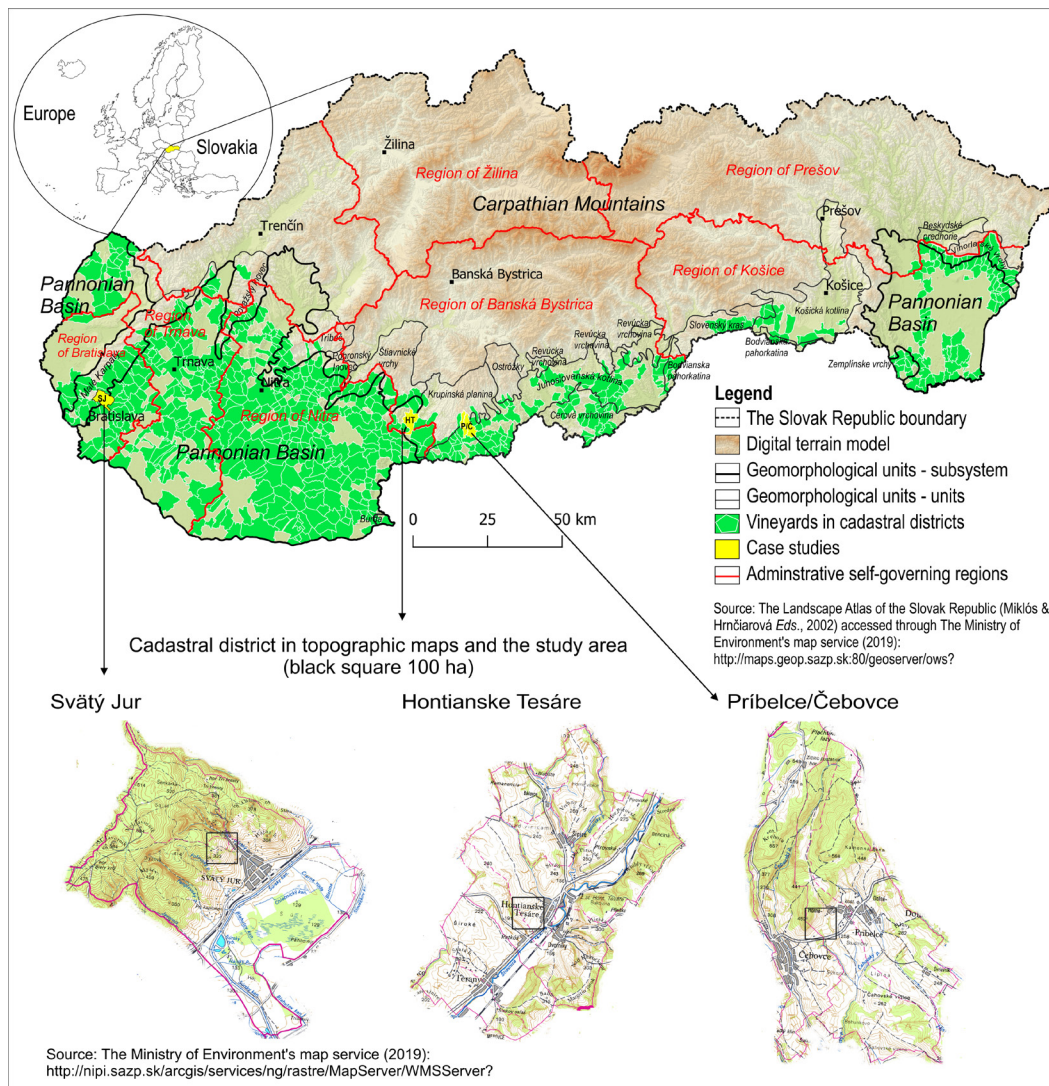


Figure 1: The distribution of vineyards in cadastral districts and geomorphological subsystems and particularly in the Carpathian Mountains. The location of case studies. Source: Authors' interpretation of maps.
 Figura 1: La distribución del viñedo en los distritos catastrales y sub-sistemas geomorfológicos, especialmente en los Cárpatos. Localización de las zonas de estudio. Fuente: Interpretación de los autores a partir de mapas.



Figure 2: (a) Urban sprawl and restored vineyards in the municipality of Svätý Jur (March 2017); (b) Restored vineyards on smoothly undulating terrain in the Hontianske Tesáre cadastral district (May 2011); (c) Vineyards overgrown with shrubs and old trees of *Castanea Sativa Mill.* which are typical for vineyards of the Pribelce and Čebovce cadastral districts (July 2016) (c). Source: Authors' collection.

Figura 2: (a) Expansión urbana y viñedos restaurados en el municipio de Svätý Jur (marzo, 2017). (b) Viñedos restaurados en terrenos suavemente ondulados en el distrito catastral de Hontianske Tesáre (mayo, 2011). (c) Viñedos cubiertos de arbustos y árboles viejos de *Castanea sativa Mill.*, que son típicos de los viñedos de los distritos catastrales de Pribelce and Čebovce cadastral (julio, 2016). Fuente: autores.

- Land abandonment often means gradual overgrowing of vineyards with shrubs and this process was markedly visible in a case study of the cadastral district of Příbelce and Čebovce (Figure 2c). Land abandonment affects mainly hilly and mountainous zones worldwide (Pepe *et al.*, 2019). Abandoned vineyards typically occur in areas with less optimal natural conditions for wine growing or in remote vineyards mainly in terrains with steeper slopes (Narbarte-Hernández *et al.*, 2020). Terraced landscapes are extremely vulnerable territories where land abandonment, particularly during extreme rainfall events may induce intensive erosion processes, even slope deformations (Pepe *et al.*, 2019). Changes in the case study in Catalunya municipalities in the north-east Spain showed dramatic decrease of the cultivated area after the crisis at the end of the 19th century related to grape *Phylloxera* (Olarieta *et al.*, 2008), and even more after the introduction of heavy machines into agriculture during the 1950s (Olarieta *et al.*, 2008).

3. Methods

3.1. Public Geodatabases on Vineyards in Slovakia

Geodata and maps were processed in Geographic Information System (GIS) Quantum GIS (QGIS) A Coruña 3.10.1. QGIS is a free and open-source cross-platform desktop GIS. A coordinate reference system S-JTSK (Greenwich) / Krovak East North (EPSG code 5514) was applied. Geodata applied in the article were accessed from Open Geospatial Consortium (OGC) Web Map Services (WMS). Publicly free online maps provided by national OGC WMS were accessed through the HTTP protocol using a WMS QGIS client.

Maps of vineyards distribution in cadastral districts and geomorphological units covering the national level were downloaded from the Landscape Atlas of the Slovak Republic (Miklós & Hrnčiarová, 2002) which was available online through OGC WMS provided by the Slovak Environmental Agency (Slovak Environmental Agency, 2019). It is The Ministry of Environment's map service (OGC WMS 1.3.0) conforming the INSPIRE technical rules for the INSPIRE view service. This service provides geospatial data in the environmental sector in the form of digital maps at national level.

Territorial boundaries of the Slovak Republic, cadastral districts and vineyard plots were accessed through OGC WMS of the Cadastre of Real Estate provided by the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA SR) at Geoportal websites (Geoportal, 2019).

Quantitative data on vineyards at national level in regions containing cadastral districts with vineyards were extracted from DATACube online system (Statistical Office of the Slovak Republic, 2019).

Current ortophotomaps (2019) a topographic map (2019) were accessed from the Basic Data Base for the GIS (ZBGIS®). ZBGIS is a part of the Information System of Geodesy, Cartography and Cadastre and it is provided and maintained by the Geodesy Cartography and Cadastre Authority of the Slovak Republic under the Act No. 215/1995 Coll. on Geodesy and Cartography, as amended (Geoportal, 2019).

Historical data (1952-1957) – military topographic maps of scale 1:25,000 were accessed through OGC WMS provided by the Slovak Environmental Agency (Slovak Environmental Agency, 2019).

3.2. Quantitative Evaluation of Vineyards Transformations at National Level

The number of cadastral areas with vineyards within the geomorphological units that distinguish lowlands and mountains was evaluated. In particular, the area of vineyards in mountain geomorphological units was calculated, as vineyard terraces can potentially occur mainly on mountain slopes. However, terraces can also occur locally on undulating lowland terrain. The results at national level thus provided only a rough and general overview of the possible occurrence of terraced vineyards.

The geographical distribution of vineyards in Slovakia was supplemented by quantitative data from the national online system DATACube (Statistical Office of the Slovak Republic, 2019); the area of vineyards [ha] was evaluated in the self-governing regions of the Slovak Republic.

Quantitative data on vineyards (area) for period from 1996 to 2018 were further processed in MS Excel™ 365 to create a table and a graph. A trend line was calculated as a moving average in the graph. The moving average method is used to calculate trend of time data series to smooth out short-term fluctuations and highlight longer-term trends or cycles.

Quantitative evaluation of the distribution of vineyards in the self-governing regions of Slovakia, in geomorphological units and recent changes in vineyards (1996 - 2018; [ha]) were presented in the supplementary material. Until now, no research on vineyards has been carried out at national level. The article therefore contains results characterizing the situation of vineyards at national level. These results have indicative character and they were used to support results of three case studies.

3.3. Quantitative Evaluation of Vineyards Transformations and Legal Status in the Cadastre of Real Estate

A case study area was set up to 100 ha and terraced vineyards were indicated within three study areas. The current situation of the vineyards (2019) according to the data derived from the ZBGIS geodatabase largely

corresponds to the current land cover shown in the orthophotomaps (2019). Current situation of vineyards was overlaid with database of vineyard plots registered at the Cadastre of Real Estate. We evaluated the match or discrepancy between the actual vineyard present in the country and the officially registered vineyard. Three situations were expected: a vineyard plot was officially registered and it was present in the country; a vineyard plot was not officially registered but was present in the country; and a vineyard plot was officially registered but was not present in the country. Terraced vineyards were marked according to the orientation of a plot in a terrain shown on the ZBGIS maps; if the plot is aligned with the direction of the slope, a vineyard would not be terraced; if the plot is aligned in the direction of the contours, there is a high predisposition that the vineyard is terraced. Terracing was finally verified in the field.

The field research documenting the terraced vineyards using photographs was carried out in the following cadastrals and dates: Svätý Jur (March 2017); Hontianske Tesáre (May 2011); Príbelce / Čebovce (July 2016).

Historical maps were used for a multi-temporal analysis of vineyards changes. The quantitative comparison of the vineyards' changes during the last 70 years was performed in QGIS using the attribute calculator for the vector layer of vineyards. The vineyards' area was [ha] was calculated from the following vector layers: historical vineyards (1952-1957), current vineyards identified in ZBGIS maps (2019) and vineyard plots registered at the Cadastre of Real Estate (2019). Vector layers were digitised from raster images of maps accessed through OGC WMS. The following parameters of vineyards' acreage [ha] were further calculated using Basic Statistic for numeric fields: count of polygons, total sum, mean, median, standard deviation of values, minimum, maximum and range of values, first and third quartile and interquartile range.

4. Results

4.1. Evaluation of Vineyards Transformation in Slovakia

Cadastral districts with vineyards (810) represent about 28% of the total number of cadastrals in Slovakia (the Statistical Office of the Slovak Republic registered 2890 cadastrals in 2016). Totally, 504 cadastral districts with vineyards had position in the Pannonian Basin (544,270.87 ha) (73.91%) and 306 cadastral districts were in 16 units of the Carpathian Mountains (192,118.93 ha) (26.09%) (Supplement 1). In this regard, it should be noted that potential terraced vineyards mostly occupied the slopes of the Carpathians in central southern Slovakia and spread locally in the mountains surrounded by the Pannonian basins (for instance Malé Karpaty Mts. in Western Slovakia; Zemplínske Vrchy Mts. and Vihorlatské Vrchy Mts. in Eastern Slovakia). The Juhoslovenská Kotlina Basin in the central southern

part of Slovakia with its typical alluvial plains of the river Ipel' belongs to the Carpathian Mountains and the slopes of undulating hilly terrain are covered with 66,903.90 ha of vineyards. It is the highest score of vineyards acreage in the Carpathians in Slovakia (34.82%). On the second position an extensive area of vineyards (27,506.42 ha) was documented in the Malé Karpaty Mts. (14.32%). Noteworthy, extensive vineyards are also in the Cerová Vrchovina Mts. (16,856.58 ha) (8.77 %), in the Krupinská Planina Mts. (14,183.92 ha) (7.38%) and in the Štiavnické Vrchy Mts. (11,401.28 ha) (5.93%) and well known vineyards are also in the Vihorlatské Vrchy Mts. (5.42%). It should be noted here that not all vineyards in the mountains are terraced, as documented in Figure 3. historical parcels on the slopes (green) were not always aligned with the direction of the contours.

Vineyards underwent transformations, meaning mainly reduction of their area in the recent two decades. Supplementary material 2 shows a graph interpreting the transformations of vineyards in Slovakia over the last 22 years, where the general trend reflected a reduction in vineyards from 29,061.27 ha (1996) to 26,237.20 ha (2018). In 2002, there was a significant decrease in vineyards (27,053.44 ha). Similarly, the largest administrative region with vineyards - Nitra followed this trend as well as the region of Bratislava and Trnava. On the contrary, the Košice and Banská Bystrica regions exhibited a balanced trend.

4.2. Evaluation of Vineyards Transformation in Case Studies and Legal Status in the Cadastre of Real Estate

A qualitative visual comparison in Figure 3, at the top of the figure shows that the best coincidence between historical land cover (green colour in Figure 3), current plots registered at the Cadastre of Real Estate (black colour in Figure 3) and current land cover was observed in the case study of Svätý Jur (Figure 3a). Overgrown abandoned terraced vineyards and small terraced historical plots were consolidated into one medium-sized plot (Figure 3b). Some plots which were transformed from vineyards to urban areas were properly delimited (Figure 3c). In the case study of Hontianske Tesáre, new medium-sized plots and small plots were present (Figure 3d). However, in none of them we found correspondence with historical lands and terraces could not be marked according to the arrangement and orientation of plots on the slopes of rolling hills. Terraces were confirmed during a field survey. In the case study Príbelce / Čebovce, all historical plots were merged into medium-sized blocks and bounded to vineyards without any evidence of the newly built-up terraces. Therefore, in the case studies of Hontianske Tesáre and Príbelce / Čebovce terraces could be indicated only in orthophotomaps and further verified in the field (Figure 3e).

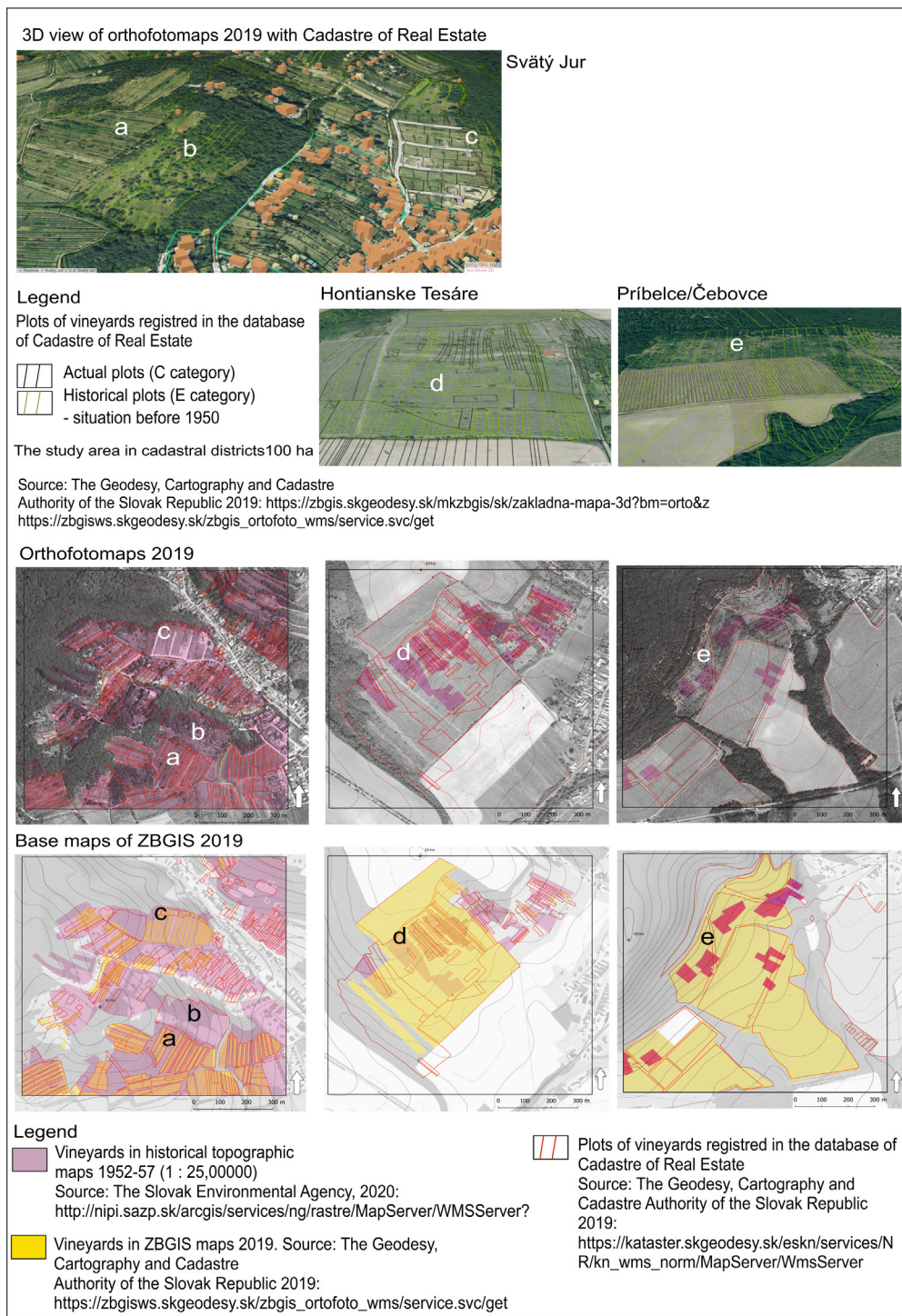


Figure 3: (a) Vineyards in the case studies. Coincidence with the land cover – cultivated terraced vineyards and plots registered as vineyards and plots aligned with counter lines direction; (b) overgrown abandoned terraced vineyards and small terraced historical plots were consolidated into one medium-sized plot; (c) vineyards transferred to urban plots; (d) new cultivated terraced vineyards on plots which do not correspond with terraces; (e) new overgrown abandoned terraced vineyards on plots which do not correspond with historical parcels.

Figura 3: (a) Viñedos en las zonas de estudio. Coincidencia en la cobertura del suelo: viñedos y parcela con terrazas cultivadas y registradas como viñedos y parcelas alineadas con las curvas de nivel. (b) Viñedos en terrazas abandonadas cubiertas con vegetación y parcelas históricas en pequeñas terrazas que se consolidaron en una parcela de tamaño mediano. (c) viñedos transferidos a parcelas urbanas. (d) nuevos viñedos cultivados en terrazas, que no se corresponden con zonas aterrazadas. (e) nuevos viñedos aterrazados abandonados en parcelas que no se corresponden con parcelas históricas.

A quantitative comparison of statistics from three case studies (Table 2) showed that historic vineyards were the most widespread in Svätý Jur (57.72 ha) and still persist geographically in almost the same localities (the current area was 17.38 ha according to ZBGIS and plots (28.23 ha). The current mean area of vineyard land was 0.11 ha and the total number of plots was 262. The second locality where vineyards historically appeared in a large extent

was the case study of Hontianske Tesáre (9.06 ha). Recently, their area indicated in ZBGIS map expanded to 27.30 ha and 35.40 ha was registered officially at the Cadastre of Real Estate. The mean size of a vineyard plot was higher than in Hontianske Tesáre – 0.38 ha and total number of plots was lower – 92. The most intensive transformation of land cover over the last 70 years was observed in the locality of Príbelce / Čebovce. Whereas in

Table 2: Statistical summary of vineyards area and changes from 1952-1957 to 2019.

Tabla 2: Resumen estadístico de la superficie de viñedo y cambios desde 1952-1957 a 2019.

Parameters of vineyards' area [ha]	Cadastral districts and the study area of 100 ha		
	Svätý Jur	Hontianske Tesáre	Horné Príbelce
Historical vineyards in historical maps (1952-1957)			
Count	5	9	9
Sum	57.72	9.06	4.21
Mean	11.54	1.01	0.47
Median	7.83	0.96	0.35
Standard deviation of values	7.44	0.46	0.29
Minimum	2.41	0.35	0.16
Maximum	23.39	2.08	1.08
Range	20.98	1.73	0.92
First quartile	7.67	0.68	0.22
Third quartile	16.42	1.15	0.59
Interquartile range	8.75	0.48	0.37
Current vineyards in the ZBGIS map (2019)			
Count	76	5	2
Sum	17.38	27.30	41.19
Mean	0.23	5.46	20.59
Median	0.13	0.08	20.59
Standard deviation of values	0.27	10.14	10.05
Minimum	0.02	0.04	10.55
Maximum	1.83	25.72	30.64
Range	1.81	25.68	20.09
First quartile	0.09	0.04	10.55
Third quartile	0.24	1.41	30.64
Interquartile range	0.15	1.36	20.09
Current vineyards in the Cadastre Map of Real Estate (2019)			
Count	262	92	31
Sum	28.23	35.40	55.47
Mean	0.11	0.38	1.79
Median	0.08	0.09	0.08
St dev (pop)	0.23	1.32	2.97
Minimum	0.01	0.01	0.01
Maximum	3.45	9.23	11.70
Range	3.44	9.22	11.69
First quartile	0.05	0.05	0.04
Third quartile	0.12	0.13	2.51
Interquartile range	0.07	0.08	2.48

the past there were only 4.21 ha of vineyards, today their area indicated in the ZBGIS map was almost ten times larger – 41.19 ha and more than ten times larger than the area of vineyard plots – 55.47 ha. The vineyards mean acreage was the largest of the case studies – 1.79 ha and the total number of plots was 31.

The terraced vineyards have been attacked with urbanisation since the last decades in the municipality of Svätý Jur and this process was observed only in this case study. Almost half of the studied area was covered with vineyards before 1950 and the area was reduced to the current approximately one third. Compared to other case studies, the historical distribution of plots is identical to their current arrangement. The case study of Hontianske Tesáre represents intensively cultivated vineyards on newly built-up terraces and it is an example of vineyards restoration. The case study of Príbelce / Čebovce showed historically the lowest area of vineyards which expanded to the current 55.47 ha but currently, new terraced vineyards have been abandoned and overgrown with shrubs. Although, Príbelce / Čebovce had about half of the study area covered with vineyards their arrangement, terraces and size of plots is completely new and observed characteristics of vineyard area (size and orientation in terrain) have no relationship with the historical divisions of plots.

5. Discussion

The results on recent vineyards transformations, evaluation of their historical progress or decline could help landscape planners to predict their future development. Further, the expected trends of vineyards transformation and stimulation of their proper management are discussed.

5.1. Risks of Urbanisation of Terraced Vineyards

Sloping terrains with vineyards in the vicinity of cities and towns has become a very attractive area for investment groups and suffer for the urban sprawl (Štefunková & Hanušin, 2019). Former vineyards alternate with smaller residential houses or solitary villas (Šveda *et al.*, 2016). These locations are attractive mainly due to their high aesthetic value and nice views from the hilly terrain to the surrounding countryside and city. (Štefunková & Hanušin, 2019). The authors indicated that up to 7% of large-block terraced vineyards were affected by the recent urbanisation in the cadastral district of Svätý Jur. Once, a vineyard is urbanised there would not be a way back. Spontaneously spreading urbanisation in vineyards can negatively impact and destroy the vineyard landscape values forever in a short time. The intensified urbanization in vineyards documented in this article was also observed in other case studies from Slovakia (Kopecká & Rosina, 2014; Izakovičová *et al.*, 2017) as well as in other Eastern Bloc Communist coun-

tries (Grigorescu *et al.*, 2012; Novák *et al.*, 2014) and Mediterranean countries (Salvati & Sabbi, 2011; Egidi *et al.*, 2020).

5.2. The Importance of Terraced Vineyards Preservation and Restoration

The village of Svätý Jur represents a typical terraced vineyard landscape, in which many terraces have been restored, although the landscape has changed under the pressure of urban sprawl since the last decade (Figure 2a;3c). Svätý Jur was selected as one of three pilot territories in the research of historical structures of agricultural landscape (Špulerová & Štefunková, 2009) due to well preserved traditional vineyard landscape (Figure 2a; 3a). Vineyard landscape has a high visual, cultural, and historical value (Löw & Míchal, 2003). According to the results of the article and the case studies performed in Svätý Jur (Lieskovský *et al.*, 2013; Štefunková & Hanušin, 2019) we can state that such a traditional terraced vineyard landscape has been becoming rare despite the high visual-aesthetic values (Supuka *et al.*, 2011), cultural heritage (Paudišová, 2011; Fal'an *et al.*, 2016; Ažman Momirski, 2019b) and high natural value and biodiversity (Rusterholz *et al.*, 2020).

Landscape values are very important arguments for spatial planning and territorial development why to protect the vineyard landscape. For instance, traditional terraced landscapes are protected in Slovenia, in the Register of Slovenian Cultural Heritage which is maintained by the Slovenian Ministry of Culture (Ažman Momirski, 2019b). Even, extensively cultivated or abandoned vineyards may positively influence birds' diversity as proved (Verhulst *et al.*, 2004) in the case study in Hungary. As the authors noted, the species richness of abandoned Hungarian vineyards and meadows has not generally decreased. However, this process may have adverse effects on rare and threatened birds. Therefore, the maintenance of existing extensive farming systems shall be implemented very sensitively into the CAP at European level. Traditional wine-growing landscapes with small-vineyards, their terraces, stone walls, wine cellars and sheds not only in Slovakia are cultural and historical monuments of the countryside (Ažman Momirski, 2019a,b; Agnolleti *et al.*, 2015). Traditional vineyards are not legislatively protected but they deserve attention of the society (Krivosudský, 2014).

From the second half of the 19th century until the recent past, the wine-growing landscape has fluctuated between the extensification of the vineyards associated with abandonment and strong intensification. (Štefunková & Hanušin 2019). Therefore, the right economic and social incentives need to be found, especially for young farmers, to restore old vineyards and to benefit from ancestral heritage in future. It means active management of the abandoned vineyards and at the same time, regulation of the urbanisation process (Lieskovský *et al.*, 2013). Small farmers – viticulturists need legislative protection and economic support for

farming activities to become effective in their daily lives (Lieskovský *et al.*, 2013). The main reason for leaving the terraced vineyards is the higher financial input, which is required for viticulture on small-scale terraces than subsidies for non-terraced areas. The CAP subsidies strongly encouraged the establishment of large wine terraces. Therefore, despite the various benefits of terraced vineyards and the current subsidies for vines on terraces, this method of cultivation in Slovakia is unprofitable (Štefunková & Hanušin, 2019). Gioacchino *et al.* (2019) carried out research aimed at the willingness of local society to pay additional costs of maintaining dry stone terraces to prevent negative changes in the well-being of the population. Results in questionnaires (the Etna region in Italy) indicated differences amongst studied zones but in general referred to the existing willingness to subsidize farmers with certain donations to maintain wine-growing terraces.

Some vineyards on the slopes of the Malé Karpaty Mts. (the municipality of Rača) have been one of the most important wine centers since feudalism and have existed probably with certain local interruptions in some localities since the time of the Roman Empire (Krivosudský, 2014; Štefunková & Hanušin, 2019). These vineyards represent unique small-scale landscape elements including a variety of narrow-band terraces, stone mounds, walls or heaps and stone vineyard sheds. Based on knowledge on traditional and valuable features of the vineyard landscape, wine routes have become popular since the recent decades in Slovakia (Habán *et al.* 2012). Slovakia has wine routes (for instance the Small Carpathian Wine Route, Nitra – the Royal Wine Route, the Hont Wine Route, the Tokaj Wine Route and the Wine Route of Zahorie) with the potential for the development of cross-border tourism because these routes are associated with the “European Wine Magistral”. The aim of the wine routes is to support local tourism activities connected with viticulture and wine processing. Each of the case studies has a wine route passing the cadastral district. In the cadastral district of Svätý Jur it was the Small Carpathian Wine Route (MVC, 2020), in Hontianske Tesáre it was the Hont Wine Route (Hont Región, 2020), and in Príbelce / Čebovce it was the Wine Route of Veľký Krtíš (VKVC.SK, 2020). The future socio-economic development of the vineyard landscape could be based on agritourism activities related to wine. Therefore, if the vineyard landscape shall be attractive for tourists then it would be necessary to protect its visual quality and the landscape character.

Natural terroir units and mosaic of vineyard landscape influence typical taste of wines (Gábor *et al.*, 2016). A study of the Mediterranean mountain region of Piorat in north-eastern Spain showed that although most farms grew a mosaic of traditional crops and had small mechanized areas, the minority group followed an intensification and specialization strategy based on new mechanized terraces of the vineyard (Cots-Folch *et al.*, 2008). Case studies from Hungary (wine-regions of Tihany and Csopak) in 2005 showed that 5325 registered winegrowers cultivated 2270 hectares (0.43 ha per capita). Most

winemakers (95%) produced wine for domestic trade and had a special interest in the reputation of the terroir. On the other hand, several large wineries focused only on mass production and were not interested in producing locally specific vineyards (Mike & Megyesi, 2018). Another survey conducted in 2013 in Bulgaria provided the opinion of 30 medium and small wine-growing farms, which considered maintaining ecological balance to be very important to produce healthy food (Toteva & Atasoy, 2014). The authors thus proposed a vision for the future production of regional or locally specific wines characterizing a “healthy” country.

5.3. *Legal Stimuli for the Viticulture Preventing Abandonment of Terraced Vineyards*

The results of the article documented the general trend of vineyards abandonment based on data from the Statistical Office of the Slovak Republic (2019) (Supplement 2). The CAP subsidies work efficiently for large-scale farming. However, small farmers, who usually cultivate small-size traditional vineyards struggle with administrative obstacles. The CAP subsidies were not targeted at the most sensitive agricultural areas where they had to support both the landscape quality and the wellbeing of small farmers. After the implementation of the CAP policy 2004-2005, rural identity gradually disappeared from the management of agriculture, especially in the traditional agricultural country in Slovakia (Bezák & Dobrovodská, 2019).

Well maintained terraces prevent water erosion (Lieskovský *et al.*, 2014) and deserted terraced may induce erosion processes. Papčo (2011) observed in the Nitra Uplands that vineyards caused erosion events in the past. The gullies displayed on the maps from 1783 were in the sites of the former terraced vineyards. Similar erosion processes in vineyards with abandoned terraces were observed in Spain (Rodrigo-Comino *et al.*, 2019), Italy (Tarolli *et al.*, 2019) and possibly in other countries. Therefore, considering the erosion aspect an adequate maintenance is required to prevent the destruction of terraces, including localities where new terraces were built-up in the recent decades but currently are abandoned as we documented in the case study of Príbelce / Čebovce (Figure 2c, Figure 3e) or Svätý Jur (Figure 3b).

Štefunková & Hanušin (2019) found out that not only traditional vineyards were abandoned in the cadastral district of Svätý Jur but, also modern vineyards that arose during the period of collectivism. The authors observed slightly higher abandonment of large-sized terraced vineyards than large-sized non-terraced vineyards. In Svätý Jur, between 2015 and 2016, modern terraced vineyards covered 20% and their area was reduced to almost 4%; and similarly, the acreage of non-terraced vineyards decreased from 12% to 2%.

Pilot project The EC PHARE SR98 / IB / AG02-2001 twinning project supported by the European Union (EU) was implemented in selected wine-growing municipali-

ties and its aim was to develop a methodology for classifying vineyards in the national register in accordance with the EU legislation. Act no. 332/1996 (§ 25) as amended by later regulations on viticulture and wine laid down rules for viticulture facilities. Every subject with at least 300 vines or vineyard of more than 500 m² area is obliged get to be registered. The application for registration must be submitted by the user of the vineyard, not the owner (Matečný, 2014). As Matečný (2014) emphasized, terraces are marked as terrain edges in basic topographic maps, but vineyard plots are not correctly registered in cadastral maps. We confirmed this situation in all three case studies, but some differences were observed. While in the case study of Svätý Jur there was a considerable effort to register new vineyards according to historical plots, in the case study of Hontianske Tesáre and Príbelce / Čebovce new built-up terraces were not documented on the map of plots. The plots of historic small vineyards with plots aligned to the slope direction were merged into medium-sized blocks (1-10 ha), but without evidence of terraces.

Registration of terraces should be mandatory when new vineyards are registered in the Cadastre of Real Estate. The soil on terraces has a higher value than soil on un-terraced slopes. Defining the exact area of terraces is subsequently important in the implementation of Good Agricultural and Environmental Conditions (GAEC) rules, which came into force after accession to the EU. As part of the measures taken since 2008 (Government Decree No. 50/2008) destroying of vineyards terraces has been banned and their maintenance must be performed. However, only if they are properly registered and we know that they exist. Therefore, it is important to note that the recommended potential land use based on the official national classification of basic soil ecological units, which intend to predict optimal land use for a particular unit of the soil, does not provide relevant information on soil quality on terraces (Slámová *et al.* 2015). The authors noted that the soil on the terraces has qualitatively different attributes than the soil on un-terraced slopes, but classification does not recognize the soil on terraces. Nevertheless, ancient peasants improved the soil conditions, mainly by removing rock fractions from the terraced soils, and the rock fraction was used for built-up terraces or nearby properties. In addition, terraces with flats or gentle slopes (with little to no risk of water erosion) have an optimal degree of inclination for cultivation. The official national classification of soil-ecological units shall consider these real soil attributes on terraces in order to provide adequate recommendations for their optimal land use management and related subsidies.

6. Conclusions

Natural settings in Slovakia limit the distribution of vineyards especially to its Southern parts, mainly to lowlands of the Pannonian Basin and foothills of the Carpathian Mountains which surround the lowlands. In

general, the area of vineyards in Slovakia has decreased since the last two decades (1996 – 2018). The area has shrunk due to several factors and this article has only yielded results on the loss of vineyards due to urbanization and abandonment.

The urbanization was documented in the case study of Svätý Jur and confirmed in the same locality by other authors or in other localities in Slovakia. Urbanization affects vineyards throughout Europe. It was indicated in the Eastern Bloc Communist countries as well as in the Mediterranean countries. In parallel with urbanization, the vineyards are being abandoned. This process was observed in Svätý Jur. While vineyards covered approximately half of the area of the cadastral district before 70 years, now the area has been reduced to the current approximately one third. Compared to the other two case studies, the highest number of vineyard plots (262/100 ha) and the lowest average area (0.11 ha) was observed in this case study. This indicates that features of a traditional vineyard landscape with small-sized terraced vineyards appear in the current landscape character and shall be protected, as it is for example in Slovenia. While the urbanization of terraced vineyards is a phenomenon related to a nearby city, the abandonment of vineyards has nothing to do with one dominant factor. However, according to previous studies, it can be said that the vineyards are mostly abandoned due to low economic efficiency of vineyard cultivation.

On contrary to general trend of vineyards decline in Slovakia, locally, the area of vineyards increased over the last 70 years, and therefore we documented this transformation in two case studies (Hontianske Tesáre and Príbelce / Čebovce). The most intensive expansion of vineyards was observed in the case study Príbelce / Čebovce (4.21 ha in 1950 increased approximately tenfold by 2019) and almost completely new terraced vineyards were established. New medium-sized plots of vineyards were created without regard to the historical land use and the characteristic features of the traditional wine-growing landscape. In both case studies, new built-up terraces were not documented in the current cadastral map. Evidence of terraces on plots registered in the Cadastre of Real Estate shall be mandatory to avoid incorrect classification of the cultivated soils on terraces that are of higher quality than the soils on plots without terraces. In the both case studies, the small plots of land that existed in 1950 were merged into medium-sized blocks (1-10 ha), but without any evidence of terraces. New modern terraces were therefore documented only in photographs and ortho-photomaps. However, well-maintained terraced vineyards, although modern, can prevent soil erosion. In addition, the wine-growing landscape with preserved characteristic features has a great agritourism potential. Agritourism activities may supply the economic loss from planting grapes in the event of diseases or a sudden fall in wine prices on the market affected by global economic forces. However, to make the wine-growing and wine processing business sustainable, the local circular economy must generate profits from local and regional

wine production. In this context, CAP subsidies are expected to be of particular benefit to small and medium-sized farmers who maintain a traditional terraced wine-growing landscape.

Acknowledgments

This work was supported by the agency VEGA of the Slovak Republic, Grant No. 1/0868/18.

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Supplementary material

Supplement 1: The distribution vineyards in 810 cadastral districts in geomorphological subsystems and the Carpathian Mountains units. Source: Authors' interpretation of geodata from The Atlas of the Slovak Republic (Miklós & Hrnčiarová, 2002).

Geomorphological subsystem/unit	Area [ha]	
Pannonian Basin	544,270.87	
Carpathian Mountains	192,118.93	[%]
Revúcka Vrchovina	4,403.26	2.29
Štiavnické Vrchy	11,401.28	5.93
Malé Karpaty	27,506.42	14.32
Krupinská Planina	14,183.92	7.38
Tribeč	7,962.23	4.14
Beskydské Predhorie	1,642.97	0.86
Cerová Vrchovina	16,856.58	8.77
Ostrôžky	739.64	0.38
Burda	1,553.45	0.81
Juhoslovenská Kotlina	66,903.90	34.82
Bodvianska Pahorkatina	5,147.23	2.68
Považský Inovec	7,590.02	3.95
Zemplínske Vrchy	4,891.37	2.55
Pohronský Inovec	2,831.72	1.47
Slovenský Kras	8,086.54	4.21
Vihorlatské Vrchy	10,418.40	5.42
Total	736,389.80	100.00

Supplement 2: Changes (1996-2018) of vineyard area [ha] in Slovakia and in self-governing regions where vineyards exist.
 Source: Authors' interpretation of data from the Statistical Office of the Slovak Republic (2019).

