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Fotografija na naslovnici: Na poti med brezštevilnimi terasami z zorečim rižem v Nepalu (fotografija: Sandi Kelnerič).

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CENTRAL SETTLEMENTS IN SLOVENIA IN 2016

CENTRALNA NASELJA V SLOVENIJI LETA 2016

Janez Nared, David Bole, Mateja Breg Valjavec, Rok Ciglič, Maruša Goluža, Jani Kozina, Nika Razpotnik Visković, Peter Repolusk, Petra Rus, Jernej Tiran, Majda Černič Istenič

Because of their compact layout and functional connection, Radovljica and Lesce function as a settlement cluster.
Radovljica in Lesce zaradi strnjene lege in funkcijske povezanosti delujeta kot eno – stično naselje.

Central settlements in Slovenia in 2016

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ABSTRACT: This article presents central settlements in Slovenia and their main characteristics in 2016. We defined central settlements based on services of general interest and the population of an individual settlement, and developed the analysis further by using competitiveness indicators. We defined 360 central settlements at six levels of centrality, among which the significance of Ljubljana as a national center of international importance and the significance of intermunicipal, local, and rural centers are increasing. The significance of certain regional centers at the second and third levels of centrality is decreasing. The level of services of general interest supplied to Slovenian territory is relatively appropriate, but it should be improved by promoting competitiveness, especially in centers of national and regional importance.

KEY WORDS: geography, settlement system, central settlements, services of general interest, cohesion, competitiveness, polycentrism, settlement clusters, conurbations, Slovenia

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1 Introduction

Central settlements have been studied since von Thünen's (1842) work on the topic, but the concept was established only with Christaller's (1933) central place theory. In it, central settlements are defined as »major and minor political, cultural, economic, and transport centers that arose as an expression of the political, cultural, and economic operation of human society and that must therefore be considered the basic elements in the functional construction of social life« (Vrišer 1967, 143). Christaller understood them as the centers of regions that shape and define the region through their area of influence. Because of constant mutual influence, regions and their centers are constantly adapting to changing conditions, which also changes the system of central settlements. In the system of central settlements, an important role is played by central functions, such as commerce, crafts, transport, education, healthcare, administration, and cultural institutions. If the surrounding functional area is small, the settlement has only basic, frequently used central functions that are available to users in the vicinity of their residences, but, as settlements' level of centrality increases, these functions become increasingly diverse (Vrišer 1967).

Central settlements in Slovenia have been studied since the 1960s (Vrišer 1967; Kokole 1971; Pak, Batagelj and Hrvatin 1987; Vrišer 1988; Cigale 2002; Strategija … 2004; Drozg 2005; Benkovič Krašovec 2006; Zavodnik Lamovšek, Drobne and Žaucer 2008; Rus, Razpotnik Visković and Nared 2013). They are characterized by constant changes in their definition, in part due to changing methodology, but more due to spatial and social changes (Nared, Bole and Ciglič 2016). Different authors have used various functions and various numbers of levels of centrality, and the manner in which they obtained their data has also varied (surveys and institutionalized data sources; Table 1).

As these studies showed, the structure of central settlements at higher levels is relatively stable, but greater changes are visible in central settlements at lower levels, especially because of spatial and social changes in past decades: local government reform, centralization, digitization and increased internet use, construction of the freeway network and increasing mobility, suburbanization and post-suburbanization, demographic changes, tertiarization of the economy, privatization of public services, and the economic crisis (Bole et al. 2012; Rus, Razpotnik Visković and Nared 2013; Nared, Bole and Ciglič 2016). The otherwise scant modern studies of central settlements have added new aspects to the original examination of supply with services. At the forefront are discussions of the ratio between cohesion and competitiveness (Meijers 2008), and examinations of functional regions (Karlsson and Olsson 2006; Zavodnik Lamovšek 2011) and functional polycentrism (Green 2007). Meijers (2007) believes that it is necessary to further develop central place theory because towns are not only connected vertically, but also horizontally through sharing functions (i.e., conurbations) and functional specializations. Such »networking« is typical of the global economy, especially for growing service sectors such as finance, IT, the creative industry, and so on (Sassen 1991; Castells 1996).

This article examines the network of central settlements in Slovenia in 2016 from the perspective of supply with services of general interest (i.e., the functional aspect). The functional aspect of defining central settlements, which can be understood as an analysis of ensuring the cohesiveness of the entire national territory, is further developed with selected elements of competitiveness or, specifically, an analysis of the distribution of researchers, patents, and the largest export companies. This article is based on the project The Polycentric Network of Centers and Accessibility of the Population to Services of General Interest and General Economic Interest (Nared et al. 2016), which was financed by the Slovenian Ministry of the Environment and Spatial Planning as part of revamping Slovenia's current spatial strategy.

2 Methods

We based our analysis of central settlements on services of general interest, which government bodies define as such and for which special public service obligations apply (ESPON Evidence Brief 2013; Noguera-Tur and Martínez 2014). Following examples from abroad (Meijers 2007), we limited the broader selection of services to four main functions: public administration, education, healthcare, and the judiciary. This narrower selection of services of general interest made it possible to define central settlements relatively transparently. With the addition of new functions, the definition of central settlements would be less transparent because the various functions appear in the same settlements and the addition of new functions

Table 1: A comparison of the criteria and findings of three selected studies (Kokole 1971; Vrišer 1988; Cigale 2002 (Rus 2013).

	Kokole (1971)	Vrišer (1988)	Cigale (2002)
Collecting data on central activities	Qualitative approach: directories, telephone books, lists of institutions, survey; quantitative approach: active population in the town-serving sector	Qualitative approach: directories, telephone books, lists of institutions, Register of Companies and Associations, Register of Private Entrepreneurs, census; quantitative approach: ratio between population and number of employed (jobs) in tertiary and quaternary activities by local communities (with towns treated as a whole)	Qualitative approach: Slovenian telephone book, information on post office branches, information on health centers, information on primary schools, survey
Determining the scope of the area of influence	Surveying primary schools	Surveying local communities / community offices	Surveying primary schools: determining where residents satisfy different needs for different services
Number of levels of centrality	Nine: Kokole does not name levels of centrality, but only defines the level	Seven (five): local centers, rural or industrial centers, communal or municipal centers, district centers, area centers, provincial centers, centers of Yugoslav republics	Three: macro-regional centers, meso-regional centers, micro-regional centers
Classifying central settlements by hierarchical level of centrality	Classification of indicators based on frequency of occurrence	Classification of indicators based on frequency of occurrence	Supply with functions / service activities: • Activities present in 150 to five hundred settlements; • Activities present in more than fifty and fewer than one hundred settlements; • Activities present in fewer than twenty settlements

would not offer significantly different results. We designed a database of centers' supply with services of general interest; in addition to georeference data this also included metadata necessary for constantly updating the database. It includes 703 settlements with at least one of four main functions. The database is based on the Slovenian Business Resister (AJPES) and databases at ministries and agencies.

Proceeding from definitions of central settlements to date, proposals from a focus group, and a workshop with stakeholders (Policentrično omrežje … 2015), we defined six levels of centrality (Table 2). On the one hand, the level of centrality was defined based on the population in a particular settlement and, on the other hand, individual functions were ascribed the corresponding level of centrality. Assessment of the overall level of centrality was made using a combined index of level of centrality (l_{cen}). The index equally weighted the average level of centrality from the four functions $\left(\frac{\sum_1^4 f!}{4}\right)$ and the level of centrality based on population (l_{pop})

$$l_{cen} = \frac{\frac{\sum_1^4 f}{4} + l_{pop}}{2} \quad (1)$$

Table 2: Level of centrality for settlements and criteria for individual levels.

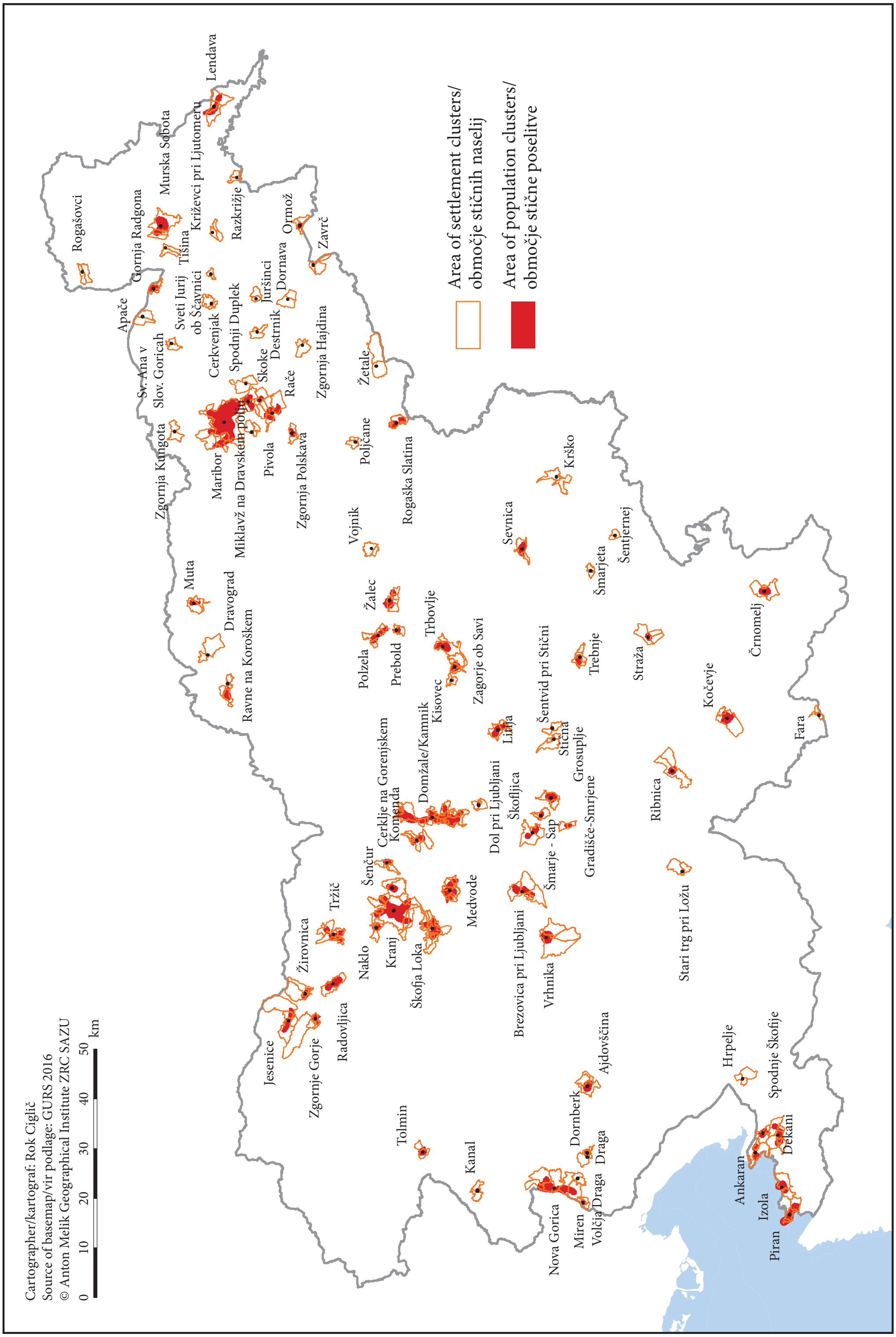
Level of centrality	Population	Expected functions
1. National center of international importance	≥ 100,001	• Public university • University medical center • Higher court
2. Center of national importance	20,001–100,000	• College, university faculty, or academy • Large general hospital
3. Center of regional importance	10,001–20,000	• District court • Junior college • Hospital • High school
4. Center of inter-municipal importance	3,001–10,000	• Health center • Local government office • Local court
5. Center of local importance	1,501–3,000	• Full primary school • Health station • Municipal headquarters
6. Center of rural importance	501–1,500	• Branch primary school

In classifying the settlements into individual levels of centrality, we defined the following classification limits (Table 3).

Table 3: Classification limits for defining levels of centrality.

Level of centrality	Centrality index value
1. National center of international importance	≤ 1.50
2. Center of national importance	1.51–2.50
3. Center of regional importance	2.51–3.50
4. Center of inter-municipal importance	3.51–4.50
5. Center of local importance	4.51–5.50
6. Center of rural importance	≥ 5.51
6a. Center of rural importance with fewer than 500 people	Fewer than 500 people and at least two functions

Figure 1: Settlement clusters (Nared, Bole and Ciglič 2016). ➤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40
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km
Area of settlement clusters/
območje stičnih naselij
Area of population clusters/
območje stične poselitve
Lendava
Murska Sobota
Rogašovci
Gornja Radgona
Križevci pri Ljutomeru
Tišina
Razkrižje
Ormož
Zavrč
Apače
Sveti Jurij
ob Ščavnici
Juršinci
Dornava
Sv. Ana v
Slov. Goricah
Cerkvenjak
Spodnji Duplek
Destrnik
Skoke
Rače
Zgornja Hajdina
Žetale
Zgornja Kungota
Maribor
Miklavž na Dravskem polju
Pivola
Zgornja Polskava
Poljčane
Rogaška Slatina
Vojnik
Krško
Sevnica
Šentjernej
Šmarjeta
Muta
Dravograd
Ravne na Koroškem
Žalec
Polzela
Prebold
Trbovlje
Zagorje ob Savi
Kisovec
Šentvid pri Stični
Trebnje
Straža
Črnomelj
Kočevje
Fara
Litija
Stična
Grosuplje
Ribnica
Cerklje na Gorenjskem
Komenda
Domžale/Kamnik
Dol pri Ljubljani
Škofljica
Šmarje - Sap
Gradišče-Smrjene
Šenčur
Tržič
Žirovnica
Naklo
Kranj
Škofja Loka
Medvode
Brezovica pri Ljubljani
Vrhnika
Stari trg pri Ložu
Jesenice
Zgornje Gorje
Radovljica
Tolmin
Kanal
Dornberk
Draga
Ajdovščina
Nova Gorica
Miren
Volčja Draga
Hrpelje
Spodnje Škofije
Dekani
Ankaran
Izola
Piran

Because of dispersed settlement, in Slovenia there are a large number of well-supplied settlements with a population below five hundred, which was initially defined as the lower population limit in a central settlement. We therefore added a new category of central settlements with a population below five hundred but that had to contain at least two of the four functions examined.

We also determined that several administrative settlements are located close to one another but that the functions are uniformly distributed between them, which means that an individual settlement is not necessarily sufficiently large or supplied, but, if it is combined with another, then the combined settlement may satisfy the criteria of both size and supply. These types of settlements are called settlement clusters (such settlements are underlined in the text). We defined them as a set of morphologically connected settlements that, despite their administrative division into several settlements, operate as a functionally connected whole. Such settlements had to satisfy two criteria: the majority (> 50%) of their population had to live in areas of high density of numbered housing (> 1.5 house numbers per hectare in a diameter of 800 m) and areas of high density had to be continuously connected with at least one such area in another settlement. In this manner we defined fifty-six areas, further verified them through visual inspection of aerial photos and review of the presence of the four functions, and thus expanded the list of central settlements with an additional twenty-nine settlement clusters (Figure 1). Using settlement clusters, we were better able to assess the level of supply, especially in areas of compact settlement, and the sharing of functions between individual settlements; for example, Nova Gorica–Šempeter–Vrtojba, Piran–Lucija, and so on (Nared, Bole and Ciglič 2016).

For analyzing the network of central settlements from the perspective of competitiveness, we studied three indicators: exports in millions of euros per company headquarters in 2015 (SLOEXPORT 2016), number of researchers per workplace (SICRIS 2016), and number of patents per place of patent holder between 1991 and 2016 (Patenti 2016). The last two indicators are often a component of measuring global competiveness indicators (Global Competitive … 2016) and global creativity indexes (Global Creativity … 2016), and so they are also appropriate for this analysis of competitiveness. The statistical correlation between settlement size, supply with services of general interest, and competitiveness was calculated using Spearman's correlation coefficient (ρ).

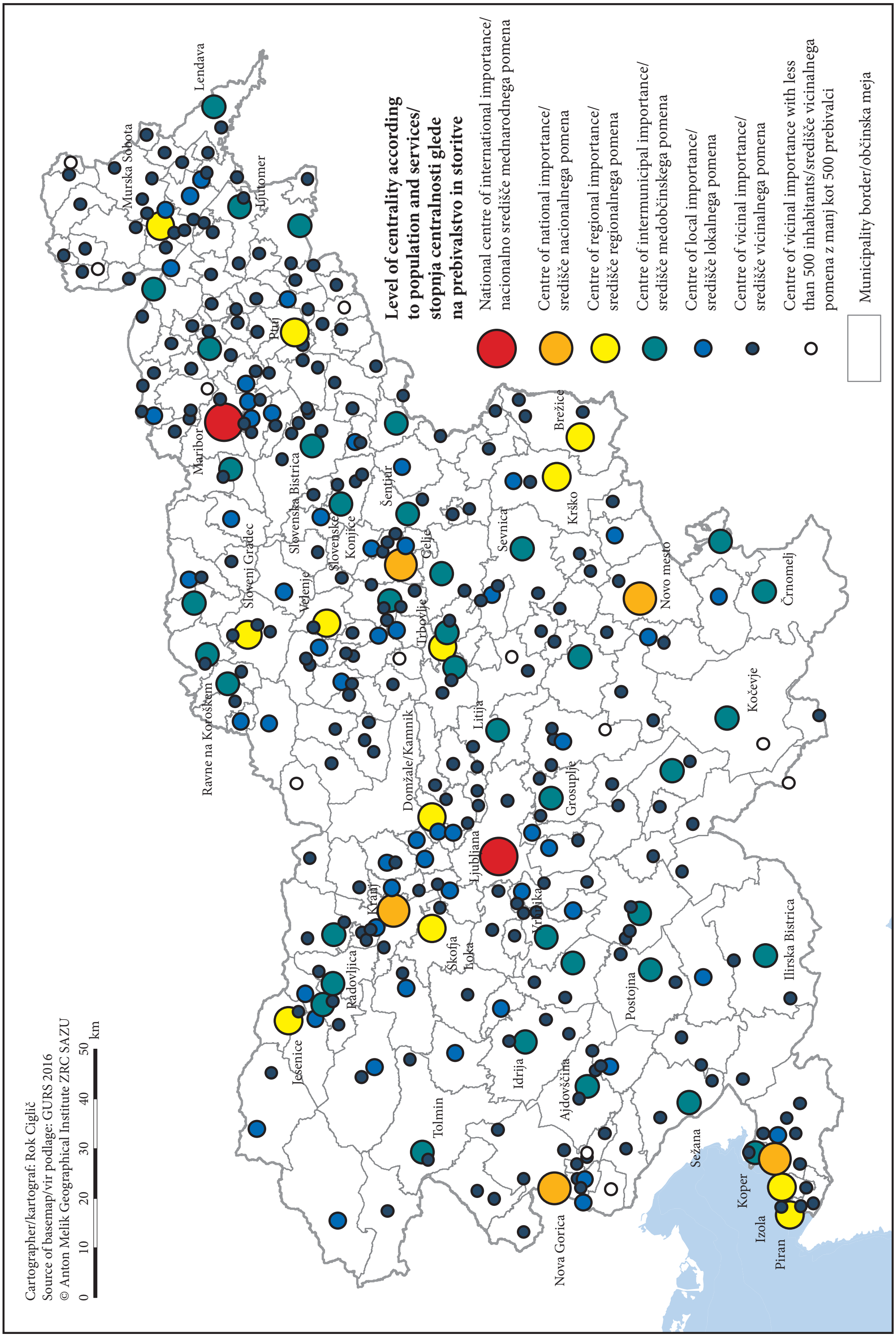
3 Results

Using the methodology presented, we defined 360 central settlements in Slovenia (Figure 2) with a total population of 1,318,051, which is just under 9.2% of the country's settlements and 64% of its population. Two settlements are national centers of international importance (Ljubljana and Maribor), five are centers of national importance (Celje, Nova Gorica, Koper, Novo mesto, and Kranj), twelve are centers of regional importance (Domžale–Kamnik, Ptuj, Velenje, Jesenice, Murska Sobota, Trbovlje, Piran, Slovenj Gradec, Izola, Škofja Loka, Brežice, and Krško), thirty-eight are centers of inter-municipal importance, fifty-five are centers of local importance, and 248 are centers of rural importance, among which we also classified forty-nine centers with a population under five hundred but at least two main functions; in the text, settlement clusters are underlined.

From the perspective of the central functions and size of a settlement, Ljubljana is far in the lead. As the country's second-largest city, Maribor also preserves an important role. Among the other regional centers, the second level of centrality is achieved by five settlements (Celje, Nova Gorica, Koper, Novo mesto, and Kranj), and the third level by four (or five) (Murska Sobota, Trbovlje, Slovenj Gradec, and the conurbation of Krško–Brežice). The weakest among the regional centers is Postojna, which is ranked at the level of inter-municipal centers. With regard to the size of the settlement and its economic strength, Velenje is undersupplied with functions, which is largely a consequence of its location between two nearby regional centers: Celje and Slovenj Gradec.

Ljubljana has great administrative and economic influence, and is becoming an important metropolitan center. The economic significance of settlements at the second and third levels of centrality is weakening, but increased influence can be noted at the level of municipal centers, which may be ascribed to local

Figure 2: Central settlements in Slovenia, 2016. ➤



Level of centrality according to population and services/ stopnja centralnosti glede na prebivalstvo in storitve
National centre of international importance/ nacionalno središče mednarodnega pomena
Centre of national importance/ središče nacionalnega pomena
Centre of regional importance/ središče regionalnega pomena
Centre of intermunicipal importance/ središče medobčinskega pomena
Centre of local importance/ središče lokalnega pomena
Centre of vicinal importance/ središče vicinalnega pomena
Centre of vicinal importance with less than 500 inhabitants/središče vicinalnega pomena z manj kot 500 prebivalci
Municipality border/občinska meja
Cartographer/kartograf: Rok Ciglič
Source of basemap/vir podlage: GURS 2016
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Slovenj Gradec
Velenje
Žalec
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Novo mesto
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Ravne na Koroškem
Litija
Kočevje
Domžale/Kamnik
Grosuplje
Ljubljana
Kranj
Vrhnika
Škofja Loka
Radovljica
Jesenice
Postojna
Ilirska Bistrica
Idrija
Ajdovščina
Tolmin
Sežana
Nova Gorica
Koper
Izola
Piran

government reform and the »localization« of regional policy; decisions on regional projects are made by mayors, who favor local projects.

The creation of many new municipalities had a major impact on the number of central settlements at the sixth level, especially those that do not achieve the threshold of five hundred residents. In line with the size structure of Slovenian municipalities, these settlements predominate in eastern Slovenia.

With regard to settlement clusters, it is especially relevant to mention Domžale–Kamnik and Nova Gorica. The settlement cluster of Domžale–Kamnik is only a morphologically connected settlement without shared functions because both of the main settlements are centers of inter-municipal importance. In contrast, the morphological connection of Nova Gorica and the settlements of Šempeter pri Gorici, Kromberk, Pristava, Rožna Dolina, Solkan, and Vrtojba is further enhanced by shared functions, especially between Šempeter pri Gorici and Nova Gorica.

It is also interesting to compare the level of centrality from the perspective of settlement size and how well a settlement is supplied with individual functions. Large settlements are generally better supplied with functions than smaller ones. If the level of centrality by function exceeds the level of centrality by population, the settlement is oversupplied and, in the opposite case, it is undersupplied (Figure 3).

Oversupply is especially characteristic of settlements in less urbanized parts of the country, which can be explained by the conscious uniform provision of functions across the entire territory of the country as a result of the policy of polycentric urban development from the 1960s onward. Here it has to be taken into account that, in adapting the functions to the size of the settlement, more sparsely settled areas faced a relatively poor supply of functions.

Undersupply is especially characteristic of settlements near major towns, which is a consequence of suburbanization, which has been prominent especially in the last forty years (Ravbar 1997; 2005). Because residents moved to the outskirts of towns, the populations of these settlements have grown greatly, but the supply of functions has not adapted sufficiently quickly to this.

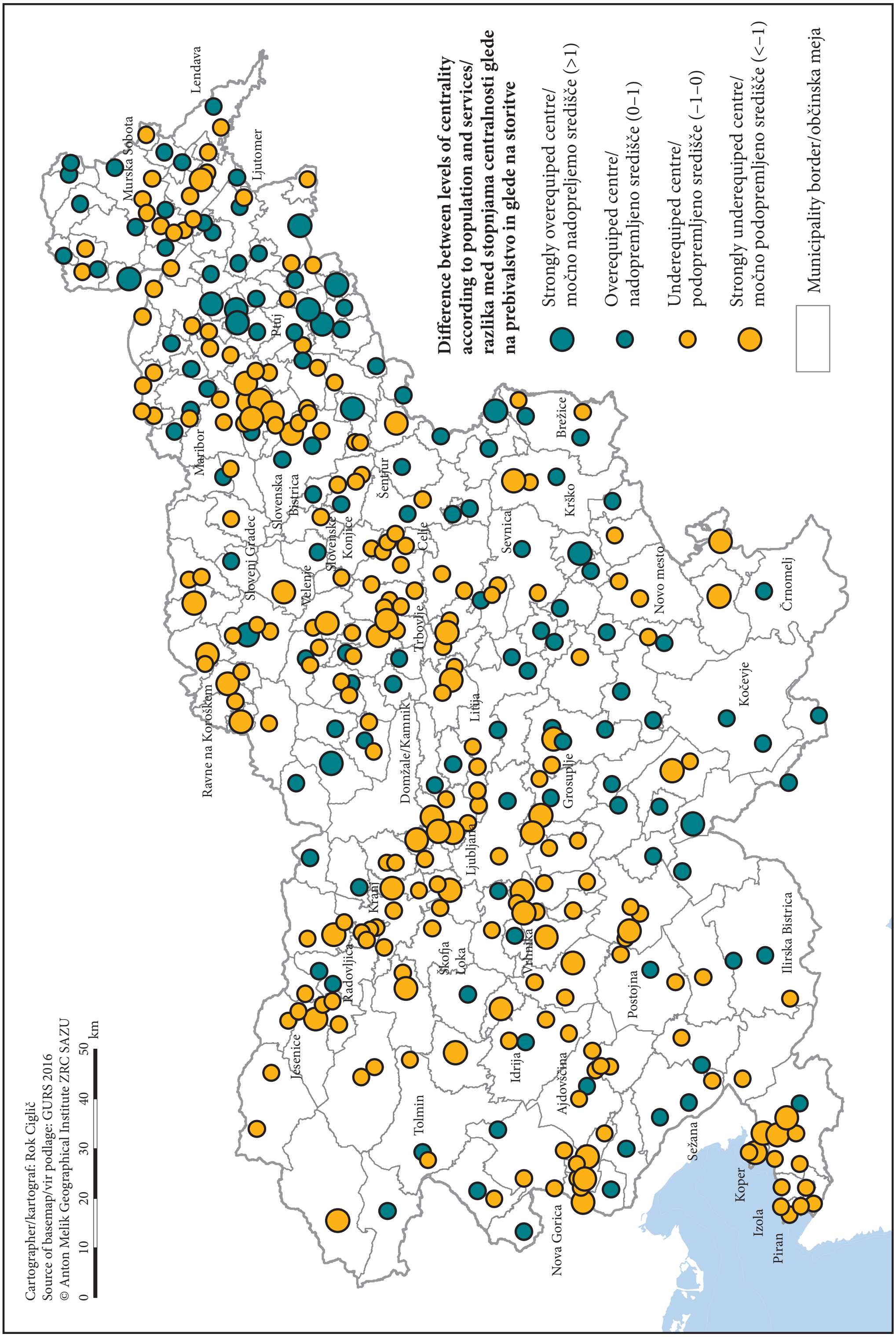
Among the central settlements, only twenty-three contain the seat of a major export company (more than 0.5% of Slovenian exports). In this regard, Ljubljana, Novo mesto, and Velenje stand out, which together account for over 50% of all Slovenian exports. Among the major central settlements, Maribor (Level 1), Murska Sobota, Slovenj Gradec, Trbovlje, Brežice, and Izola (Level 3) have no headquarters of a major export company at all. With regard to level of centrality, relatively weak positions are also held by Celje, Kranj, and Nova Gorica (Level 2) and Domžale–Kamnik, Ptuj, and Krško (Level 3). Conversely, there are many export companies in Škofja Loka (Level 3) and certain central settlements at lower levels, such as Slovenska Bistrica and Idrija (Level 4), Mežica and Zreče (Level 5), and Nazarje and Spodnja Idrija (Level 6).

In 2016, Slovenian research organizations employed 10,100 researchers on a full-time, additional-time, or part-time basis, which is equivalent to 8,988 full-time researchers. Their distribution among the sixty-nine central settlements is somewhat more dispersed than that of export-oriented companies, but among them stands out Ljubljana (69%), followed at a great distance by Maribor (12%), and the remaining centers have significantly fewer researchers. More than one percent of researchers are also found in Koper, Novo mesto, Celje, and Rodica.

In the period from 1991 to 2016, around 5,800 patents were issued in Slovenia. Their distribution among central settlements was more dispersed than that of researchers and export-oriented companies because patents may also be registered by natural persons. Nonetheless, among the 228 central settlements Ljubljana once again strongly stands out with 31% of all Slovenian patents, followed at a great distance by Maribor (7%), Velenje, Kranj, and Novo mesto (3% each), and Celje (2%), whereas the remaining settlements had less than two percent of patents issued.

The competitiveness of central settlements is moderately statistically correlated with their size and supply with functions (Table 4). The not very robust correlations primarily result from the great strength of Ljubljana, the relatively low competitiveness of Maribor, Level 2 settlements, and most Level 3 settlements, and the relatively high competitiveness of certain settlements at lower levels of centrality.

Figure 3: Difference between level of centrality by function and level of centrality by population of the settlement. ➤
Figure 4: Competitiveness of central settlements in Slovenia in terms of export companies, researchers, and patents. ➤ p. 18


Difference between levels of centrality according to population and services/ razlika med stopnjama centralnosti glede na prebivalstvo in glede na storitve
Strongly overequiped centre/ močno nadopreljemo središče (>1)
Overequiped centre/ nadopremljeno središče (0–1)
Underequiped centre/ podopremljeno središče (−1–0)
Strongly underequiped centre/ močno podopremljeno središče (<−1)
Municipality border/občinska meja
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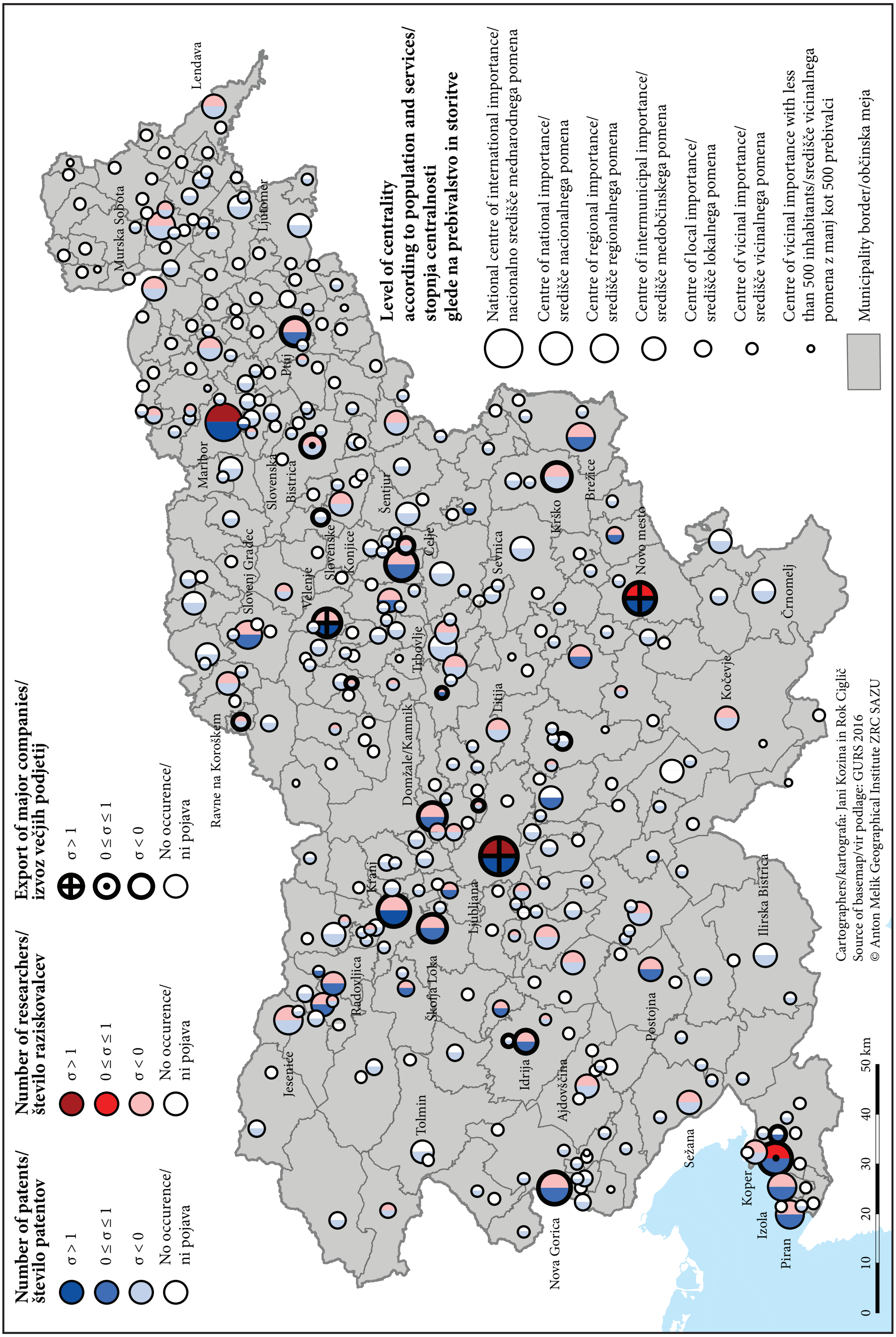
Maribor
Slovenska Bistrica
Slovenske Konjice
Šentjur
Brežice
Krško
Sevnica
Celje
Slovenj Gradec
Velenje
Trbovlje
Novo mesto
Črnomelj
Ravne na Koroškem
Domžale/Kamnik
Litija
Grosuplje
Kočevje
Ljubljana
Kranj
Radovljica
Jesenice
Škofja Loka
Vrhnika
Idrija
Postojna
Ilirska Bistrica
Tolmin
Ajdovščina
Nova Gorica
Sežana
Koper
Izola
Piran


Number of patents/
število patentov
σ > 1
0 ≤ σ ≤ 1
σ < 0
No occurence/
ni pojava
Number of researchers/
število raziskovalcev
σ > 1
0 ≤ σ ≤ 1
σ < 0
No occurence/
ni pojava
Export of major companies/
izvoz večjih podjetij
σ > 1
0 ≤ σ ≤ 1
σ < 0
No occurence/
ni pojava
Level of centrality
according to population and services/
stopnja centralnosti
glede na prebivalstvo in storitve
National centre of international importance/
nacionalno središče mednarodnega pomena
Centre of national importance/
središče nacionalnega pomena
Centre of regional importance/
središče regionalnega pomena
Centre of intermunicipal importance/
središče medobčinskega pomena
Centre of local importance/
središče lokalnega pomena
Centre of vicinal importance/
središče vicinalnega pomena
Centre of vicinal importance with less
than 500 inhabitants/središče vicinalnega
pomena z manj kot 500 prebivalci
Municipality border/občinska meja
Lendava
Murska Sobota
Ljutomer
Ptuj
Maribor
Slovenska Bistrica
Slovenske Konjice
Šentjur
Celje
Brežice
Krško
Sevnica
Novo mesto
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Kočevje
Litija
Trbovlje
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Slovenj Gradec
Ravne na Koroškem
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Tolmin
Idrija
Ajdovščina
Nova Gorica
Postojna
Ilirska Bistrica
Sežana
Koper
Izola
Piran
0
10
20
30
40
50 km
Cartographers/kartografa: Jani Kozina in Rok Ciglič
Source of basemap/vir podlage: GURS 2016
© Anton Melik Geographical Institute ZRC SAZU

Table 4: Statistical correlation between the competitiveness of central settlements and their size and supply of services (Spearman's correlation coefficient).

	Exports (€ million) (23 settlements)	Number of researchers (69 settlements)	Number of patents (228 settlements)
Settlement level by education	0.399	**0.651**	**0.489**
Settlement level by healthcare	*0.511*	**0.480**	**0.511**
Settlement level by public administration	**0.644**	*0.271*	**0.478**
Settlement level by judiciary	*0.509*	**0.514**	**0.470**
Average level by education, healthcare, public administration, and judiciary	*0.475*	**0.544**	**0.539**
Settlement level by population	**0.572**	**0.531**	**0.601**
Average level by education, healthcare, public administration, judiciary, and population	*0.524*	**0.557**	**0.592**

Italic text: correlation significant at $p < 0.05$ (two-tailed).
Boldface text: correlation significant at $p < 0.01$ (two-tailed).

4 Discussion

Regional policy and promoting the development of a polycentric system of settlement played an important role in shaping the settlement system in the past (Drozg 2005; Nared 2007). In addition to the abstract orientation of spatial development towards a polycentric settlement system, this was especially contributed to by both major reforms of local government: the introduction of the communal system in the 1960s, and the establishment of new municipalities in the 1990s (Drozg 2005; Rus, Razpotnik Visković and Nared 2013). This also explains the good supply to settlements at the fourth, fifth, and sixth levels of centrality. On the other hand, the role of Ljubljana is strengthening (Bole 2004; 2011; Nared 2007; Ravbar 2007; 2009; 2011; Ravbar, Bole and Nared 2005), which has especially been apparent after the most recent economic crisis, when Ljubljana has offered employment to an increasing number of people from the surrounding area (Bole et al. 2012; Rus, Razpotnik Visković and Nared 2013). However, one must be cautious in explaining the role of Ljubljana because data on commuting, based on which the influence of centers was analyzed (Nared et al. 2016), is connected with information about jobs. This can lead to errors because the job location is often cited as the company headquarters (e.g., in the official information at AJPES, the legal records office), and not at its branch locations distributed throughout Slovenia (e.g., Mercator grocery stores, Petrol gas stations, or the Slovenian Armed Forces).

In the past decades, the role of individual regional centers has been weakening, especially that of Postojna, Kranj (Rus, Razpotnik Visković and Nared 2013), and Murska Sobota, which on the one hand points to the leveling of development within regions, and on the other hand to the increasing divide between Ljubljana and other settlements.

The current situation has been strongly influenced by the polycentric arrangement of functions in the past, which points to the path-dependent development of the settlement system (Martin and Sunley 2006; Bristow and Healy 2014). This is especially reflected in the divide between the level of centrality based on settlement size and the level of centrality based on functions in the settlement, where it can be observed that functions only slowly adapt to demographic changes. A similar conclusion can also be drawn from the distribution of researchers, who are concentrated in the two main university centers, whereas patents, which also ought to reflect the activity of the academic sphere to a certain degree, are distributed among considerably more settlements. At the same time, the results point to the influence of past ideologies on spatial planning because polycentrism was also a goal of social planning under communism. Vrišer (1978) thus mentions the development of a polycentric system in line with the organization of systems of »basic organizations of associated labor,« »self-management,« and similar concepts of that era.

Despite a different methodology used, our findings agree with those in a study carried out in Norway, in which Dale and Sjøholt (2007) used a definition of central settlements based on commercial and noncommercial functions within walking distance to determine that specialized services and market-oriented functions are especially concentrated in settlements with a high level of centrality, where competitiveness thus comes to the fore. On the other hand, places with a low level of centrality lose market services and retain only basic functions such as schools and general stores. There, ensuring the basic cohesion of national territory is at the forefront.

In general, it is difficult to compare our study with modern investigations by researchers in other countries, who have focused more on the role of competitiveness and the functional organization of polycentric systems than uniform provision of functions. They have especially highlighted the networking and economic specialization of settlements and regions (Parr 2004), physical polycentrism, which is measured through commuting or employment in particular centers, political-administrative polycentrism, which is a result of the administrative division of territory, functional polycentrism, which arises due to the specialization of towns within the urban system, and regional-identity polycentrism, which is a result of historical, symbolic, and sociocultural processes (Kloosterman and Musterd 2001).

Defining central settlements based on services of general interest captures the aspect of competitiveness only from the perspective of establishing a supportive environment, and therefore it is appropriate for defining and directing the spatial organization of the country, but is less appropriate for directing economic development. Namely, defining the level of centrality is closely connected with the policy of polycentric development, which is one of the basic goals of spatial development in Europe and for which the so-called European Spatial Development Perspective (Evropske prostorske razvojne perspektive 2000) emphasizes three goals of spatial development in the European Union:

- Economic and social cohesion;
- Conservation of natural resources and cultural heritage; and
- More balanced competitiveness of European territory.

It is through polycentric development that countries ought to achieve these goals. Slovenia is following the guidelines established, whereby attention is focused on ensuring basic coverage of the country's territory with services of general interest and social cohesion, but Slovenia is less consistent in ensuring more balanced territorial competitiveness.

5 Conclusion

This article used selected services of general interest (public administration, education, healthcare, and the judiciary) to determine which settlements comprised the network of central settlements in Slovenia in 2016 and what are their chief characteristics.

Based on our own methodology, we defined six levels of central settlements and matched the corresponding settlements to them:

1. National centers of international importance (two settlements; in this case, Maribor is a settlement cluster, which means that together with certain other settlements forms a group of morphologically connected settlements that, despite their administrative division into several settlements, operate as a functionally connected whole; in the text, settlement clusters are underlined): Ljubljana and Maribor;
2. Centers of national importance (5): Celje, Nova Gorica, Koper, Novo mesto, and Kranj;
3. Centers of regional importance (12): Domžale-Kamnik, Ptuj, Velenje, Jesenice, Murska Sobota, Trbovlje, Piran, Slovenj Gradec, Izola, Škofja Loka, Brežice, and Krško;
4. Centers of inter-municipal importance (38);
5. Centers of local importance (55); and
6. Centers of rural importance (248).

The 360 central settlements were importantly influenced by historical development; among other things, especially by both local government reforms, which in many ways defined the development of the polycentric settlement system in Slovenia, especially from the perspective of cohesion at the level of centers of inter-municipal, local, and rural importance. Among other factors, we highlight strong centralization, which is a consequence of the concentration of essential national institutions in the capital city. Economic development also follows this, which is evidenced by Ljubljana's dominant share of export companies, researchers, and patents.

From the perspective of uniform spatial coverage, the supply of Slovenian territory with services of general interest is relatively satisfactory, but this should be improved with elements that promote competitiveness. In these efforts, attention should especially be directed toward centers of national and regional importance.

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Centralna naselja v Sloveniji leta 2016

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COBISS: 1.01

IZVLEČEK: Namen prispevka je predstaviti centralna naselja v Sloveniji in njihove poglavitne značilnosti leta 2016. Centralna naselja smo opredelili na podlagi storitev splošnega pomena in števila prebivalcev v posameznem naselju ter analizo nadgradili s kazalniki konkurenčnosti. Na šestih stopnjah centralnosti smo opredelili 360 centralnih naselij, med katerimi narašča pomen Ljubljane kot nacionalnega središča mednarodnega pomena ter središč medobčinskega, lokalnega in vicinalnega pomena. Manjša se pomen nekaterih regionalnih središč na drugi in tretji stopnji centralnosti. Opremljenost slovenskega ozemlja s storitvami splošnega pomena je razmeroma ustrezna, a bi jo bilo treba nadgraditi s spodbujanjem konkurenčnosti, zlasti v središčih nacionalnega in regionalnega pomena.

KLJUČNE BESEDE: geografija, sistem poselitve, centralna naselja, storitve splošnega pomena, kohezivnost, konkurenčnost, policentrizem, stična naselja, somestja, Slovenija

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1 Uvod

Centralna naselja so predmet strokovne razprave že vse od von Thünenovega dela (von Thünen 1842), a so se uveljavila šele s Christallerjevo (1933) teorijo centralnih naselij. V njej so centralna naselja opredeljena kot »*večja in manjša politična, kulturna, gospodarska in prometna središča, ki so nastala kot izraz političnega, kulturnega in gospodarskega delovanja človeške družbe in jih zato moramo smatrati kot temeljni element v funkcijski zgradbi družbenega življenja*« (Vrišer 1967, 143). Christaller jih pojmuje kot središča regij, ki prek svojih vplivnih območij regijo oblikujejo in opredeljujejo. Regije in njihova središča se zaradi nenehnega sovplivanja stalno prilagajajo spreminjajočim se razmeram, s čimer se spreminja tudi sistem centralnih naselij. Pri sistemu centralnih naselij imajo pomembno vlogo centralne funkcije, kot so trgovina, obrt, promet, šolstvo, zdravstvo, upravne in kulturne ustanove. Če je zaledje majhno, ima naselje le temeljne, pogosto uporabljane centralne funkcije, ki so uporabnikom na voljo v bližini bivališča, z naraščanjem stopnje centralnosti naselja pa so funkcije vse bolj raznovrstne (Vrišer 1967).

Centralna naselja v Sloveniji preučujemo že od 60-ih let preteklega stoletja (Vrišer 1967; Kokole 1971; Pak, Batagelj in Hrvatin 1987; Vrišer 1988; Cigale 2002; Strategija … 2004; Drozg 2005; Benkovič Krašovec 2006; Zavodnik Lamovšek, Drobne in Žaucer 2008; Rus, Razpotnik Visković in Nared 2013). Značilne so stalne spremembe v njihovem opredeljevanju, deloma zaradi spremenjene metodologije, še bolj pa zaradi prostorskih in družbenih sprememb (Nared, Bole in Ciglič 2016). Avtorji so uporabljali različne funkcije in različno število stopenj centralnosti, različno je bilo tudi pridobivanje podatkov (ankete, institucionalizirani viri podatkov; preglednica 1).

Kot so pokazale omenjene študije, je struktura centralnih naselij na višjih stopnjah razmeroma stabilna, večje spremembe pa so vidne v centralnih naseljih nižjih stopenj, zlasti zaradi prostorskih in družbenih sprememb v preteklih desetletjih: reforme lokalne samouprave, centralizacije, digitalizacije in povečane rabe interneta, izgradnje avtocestnega križa in naraščajoče mobilnosti, suburbanizacije in postsuburbanizacije, demografskih sprememb, terciarizacije gospodarstva in privatizacije javnih služb ter gospodarske krize (Bole s sodelavci 2012; Rus, Razpotnik Visković in Nared 2013; Nared, Bole in Ciglič 2016).

Sicer redke sodobne raziskave centralnih naselij so izhodiščno preučevanje opremljenosti s storitvami nadgradile z novimi vidiki. V ospredju so razprave o razmerju med kohezivnostjo in konkurenčnostjo (Meijers 2008), razprave o funkcijskih regijah (Karlsson in Olsson 2006; Zavodnik Lamovšek 2011) in funkcijskem policentrizmu (Green 2007). Meijers (2007) meni, da je treba teorijo centralnih naselij nadgraditi, saj se mesta ne povezujejo le navpično, temveč tudi vodoravno prek delitve funkcij (somestja) in funkcijske specializacije. Takšno »mrežno« povezovanje je značilnost globalnega gospodarstva, zlasti rastočih storitvenih sektorjev, kot so finance, informatika, ustvarjalna industrija in podobno (Sassen 1991; Castells 1996).

Namen prispevka je preučiti omrežje centralnih naselij v Sloveniji leta 2016 z vidika opremljenosti naselij s storitvami splošnega pomena (funkcijski vidik). Funkcijski vidik opredeljevanja centralnih naselij, ki ga lahko razumemo kot analizo zagotavljanja kohezivnosti celotnega državnega ozemlja, smo nadgradili z izbranimi elementi konkurenčnosti, natančneje z analizo razporeditve raziskovalcev, patentov in največjih izvoznih podjetij. Prispevek je nastal na podlagi projekta *Policentrično omrežje središč in dostopnost prebivalstva do storitev splošnega in splošnega gospodarskega pomena* (Nared s sodelavci 2016), ki ga je financiralo Ministrstvo Republike Slovenije za okolje in prostor v okviru prenove veljavne prostorske strategije Slovenije.

2 Metode

Pri analizi omrežja centralnih naselij smo se oprli na storitve splošnega pomena, ki jih državni organi opredelijo kot storitve v splošnem interesu in se zanje uporabljajo posebne obveznosti javne službe (ESPON Evidence Brief 2013; Noguera-Tur in Martínez 2014). Širši nabor storitev smo po tujih zgledih (Meijers 2007) omejili na štiri poglavitne funkcije, in sicer javno upravo, šolstvo, zdravstvo in sodstvo. Ožji nabor storitev splošnega pomena je omogočil razmeroma pregledno opredelitev centralnih naselij. Ob dodajanju novih funkcij bi bilo določanje centralnih naselij manj pregledno, ker se različne funkcije pojavljajo v istih naseljih, pa dodajanje novih funkcij ne bi prineslo bistveno drugačnih rezultatov. Izoblikovali smo podatkovno zbirko opremljenosti središč s storitvami splošnega pomena, ki poleg georeferenciranih podatkov vsebuje tudi meta podatke, potrebne za sprotno posodabljanje podatkovne zbirke. V njej smo zajeli 703 naselja

Preglednica 1: Primerjava meril in rezultatov treh izbranih študij (Kokole 1971; Vrišer 1988; Cigale 2002) (Rus 2013).

	Kokole 1971	Vrišer 1988	Cigale 2002
zbiranje podatkov o centralnih dejavnostih	kvalitativni pristop: adresarji, telefonski imeniki, seznami ustanov, anketa; kvantitativni pristop: aktivno prebivalstvo v mestotvornem sektorju	kvalitativni pristop: adresarji, telefonski imeniki, seznami ustanov, Register delovnih organizacij in samoupravnih skupnosti, Register zasebnih podjetnikov, popis prebivalstva; kvantitativni pristop: odnos med prebivalstvom in številom zaposlenih (delovnimi mesti) v terciarnih in kvartarnih dejavnostih po krajevnih skupnostih (mesta obravnavana kot celota)	kvalitativni pristop: telefonski imenik Slovenije, podatki o poštnih poslovalnicah, podatki o zdravstvenih domovih, podatki o osnovnih šolah, anketa
ugotavljanje obsega vplivnih območij	anketiranje osnovnih šol	anketiranje krajevnih skupnosti/krajevnih uradov	anketiranje osnovnih šol – ugotavljanje, kje prebivalci zadovoljujejo različne potrebe po različnih storitvah
število stopenj centralnosti	9 Kokole stopenj centralnosti ne poimenuje, temveč določi le stopnjo	7 (5) lokalna ali krajevna središča; ruralna ali industrijska središča; komunalna ali občinska središča; distriktna ali okrožna središča; kantonalna ali okrajna središča; provincijska ali pokrajinska središča; republiška središča	3 makroregionalna središča; mezoregionalna središča; mikroregionalna središča
razvrščanje centralnih naselij v hierarhično stopnjo centralnosti	razvrstitev indikatorjev glede na pogostost pojavljanja	razvrstitev indikatorjev glede na pogostost pojavljanja	opremljenost s funkcijami/storitvenimi dejavnostmi: • dejavnosti, ki so zastopane v od 150 do 500 naseljih; • dejavnosti, ki so zastopane v več kot 50 in manj kot 100 naseljih; • dejavnosti, ki so zastopane v manj kot 20 naseljih

z vsaj eno od štirih poglavitnih funkcij. Podatkovna zbirka temelji na Poslovnem registru Slovenije (AJPES) ter zbirkah ministrstev in agencij.

Izhajajoč iz dosedanjih opredelitev centralnih naselij, predlogov fokusne skupine in delavnice z zainteresirano javnostjo (Policentrično omrežje … 2015) smo opredelili šest stopenj centralnosti (preglednica 2). Stopnjo centralnosti smo na eni strani določili na podlagi števila prebivalcev v posameznem naselju, na drugi strani pa smo posamezni funkciji pripisali, kateri stopnji centralnosti ustreza. Vrednotenje skupne stopnje centralnosti smo opravili s sestavljenim indeksom stopnje centralnosti (st_{cen}). V indeksu smo enakovredno upoštevali povprečno stopnjo centralnosti, izhajajoč iz štirih funkcij $\left(\frac{\sum_1^4 f!}{4}\right)$, in stopnjo centralnosti z vidika števila prebivalcev (st_{pop}).

$$st_{cen} = \frac{\frac{\sum_1^4 f}{4} + st_{pop}}{2} \qquad (1)$$

Preglednica 2: Stopnja centralnosti naselij in merila za posamezno stopnjo.

stopnja centralnosti	število prebivalcev	pričakovane funkcije
1. nacionalno središče mednarodnega pomena	100.001 in več	• sedež javne univerze • univerzitetni klinični center • višje sodišče
2. središče nacionalnega pomena	od 20.001 do 100.000	• sedež visoke šole, fakultete ali akademije • večja splošna bolnišnica
3. središče regionalnega pomena	od 10.001 do 20.000	• okrožno sodišče • sedež višje šole • bolnišnica • sedež srednje šole
4. središče medobčinskega pomena	od 3001 do 10.000	• zdravstveni dom • upravna enota • okrajno sodišče
5. središče lokalnega pomena	od 1501 do 3000	• popolna osnovna šola • zdravstvena postaja • sedež občine
6. središče vicinalnega pomena	od 501 do 1500	• podružnica osnovne šole

Pri razvrščanju naselij v posamezno stopnjo centralnosti smo določili naslednje meje razredov (preglednica 3).

Preglednica 3: Meje razredov pri opredeljevanju stopenj centralnosti.

stopnja centralnosti	vrednost indeksa centralnosti
1. nacionalno središče mednarodnega pomena	do 1,50
2. središče nacionalnega pomena	od 1,51 do 2,50
3. središče regionalnega pomena	od 2,51 do 3,50
4. središče medobčinskega pomena	od 3,51 do 4,50
5. središče lokalnega pomena	od 4,51 do 5,50
6. središče vicinalnega pomena	nad 5,51
6a. središče vicinalnega pomena z manj kot 500 prebivalci	število prebivalcev pod 500 in vsaj dve funkciji

Zaradi razpršene poselitve je v Sloveniji veliko število razmeroma dobro opremljenih naselij z manj kot 500 prebivalci, kar smo sprva opredelili kot spodnje število prebivalcev v centralnem naselju. Zato smo dodali novo kategorijo centralnih naselij z manj kot 500 prebivalci, ki pa so morala imeti vsaj dve od obravnavanih štirih funkcij.

Ugotovili smo tudi, da več administrativnih naselij leži tesno eno ob drugem, funkcije pa so enakomerno porazdeljene med njimi, kar pomeni, da posamezno naselje ni nujno dovolj veliko ali opremljeno, če pa jih združimo, združeno naselje zadosti tako merilu velikosti kot opremljenosti. Tovrstna naselja smo poimenovali stična naselja (v besedilu so ta naselja podčrtana). Opredelili smo jih kot skupek morfološko povezanih naselij, ki kljub administrativni razčlenjenosti na več naselij delujejo kot funkcijsko povezana celota. Takšna naselja so morala zadostiti dvema kriterijema: da imajo večino (> 50 %) svojih prebivalcev na območjih večje zgostitve hišnih številk (> 1,5 hišne številke/ha v polmeru 800 metrov), in da so območja večjih zgostitev nujno neprekinjeno povezana z vsaj še enim tovrstnim območjem drugega naselja. Tako smo določili 56 območij, jih preverili še z vizualnim ogledom letalskih posnetkov in pregledom zastopanosti štirih funkcij ter tako seznam centralnih naselij razširili za dodatnih 29 stičnih naselij (slika 1). S stičnimi naselji smo lahko bolje ocenili raven opremljenosti zlasti na območjih strnjene poselitve in delitve funkcij med posameznimi naselji, na primer Nova Gorica–Šempeter–Vrtojba, Piran–Lucija … (Nared, Bole in Ciglič 2016).

Slika 1: Stična naselja (Nared, Bole in Ciglič 2016).
Glej angleški del prispevka.

Za analizo omrežja centralnih naselij z vidika konkurenčnosti smo preučili tri kazalnike: izvoz v milijonih evrov po sedežu podjetij leta 2015 (SLOEXPORT 2016), število raziskovalcev po kraju dela (SICRIS 2016) in število patentov po kraju imetnika v obdobju 1991–2016 (Patenti 2016). Zadnja dva kazalnika sta pogosto sestavni del meritev globalnega kazalnika konkurenčnosti (Global Competitive … 2016) in globalnega kazalnika ustvarjalnosti (Global Creativity … 2016), zato sta primerna tudi za našo analizo konkurenčnosti. Statistično povezanost velikosti naselij, njihove opremljenosti s storitvami splošnega pomena in konkurenčnosti smo izračunali s pomočjo Spearmanovega korelacijskega koeficienta (ρ).

3 Rezultati

Na podlagi predstavljene metodologije smo v Sloveniji opredelili 360 centralnih naselij (slika 2), v katerih živi 1.318.051 prebivalcev, kar je slabih 9,2 % naselij in 64 % prebivalcev. Dve naselji sta nacionalni središči mednarodnega pomena (Ljubljana, Maribor), pet je središč nacionalnega pomena (Celje, Nova Gorica, Koper, Novo mesto, Kranj), 12 središč regionalnega pomena (Domžale-Kamnik, Ptuj, Velenje, Jesenice, Murska Sobota, Trbovlje, Piran, Slovenj Gradec, Izola, Škofja Loka, Brežice, Krško), 38 središč medobčinskega pomena, 55 središč lokalnega pomena, in 248 središč vicinalnega pomena, med katere smo uvrstili tudi 49 središč z manj kot 500 prebivalci, a z vsaj dvema poglavitnima funkcijama; v besedilu so stična naselja podčrtana.

Slika 2: Centralna naselja v Sloveniji 2016.
Glej angleški del prispevka.

Z vidika centralnih funkcij in velikosti naselja je močno v ospredju Ljubljana. Pomembno vlogo kot drugo največje mesto ohranja Maribor. Med ostalimi regionalnimi središči drugo stopnjo centralnosti dosega pet naselij (Celje, Nova Gorica, Koper, Novo mesto, Kranj), tretjo stopnjo pa štiri (pet) (Murska Sobota, Trbovlje, Slovenj Gradec, somestje Krško-Brežice). Najšibkejša med regionalnimi središči je Postojna, ki se uvršča na raven medobčinskih središč. Z vidika velikosti naselja in njegove gospodarske moči je s funkcijami podopremljeno Velenje, kar je v veliki meri posledica njegove lege med bližnjima regionalnima središčema, Celjem in Slovenj Gradcem.

Ljubljana ima velik upravni in gospodarski vpliv in postaja pomembno metropolitansko središče. Gospodarski pomen naselij na drugi in tretji stopnji centralnosti slabi, povečan vpliv pa znova zaznamo na ravni občinskih središč. Slednje lahko pripišemo reformi lokalne samouprave in »lokalizaciji« regionalne politike; o regionalnih projektih odločajo župani, ki dajejo prednost lokalnim projektom.

Nastanek številnih novih občin je močno vplival na število centralnih naselij šeste stopnje, zlasti tistih, ki ne dosegajo meje 500 prebivalcev. Skladno z velikostno sestavo slovenskih občin ta naselja prevladujejo v vzhodni Sloveniji.

Z vidika stičnih naselij je smiselno opozoriti zlasti na Domžale-Kamnik in Novo Gorico. Stično naselje Domžale-Kamnik je le morfološko povezano naselje brez delitve funkcij, saj sta obe glavni naselji središči medobčinskega pomena. Nasprotno pa je morfološka povezanost Nove Gorice in naselij Šempeter pri Gorici, Kromberk, Pristava, Rožna Dolina, Solkan in Vrtojba nadgrajena z delitvijo funkcij, zlasti med Šempetrom pri Gorici in Novo Gorico.

Zanimiva je tudi primerjava stopnje centralnosti z vidika velikosti naselja in z vidika opremljenosti naselja s posameznimi funkcijami. Večja naselja so praviloma bolje opremljena s funkcijami kot manjša. Če raven centralnosti po funkcijah presega raven centralnosti po številu prebivalcev, je naselje nadopremljeno, v nasprotnem primeru pa podopremljeno (slika 3).

Slika 3: Razlika med stopnjo centralnosti po funkcijah in stopnjo centralnosti glede na število prebivalcev v naselju.
Glej angleški del prispevka.

Nadpovprečno opremljena so zlasti naselja na manj urbaniziranih predelih države, kar si lahko razlagamo z zavestnim enakomernim zagotavljanjem funkcij po celotnem državnem ozemlju kot posledico politike policentričnega urbanega razvoja od 60-ih let preteklega stoletja dalje. Pri tem je treba upoštevati, da bi se ob prilagajanju funkcij velikosti naselja redkeje poseljena območja soočala z razmeroma slabo opremljenostjo.

Podopremljena so zlasti središča v bližini večjih mest, kar je posledica suburbanizacije, ki je bila izrazita zlasti v zadnjih 40-ih letih (Ravbar 1997 in 2005). Zaradi selitev prebivalcev na obrobje mest se je v teh naseljih močno povečalo število prebivalcev, oskrba s funkcijami pa se temu ni dovolj hitro prilagajala.

Med centralnimi naselji je samo v 23-ih sedež večjega izvoznega podjetja (več od 0,5 % slovenskega izvoza). V tem oziru nadpovprečno izstopajo Ljubljana, Novo mesto in Velenje, ki skupaj ustvarijo več kot 50 % vsega slovenskega izvoza. Od večjih centralnih naselij Maribor (1. stopnja), Murska Sobota, Slovenj Gradec, Trbovlje, Brežice in Izola (3. stopnja) sploh nimajo sedeža večjega izvoznega podjetja. Glede na stopnjo centralnosti so razmeroma šibki tudi Celje, Kranj in Nova Gorica (2. stopnja) ter Domžale-Kamnik, Ptuj in Krško (3. stopnja). Obratno je veliko izvoznih podjetij v Škofji Loki (3. stopnja) in nekaterih centralnih naseljih nižjih stopenj, kot so Slovenska Bistrica in Idrija (4. stopnja), Mežica in Zreče (5. stopnja) ter Nazarje in Spodnja Idrija (6. stopnja).

V slovenskih raziskovalnih organizacijah je leta 2016 za polni, dodatni in skrajšan delovni čas zaposlenih 10.100 raziskovalcev, kar ustreza 8988 polno zaposlenim raziskovalcem. Njihova razporeditev med 69 centralnimi naselji je sicer nekoliko bolj razpršena od izvozno usmerjenih podjetij, vendar med njimi izrazito izstopa Ljubljana (69 %), kateri z velikim zaostankom sledi Maribor (12 %), ostala središča pa imajo bistveno manj raziskovalcev. Več kot en odstotek slovenskih raziskovalcev je še v naseljih Koper, Novo mesto, Celje in Rodica.

V obdobju 1991–2016 je bilo v Sloveniji podeljenih okoli 5800 patentov. Njihova razporeditev med centralnimi naselji je bolj razpršena od raziskovalcev in izvozno usmerjenih podjetij, saj so lahko patentni

Preglednica 4: Statistična povezanost kazalnikov konkurenčnosti centralnih naselij z njihovo velikostjo in opremljenostjo s storitvami (Spearmanov koeficient korelacije).

	izvoz (v milijonih evrov) (N naselij = 23)	število raziskovalcev (N naselij = 69)	število patentov (N naselij = 228)
stopnja naselja glede na šolstvo	0,399	**0,651**	**0,489**
stopnja naselja glede na zdravstvo	*0,511*	**0,480**	**0,511**
stopnja naselja glede na javno upravo	**0,644**	*0,271*	**0,478**
stopnja naselja glede na sodstvo	*0,509*	**0,514**	**0,470**
povprečna stopnja glede na šolstvo, zdravstvo, javno upravo in sodstvo	*0,475*	**0,544**	**0,539**
stopnja naselja glede na število prebivalcev	**0,572**	**0,531**	**0,601**
povprečna stopnja glede na šolstvo, zdravstvo, javno upravo in sodstvo ter število prebivalcev	*0,524*	**0,557**	**0,592**

ležeče oblikovano besedilo: povezanost je značilna pri stopnji tveganja p < 0,05 (dvostranska).
krepko oblikovano besedilo: povezanost je značilna pri stopnji tveganja p < 0,01 (dvostranska).

prijavitelji tudi fizične osebe. Kljub temu med 228 centralnimi naselji ponovno močno izstopa Ljubljana z 31 % vseh slovenskih patentov, ki ji z velikim zaostankom sledijo Maribor (7 %), Velenje, Kranj in Novo mesto (vsak po 3 %) ter Celje (2 %), medtem ko imajo ostala naselja manj kot dva odstotka podeljenih patentov.

Slika 4: Konkurenčnost centralnih naselij v Sloveniji z vidika izvoznih podjetij, raziskovalcev in patentov.
Glej angleški del prispevka.

Konkurenčnost centralnih naselij je zmerno statistično povezana z njihovo velikostjo in opremljenostjo s funkcijami (preglednica 4). Ne največji povezanosti botrujejo predvsem velika moč Ljubljane, relativno nižja konkurenčnost Maribora, naselij 2. stopnje in večine naselij 3. stopnje ter relativno višja konkurenčnost nekaterih naselij nižjih stopenj centralnosti.

4 Razprava

Regionalna politika in spodbujanje razvoja policentričnega sistema poselitve sta imela v preteklosti pomembno vlogo pri oblikovanju naselbinskega sistema (Drozg 2005; Nared 2007). K temu sta poleg deklarativne usmerjenosti prostorskega razvoja v policentrični sistem poselitve prispevali zlasti obe pomembnejši reformi lokalne samouprave: uvedba komunalnega sistema v 60-ih in ustanovitev novih občin v 90-ih letih preteklega stoletja (Drozg 2005; Rus, Razpotnik Visković in Nared 2013). S tem lahko pojasnimo tudi dobro opremljenost naselij 4., 5. in 6. stopnje centralnosti. Na drugi strani se krepi vloga Ljubljane (Bole 2004 in 2011; Nared 2007; Ravbar 2007, 2009 in 2011; Ravbar, Bole in Nared 2005), kar je posebej opazno po zadnji gospodarski krizi, ko nudi Ljubljana zaposlitev vse širšemu zaledju delavcev (Bole s sodelavci 2012; Rus, Razpotnik Visković in Nared 2013). Vendar pa moramo biti pri razlagi vloge Ljubljane previdni, saj so podatki o dnevni mobilnosti, na podlagi katere smo preverjali vpliv središč (Nared s sodelavci 2016), vezani na podatke o delovnih mestih, kjer pogosto prihaja do napak, saj je kot lokacija dela večkrat naveden sedež podjetja (npr. v uradnih podatkih AJPES-a), ne pa njegove izpostave, razmeščene drugje po Sloveniji (na primer Mercator, Petrol, Slovenska vojska).

V zadnjih desetletjih slabi vloga posameznih regionalnih središč, zlasti Postojne, Kranja (Rus, Razpotnik Visković in Nared 2013) in Murske Sobote, kar na eni strani nakazuje na izenačevanje razvoja znotraj regij, na drugi pa večanje razkoraka med Ljubljano in drugimi naselji.

Na sedanje stanje je močno vplivala policentrična razmestitev funkcij v preteklosti, kar nakazuje na zgodovinsko pogojeni razvoj naselbinskega sistema (angleško *path-dependent*; Martin in Sunley 2006; Bristow in Healy 2014). To zlasti odseva v razkoraku med stopnjo centralnosti glede na velikost naselja in stopnjo centralnosti glede na funkcije v naselju, kjer je zaznati, da se funkcije le počasi prilagajajo demografskim spremembam. Do podobnega sklepa lahko pridemo tudi pri razmestitvi raziskovalcev, ki so osredotočeni v dveh poglavitnih univerzitetnih središčih, medtem ko so patenti, ki bi morali biti v določeni meri tudi odraz dejavnosti akademske sfere, razporejeni po precej več naseljih. Rezultati obenem kažejo na vpliv preteklih ideologij na prostorsko načrtovanje, saj je bil policentrizem tudi cilj družbenega planiranja v socializmu. Vrišer (1978) tako omenja razvoj policentričnega sistema skladno z organiziranostjo sistemov temeljnih organizacij združenega dela, samoupravljanja in podobno.

Navkljub različni metodologiji se naše ugotovitve ujemajo s tistimi v raziskavi, opravljeni na Norveškem, kjer sta Dale in Sjøholt (2007) na podlagi opredelitve centralnih naselij s pomočjo gospodarskih in negospodarskih funkcij v peš dostopnosti ugotovila, da se specializirane storitve in tržno usmerjene funkcije zgoščujejo zlasti v naseljih z višjo stopnjo centralnosti, kjer torej v ospredje stopa konkurenčnost. Na drugi strani kraji z nižjo stopnjo centralnosti izgubljajo tržne storitve in ohranjajo le temeljne funkcije, kot so šole in trgovine z mešanim blagom. Tam je v ospredju zagotavljanje osnovne kohezivnosti državnega ozemlja.

Sicer pa je naša raziskava težje primerljiva s sodobnimi poskusi tujih raziskovalcev, ki se bolj kot na enakomerno zagotavljanje funkcij osredotočajo na vlogo konkurenčnosti in funkcijsko organizacijo policentričnih sistemov. V ospredju so predvsem mrežno povezovanje in gospodarska specializacija naselij in regij (Parr 2004), fizični policentrizem, ki se meri z dnevno mobilnostjo ali zaposlenostjo v določenih središčih, politično-upravni policentrizem, ki je posledica upravne razdelitve ozemlja, funkcionalni policentrizem, ki nastane zaradi specializacije mest znotraj urbanega sistema, ter regionalno-identitetni policentrizem, ki je posledica zgodovinskih, simbolnih in družbeno-kulturnih procesov (Kloosterman in Musterd 2001).

Določanje centralnih naselij na podlagi storitev splošnega pomena zajame vidik konkurenčnosti zgolj z vidika vzpostavljanja podpornega okolja, zato je primerno za opredeljevanje in usmerjanje prostorske organizacije države, manj primerno pa za usmerjanje gospodarskega razvoja. Opredeljevanje stopnje centralnosti je namreč tesno povezano s politiko policentričnega razvoja, enim od temeljnih ciljev prostorskega razvoja v Evropi, pri čemer so Evropske prostorske razvojne perspektive (2000) poudarile tri cilje prostorskega razvoja Evrope:

- gospodarska in socialna kohezija,
- ohranjanje naravnih virov in kulturne dediščine ter
- teritorialno bolj uravnotežena konkurenčnost.

Te cilje naj bi države dosegle prav s policentričnim razvojem. Slovenija sledi zastavljenim usmeritvam, pri čemer sta v ospredju zagotavljanje osnovne pokritosti ozemlja s storitvami splošnega pomena in socialna kohezija, manj dosledna pa je Slovenija pri zagotavljanju teritorialno bolj uravnotežene konkurenčnosti.

5 Sklep

Namen prispevka je bil na podlagi izbranih storitev splošnega pomena (javna uprava, šolstvo, zdravstvo in sodstvo) ugotoviti, katera naselja sestavljajo omrežje centralnih naselij v Sloveniji leta 2016 in katere so njegove poglavitne značilnosti.

Na podlagi lastne metodologije smo opredelili šest stopenj centralnih naselij in jim določili ustrezajoča naselja:

1. nacionalna središča mednarodnega pomena (2 naselji; Maribor je v tem primeru stično naselje, kar pomeni, da skupaj s še nekaterimi naselji tvori skupek morfološko povezanih naselij, ki kljub administrativni razčlenjenosti na več naselij delujejo kot funkcijsko povezana celota; v besedilu so stična naselja podčrtana): Ljubljana, <u>Maribor</u>;
2. središča nacionalnega pomena (5): Celje, <u>Nova Gorica</u>, Koper, Novo mesto, <u>Kranj</u>;
3. središča regionalnega pomena (12): <u>Domžale-Kamnik</u>, Ptuj, Velenje, <u>Jesenice</u>, <u>Murska Sobota</u>, <u>Trbovlje</u>, <u>Piran</u>, Slovenj Gradec, <u>Izola</u>, <u>Škofja Loka</u>, Brežice, <u>Krško</u>;
4. središča medobčinskega pomena (38);
5. središča lokalnega pomena (55);
6. središča vicinalnega pomena (248).

Na skupaj 360 centralnih naselij je pomembno vplival zgodovinski razvoj, med drugim zlasti obe reformi lokalne samouprave, ki sta v marsičem določili razvoj policentričnega sistema poselitve v Sloveniji, še posebej z vidika kohezivnosti na ravni središč medobčinskega, lokalnega in vicinalnega pomena. Med drugimi dejavniki izpostavljamo močno centralizacijo, ki je posledica osredotočenosti bistvenih državnih institucij v glavnem mestu. Temu sledi tudi gospodarski razvoj, na kar kaže prevladujoči delež Ljubljane v izvoznih podjetjih, raziskovalcih in patentih.

Preskrba slovenskega ozemlja z obravnavanimi storitvami splošnega pomena je z vidika enakomerne prostorske pokritosti razmeroma ustrezna, a bi jo bilo treba nadgraditi z elementi spodbujanja konkurenčnosti, pri čemer naj se pozornost nameni zlasti središčem nacionalnega in središčem regionalnega pomena.

6 Literatura

Glej angleški del prispevka.

Acta geographica Slovenica, 57-2, 2017, 33–44

AIR TEMPERATURE TRENDS AT MOUNT ŚNIEŻKA (POLISH SUDETES) AND SOLAR ACTIVITY, 1881–2012

Grzegorz Urban, Karol Tomczyński

Mount Śnieżka (1,603 m), November 12th, 2011.

Air temperature trends at Mount Śnieżka (Polish Sudetes) and solar activity, 1881–2012

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ABSTRACT: This article discusses air temperature variability at Mount Śnieżka in the Sudetes from 1881 to 2012. It analyzes the relationship between changing trends in mean annual air temperature (T_{avg}) and solar activity, expressed by the mean annual Wolf number. The characteristic feature of changes in annual mean extremes (T_{max}, T_{min}) and T_{avg} at Mount Śnieżka is an upward trend. The increase of T_{min} (0.148 °C / 10 years) has been twice as fast as that for T_{max} (0.069 °C / 10 years). A strong correlation (almost 1.0) was found between the mean annual Wolf number for twenty-two-year cycles of magnetic changes in the Sun and 1988. During the 1989–2012 cycle, there was a strong increase in T_{avg} and, at the same time, a decrease in the mean annual Wolf number.

KEY WORDS: geography, air temperature, long-term trends, impact of changes, mean Wolf number, Mount Śnieżka, Poland

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1 Introduction

In recent years, much attention has been devoted to air temperature trends in the context of global warming (IPCC 2013). In such research, long and homogenous measuring series are very useful. The best sites for obtaining such series are isolated, high-elevation mountain summits free of local anthropogenic impact and preserving conditions close to those in a free atmosphere. The conditions at such locations make it possible to follow changes in air temperature over time with high reliability. All of these characteristics apply to the Mount Śnieżka Meteorological Observatory (1,603 m) in the Sudetes, operating since July 1st, 1880. The climate at Mount Śnieżka has been the subject of many studies (Głowicki 1998, 2000, 2001, 2003; Dubicka and Głowicki 2000a and 2000b; Wibig and Głowicki 2002). Nonetheless, neither its temperature measuring series going back 130 years nor its trends have been discussed.

This article analyzes the variability of annual, seasonal, and monthly mean air temperatures from 1881 to 2012. Variability of annual mean air temperature in relation to solar activity, the index of which is the Wolf number, is also discussed.

2 Data and methods

The source data used in this paper include monthly and annual mean maximum and minimum air temperatures registered at Mount Śnieżka from 1881 to 2012. The data were obtained from the archives of the German Meteorological Service (DWD) in Offenbach, Germany, and the Institute of Meteorology and Water Management, National Research Institute (IMGW-PIB) in Warsaw, Poland.

Based on monthly and annual mean maximums and mean minimums, monthly mean and annual mean temperatures were calculated as the arithmetic mean of corresponding mean extremes using the following formula: $(T_{max} + T_{min}) / 2$. This equation is commonly used for calculating the daily air temperature in North America, Australia, and several European countries (e.g., the UK; Urban 2010). Consequently, a homogenous series of monthly and annual mean values was obtained. The series is free from potential differences resulting from application of various methods of calculating daily mean values during the period analyzed, and consequently differences of calculations of monthly and annual mean values of air temperature based on measurements taken up to twenty-four times a day (Lorenc and Suwalska-Bogucka 1995; Urban 2010). Moreover, the calculation method adopted for mean air temperature works well for long (e. g., annual) time intervals (Urban 2010 and 2013).

The method used for calculating both monthly and annual mean values of air temperature yields higher monthly values in the warm season than the corresponding values provided by IMGW-PIB or the ones referred to in the literature on the subject (which combine different methods). Consequently, the differences are noticeable in the case of values for summer months, the warm season, and also a year. There are no differences for winter months (Table 1).

Table 1: Comparison of monthly and seasonal mean air temperature (°C) from 1881 to 2012 as provided by IMGW-PIB: (A) derived from various calculation methods and (B) determined using the method adopted in this work.

	January	February	March	April	May	June	July	August	September	October	November	December	Winter (December–February)	Spring (March–May)	Summer (June–August)	Autumn (September–November)	Warm season (May–October)	Cold season (January–April and November–December)	Year (January–December)
A	−7.0	−7.0	−5.0	−1.4	3.7	6.6	8.5	8.3	5.3	1.5	−2.8	−5.6	−6.5	−0.9	7.8	1.3	5.6	−4.8	0.4
B	−7.0	−7.0	−5.0	−1.3	3.9	6.8	8.8	8.6	5.5	1.6	−2.7	−5.6	−6.5	−0.8	8.1	1.5	5.9	−4.8	0.5

It must also be noted that the sites of measuring instruments have changed in the history of meteorological measurements and observations at Mount Śnieżka. Until May 31st, 1900, thermometers were attached 2.05 m above the ground to an iron stand located beside the north wall of St. Laurence's Chapel. Starting on June 1st, 1900, they were moved to a Stevenson screen placed on the platform of the former observatory building, about 16 m above the ground. Finally, since October 23, 1976, the thermometers have been enclosed in a Stevenson screen on the platform of the new observatory, about 14 m above the ground (Głowicki 1998).

The absence of an analogical measuring series taken at a relatively close distance in similar climate conditions that could be used as reference data and the lack of ground-level measurements of air thermicity in a vertical profile make it difficult to test the homogeneity of chronological data series. The air temperature measurement series carried out at Mount Śnieżka since the beginning of the twentieth century is considered homogenous (Głowicki 1998 and 2000; Wibig and Głowicki 2002). So far, there has been no study to determine whether the series homogeneity was disrupted by the location changes of thermometers in 1900 and 1976.

WALTER STAUDTE (INTERNET 1)

Figure 1: Former IMGW-PIB observatory building at Mount Śnieżka.

GRZEGORZ URBAN

Figure 2: New IMGW-PIB observatory building at Mount Śnieżka.

In order to test whether the change of the measuring instrument locations in 1900 and 1976 affected the data series homogeneity, a data quality check of series from 1881 to 1919 and from 1957 to 1995 in each category of air temperature data (T_{avg}, T_{min}, T_{max}) was carried out using the Abbe criterion (Kożuchowski 1985, following Nosek 1972; Table 2). The years 1900 and 1976, when two instrument sites were functioning, mark the midpoint of the time series tested for homogeneity. The results show that relocating the thermometers from the iron stand next to the Saint Laurence's Chapel to the old wooden observatory (Figure 1) and to the new observatory (Figure 2) did not affect the data series homogeneity.

Table 2: Homogeneity of air temperature data series at Mount Śnieżka tested using the Abbe criterion and values of annual mean air temperature (°C).

Period	Abbe test results			T_{avg} (°C)
	T_{avg}	T_{min}	T_{max}	
1881–1919	0.840/0.867/1.160	0.840/0.986/1.160	0.840/0.937/1.160	0.10
1957–1995	0.840/1.007/1.160	0.840/1.054/1.160	0.840/0.988/1.160	0.76

Based on the assessment of air temperature series at Mount Śnieżka, it is possible to draw conclusions on potential climate variability. The measuring series provides such an opportunity because of its unique length, comparable to only a few data series in Europe; namely, from Mount Säntis and Mount Sonnblick (Auer 2004). The characterization and assessment of the data series of temperatures at Mount Śnieżka from 1881 to 2012 was followed by an analysis of variability of the calculated monthly and annual mean air temperature values (the arithmetic average of corresponding mean extreme values) as well as maximum and minimum average values. Moreover, an attempt was made to determine the relationship between annual mean air temperature and the mean annual Wolf number. Wolf numbers were provided by the Royal Observatory of Belgium (SILSO data 2014).

The Wolf number (W) is derived from the formula $W = k(10g+s)$, where g is the number of sunspot groups, s is the number of individual spots, and k is a factor that varies with location and instrumentation.

3 Results

3.1 Air temperature trends

The mean annual air temperature at Mount Śnieżka for the entire 132-year period is +0.5 °C. The lowest annual mean temperature of –1.2 °C was noted in 1941, and the highest value of +2.3 °C was registered in 2000, 2006, and 2011 (Figure 5).

The trend of annual mean temperature at Mount Śnieżka from 1881 to 2012 is 0.108 °C / 10 years (Table 3). Many authors give similar values of air thermicity trends in the northern hemisphere in the twentieth century (Lorenc 1994; Karl et al. 1993; Karl, Nicholls and Gregory 1997; Schönwiese and Rapp 1997; Nojarov 2012; IPCC 2013).

The variability of annual mean extreme values (T_{max}, T_{min}) and the annual mean value (T_{avg}) of air temperature at Mount Śnieżka from 1881 to 2012 is characterized by an upward tendency. The increase rate of T_{min} is twice the increase rate of T_{max}; that is, 0.148 °C / 10 years and 0.069 °C / 10 years, respectively (Figure 3, Table 3). Consequently, a decreasing trend in the annual mean amplitude of air temperature is perceptible; that is, –0.080 °C / 10 years. T_{min} shows a continuous increase since the beginning of observation (Figure 3).

A higher rate of increase of the minimum when compared to the maximum air temperature, causing a flattening of diurnal amplitudes, is currently observed in many areas of the globe (Karl et al. 1993; Kejna 2006). This tendency has not yet been explained. It could be the result of synergy of several factors. It is probably related to the escalation of the greenhouse effect, in which greenhouse gasses slow down the rate of heat loss from Earth's surface emitting infrared radiation out into space. Hence, nights warm faster than days. On a global scale, one cause might be increased cosmic radiation, the flux of which is the highest during solar minimum activity. Cosmic rays increase the ionization of air particles at high altitudes, which can contribute to increased cloudiness over the Earth, and clouds effectively decrease the quantity of heat emitted from the Earth (Svensmark and Friis-Christensen 1997).

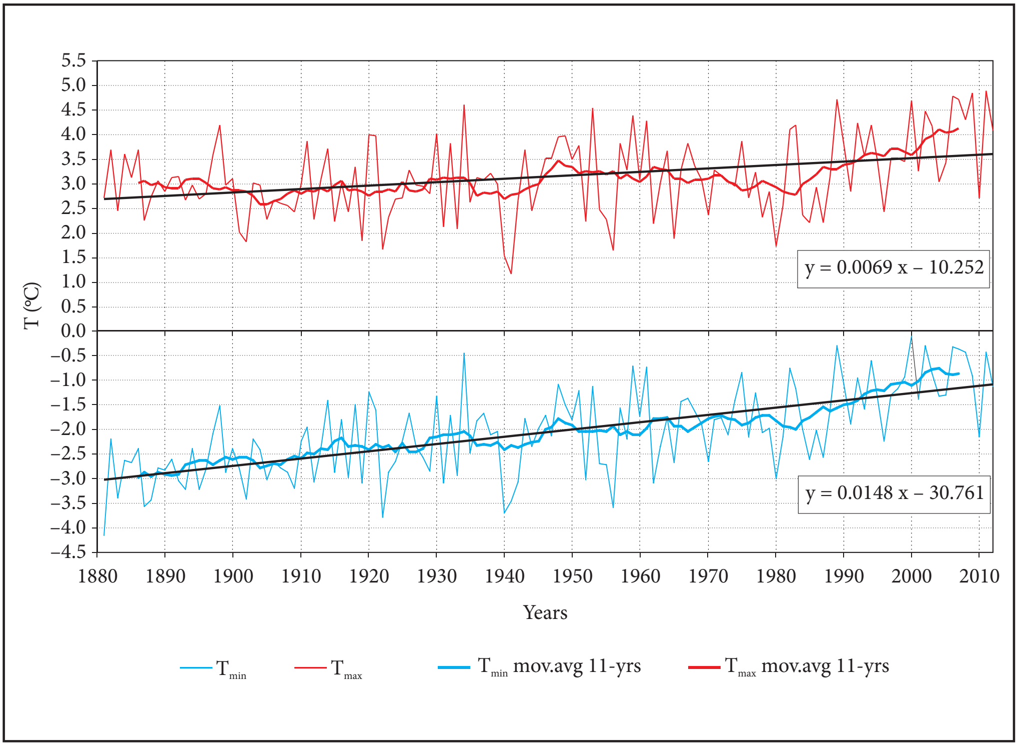

Figure 3: Changes in annual mean maximum values (T_{max}) and mean minimum values (T_{min}) of air temperature, trend line, and eleven-year mean consecutive values at Mount Śnieżka, 1881–2012.

Table 3: Mean air temperature trends at Mount Śnieżka (°C / 10 years), 1881–2012.

Period	T_{avg}	T_{max}	T_{min}
Year (Jan–Dec)	0.108	0.069	0.148
Warm season (May–Oct)	0.107	0.059	0.151
Cold season (Nov–Apr)	0.105	0.072	0.139
Winter (Dec–Feb)	0.086	0.064	0.114
Spring (Mar–May)	0.124	0.073	0.169
Summer (Jun–Aug)	0.114	0.057	0.167
Autumn (Sept–Nov)	0.106	0.070	0.138
January	0.099	0.078	0.121
February	0.076	0.043	0.109
March	0.121	0.076	0.165
April	0.149	0.104	0.194
May	0.102	0.058	0.147
June	0.099	0.044	0.154
July	0.081	0.026	0.136
August	0.162	0.113	0.210
September	0.052	0.007	0.097
October	0.146	0.128	0.164
November	0.120	0.087	0.154
December	0.090	0.061	0.119

Positive trends, with the exception of mid-annual values, are also noticeable for mean seasonal values and mean values of consecutive months (Table 3). Among the seasonal mean values, the highest increase rate occurs for spring, 0.124 °C / 10 years, and the lowest for winter, 0.086 °C / 10 years. The cold season (November–April) and the warm season (May–October) are characterized by an air temperature increase rate almost similar to the annual rate, approximately 0.11 °C / 10 years. A higher variability of temperature increase at Mount Śnieżka from 1881 to 2012 is noted for mean monthly values, from 0.052 °C / 10 years in September to 0.162 °C / 10 years in August. A high increase rate also characterizes April and October, at 0.149 °C / 10 years and 0.146 °C / 10 years, respectively (Table 3).

Since the 1970s, a systematic increase in ten-year air temperature averages from +0.5 °C to +1.5 °C has been seen (Table 4).

Table 4: Average air temperatures at Mount Śnieżka by decade, 1881–2010.

Decade	1881–90	1891–00	1901–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–70	1971–80	1981–90	1991–00	2001–10
T (°C)	0.0	0.3	–0.1	0.4	0.3	0.4	0.5	0.5	0.6	0.5	0.8	1.2	1.5

3.2 Solar activity and temperature changes

The impact of solar activity and cosmic radiation on the global climate is indisputable (Hoyt and Schatten 1997; Svensmark and Friis-Christensen 1997; Raspopov, Dergachev and Kolström 2004; Lockwood 2012; Harvey 2013). Over the past few centuries of observation, the number of sunspots has increased while the Earth has been warming. It can be concluded that solar activity affects the global climate, causing warming of the planet (Usoskin et al. 2005). This view is shared by Boryczka et al. (2012), who, based on the synchronicity of multiyear changes in air temperature in Warsaw and Wolf numbers, demonstrated that the Sun's activity is one of the principal causes of climate change.

However, in recent decades, air temperature has increased considerably, whereas solar activity has shown only small changes and, moreover, a downward trend (Lockwood 2008). Because total solar radiation, ultraviolet radiation, and cosmic ray flux have not shown any significant changing trend in the past thirty years, researchers have concluded that at least the last episode of warming must have a different cause (Usoskin et al. 2005). On the other hand, Scafetta and West (2006) postulate that global warming has been progressing at a much faster rate since 1975 than could be expected if the Sun were the sole cause.

Relating this point of view to the situation at Mount Śnieżka, it can be noted that the Wolf numbers have decreased whereas the annual mean air temperature has increased since approximately 1990 (Figures 4 and 5). The most noticeable air temperature increase at Mount Śnieżka was registered between 1989 and 2012 (Figures 3 and 5); it is also in this period that the highest annual mean air temperature in the multiyear period was noted, which was as high as 1.4 °C.

Nonetheless, it is difficult to see the relationship between the Wolf number and the annual mean air temperature based on the plot of interannual variation of those two values (Figures 4 and 5). The average duration of full solar magnetic activity cycle is twenty-two years – twice the length of the sunspot cycle. The analysis of the solar variation impact on changes in T_{avg} at Mount Śnieżka shows that T_{avg} is strongly correlated (the correlation coefficient is close to 1.0) with the mean Wolf number for twenty-two-year solar magnetic activity cycles until 1988. In the 1989–2012 cycle, T_{avg} increased considerably whereas the mean Wolf number dropped (Figure 6). It is concluded, then, that higher temperatures for the 1989–2012 cycle of solar magnetic variability may reveal a synergy of astrophysical effects, and atmospheric and oceanic circulation, modified by constantly increasing anthropogenic factors.

The synergy of factors (including solar activity) impacted the air temperature in Turkey from 1976 to 2006 (Kilcik et al. 2008). Lockwood and Fröhlich (2007) also point out the synergy of factors affecting the global air temperature increase and opposite trends in solar activity and air temperature in the last twenty years. Souza Echer et al. (2009) described similar results to those presented in this analysis, showing a high correlation between global anomalies in air temperatures and twenty-two-year solar magnetic cycles from 1880 to 2000.

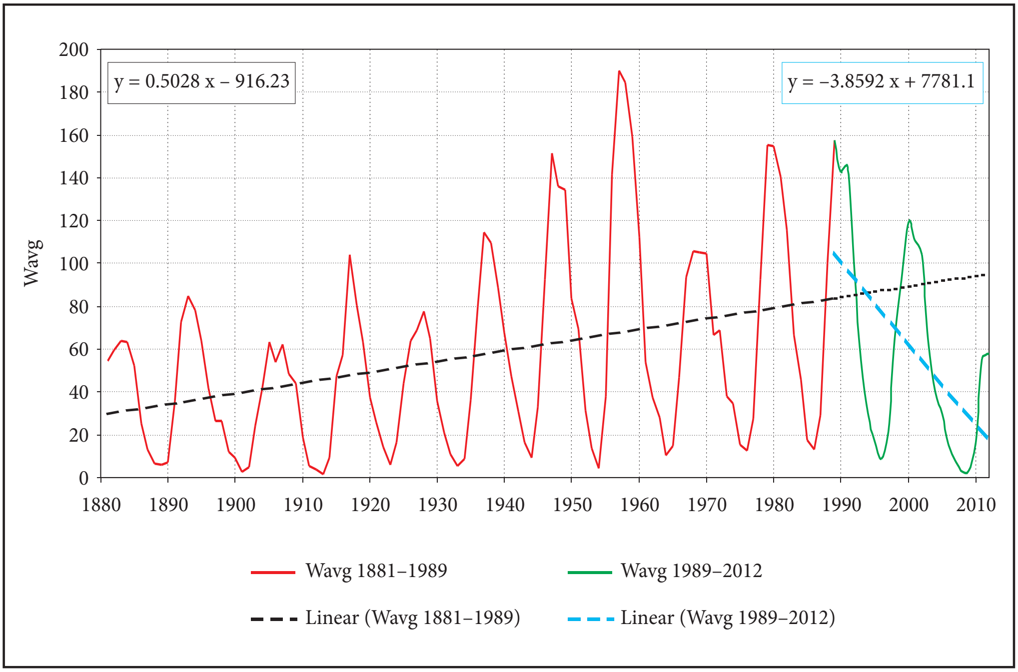

Figure 4: Plot of the mean Wolf number (Wavg), 1881–2012.

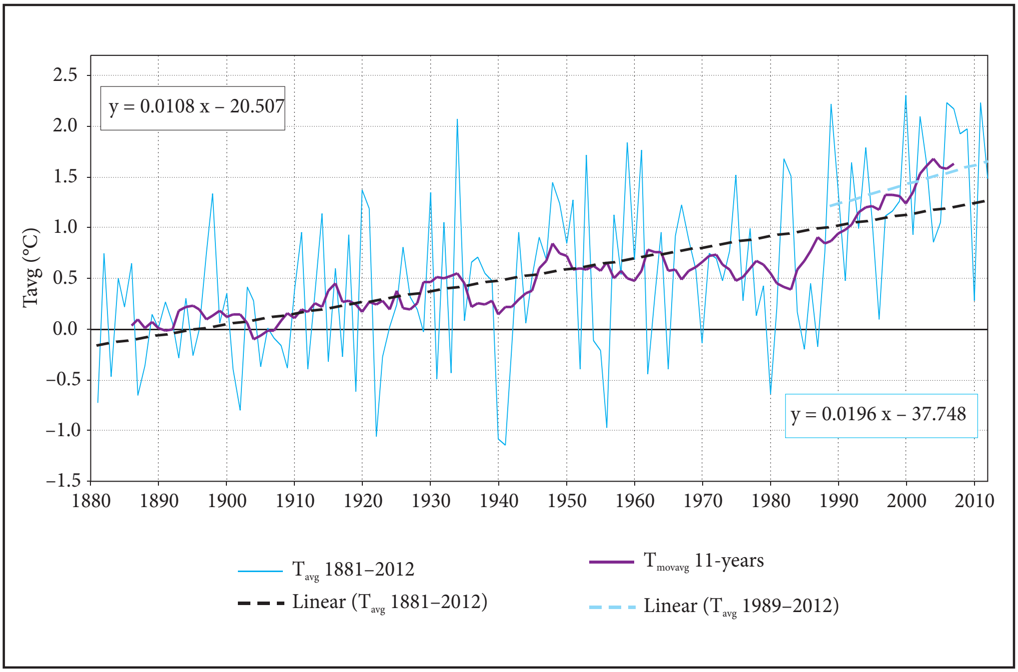

Figure 5: Annual mean air temperatures (T_{avg}) at Mount Śnieżka, 1881–2012. Note: the beginning of the second trend is 1989 because it is the beginning of the Sun's last magnetic cycle (see Figure 6). Moreover, a remarkably faster air temperature change has been noted since 1989.

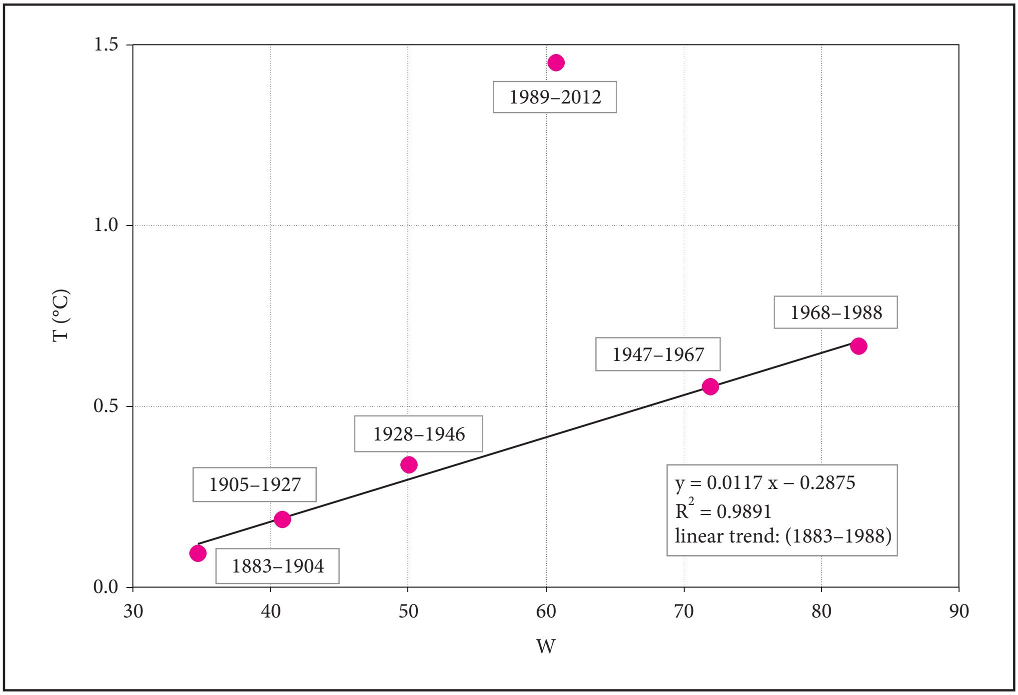

Figure 6: Mean air temperature (T) at Mount Śnieżka and the mean Wolf number (W) for the twenty-two-year solar magnetic activity cycle (1883–1988).

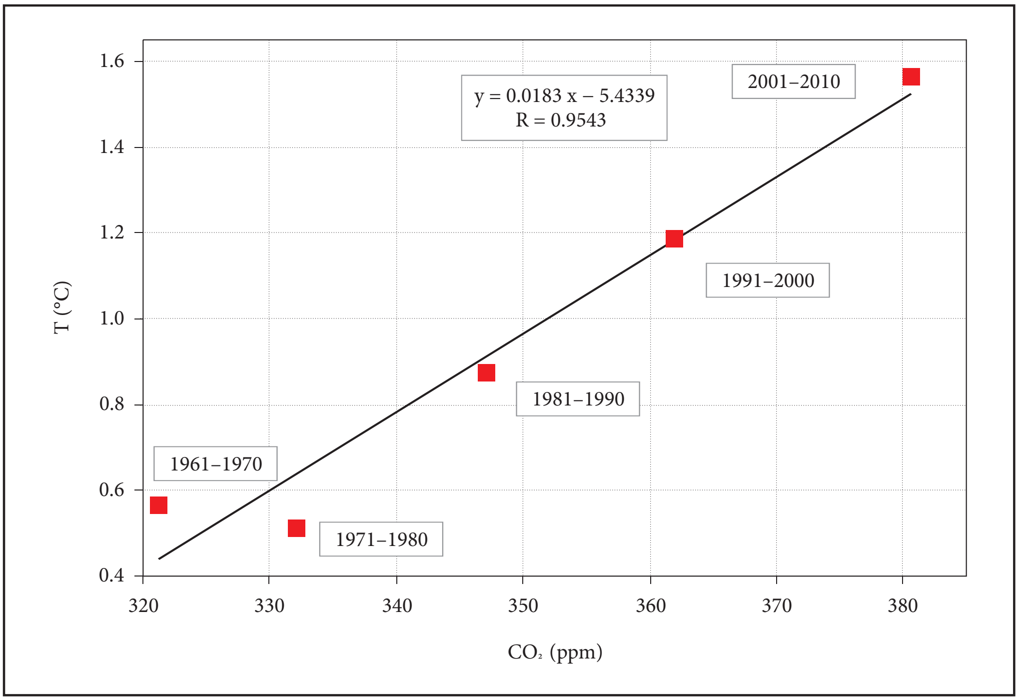

Figure 7: Relationship between ten-year average values of air temperature (T) at Mount Śnieżka and CO_2 concentration in the Earth's atmosphere, 1961–2010.

In this paper, the period between every second maximum of solar activity (eleven-year ones) was taken as a full magnetic cycle. This is due to the fact that magnetic cycle begins with the period of maximum solar activity during which the Sun's magnetic flip takes place and, after two eleven-year cycles (i. e., on average after twenty-two years), the polarity of the Sun returns to its former state (Internet 2).

In an attempt to explain the remarkably fast increase in air temperature at Mount Śnieżka despite decreased Wolf numbers from 1989 to 2012, the relationship between air temperature and CO_2 concentration in the atmosphere was analyzed. The analysis was based on CO_2 concentration in the atmosphere measurements conducted at the Mouna Loa Observatory in Hawaii since 1959. Data from Mouna Loa in Hawaii are considered to reflect global changes in CO_2 concentration in the Earth's atmosphere.

Analysis of ten-year averages indicates a strong relationship between the air temperature increase at Mount Śnieżka and the increase in CO_2 concentration. This relationship is the strongest in the last two to three decades (Figure 7).

4 Summary and conclusions

The analysis of measuring series of air temperature at Mount Śnieżka demonstrated that the relocation of measurement instruments in 1900 and 1976 did not affect the homogeneity of the data series tested (T_{avg}, T_{max}, T_{min}) and that the data can be used for climate change research. Moreover, it is one of the few continuous data series in Europe of such length and is a rich source of information on thermal conditions closely corresponding to those of the free atmosphere.

A characteristic feature of variability of annual mean extreme (T_{max}, T_{min}) and annual mean (T_{avg}) air temperature at Mount Śnieżka from 1881 to 2012 is its increasing trend.

The increase of T_{min} is twice as fast as the increase of T_{max}; that is, 0.148 °C / 10 years and 0.069 °C / 10 years, respectively. Consequently, a negative tendency for annual mean air temperature amplitude of –0.080 °C / 10 years is noticeable.

Analysis of the impact of solar activity on T_{avg} changes at Mount Śnieżka showed that T_{avg} is strongly correlated (a directly proportional linear relationship) with the mean Wolf number for twenty-two-year solar magnetic activity cycles up to 1988. However, in the case of the 1989–2012 cycle, a considerable difference can be noticed in comparison to previous cycles from 1883 to 1988. Although T_{avg} shows a high increase, the mean Wolf number has lower values. The higher temperatures during the 1989–2012 cycle of solar magnetic variability probably reveal a synergy of astrophysical effects and atmospheric and oceanic circulation modified by constantly intensifying anthropogenic factors. However, proving this hypothesis requires further research.

These conclusions are tentative because they are based on data from one station located in a medium latitude zone, where even a slight change in weather type distribution can result in changes in precipitation and temperature.

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THE SPATIAL DISTRIBUTION OF ROCK LANDFORMS IN THE POHOŘSKÁ MOUNTAINS (POHOŘSKÁ HORNATINA), CZECH REPUBLIC

Jiří Rypl, Karel Kirchner, Martin Blažek

View of the Pohořská Mountains from the Nové Hrady Foothills
(Novohradské podhůří)

The spatial distribution of rock landforms in the Pohořská Mountains (*Pohořská hornatina*), Czech Republic

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ABSTRACT: Geomorphological mapping with an emphasis on rock landforms was carried out in the Pohořská Mountains *Pohořská hornatina*) and the positional data acquired were further processed using statistical and cartographical methods. The spatial distribution of rock landforms was investigated in relation to lithology, slope, orientation, and elevation based on an analysis using ArcGIS 9.1. The spatial distribution of rock landforms was primarily determined by the index of distribution $Wij = Xi / Yj$, where Xi is the percentage representation of landforms in the appropriate category and Yj is the percentage quotient of this category in the entire area studied, and was secondarily determined according to the sum (sum distribution) of the arithmetic mean and the average deviation.

KEY WORDS: geomorphology, rock landforms, lithology, slope, orientation of relief, elevation, Pohořská Mountains (*Pohořská hornatina*), Czech Republic

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1 Introduction

The Pohořská Mountains geomorphological subunit, which is part of the Nové Hrady Mountains (*Novohradské hory*, Figure 1), is insufficiently geomorphologically explored due to its inaccessibility in the past. The border between the Czech Republic and Austria passes through the area studied. The area was part of the Iron Curtain during the Cold War, which means that it was virtually inaccessible. This area also deserves increased attention for other reasons in addition to its particular diversity of relief. The first reason is the progressive inclusion of Czech protected areas in the European Union's nature protection system. The unique landscape of the Nové Hrady Mountains with a variety of aesthetic and natural values is protected by national law no. 114/1992 as a natural park (Collection of… 1992). The second reason is anticipated interference in the environment related to carrying out many investment projects. For these reasons, this area has become the target of multilateral and vital research (e.g., Malíček and Palice 2013; Pavlíček 2004; Rypl 2010; Rypl, Kirchner and Dvořáčková 2014; Štykar 2005).

Geomorphological mapping with an emphasis on rock landforms was carried out in the Pohořská Mountains and the positional data acquired were further processed using statistical and cartographic methods.

Other authors have also dealt with the spatial distribution of rock landforms in other parts of the world. Hjort, Etzelmuller and Tolgensbakk 2010 defined the effects of scale and data source in periglacial distribution modeling in a high Arctic environment in western Svalbard, and Marmion et al. (2008) compared predictive methods for modeling the distribution of periglacial landforms in Finnish Lapland. Ridefelt, Etzelmuller and Boelhouwers (2010) dealt with spatial analysis of solifluction landforms and process rates in the Abisko Mountains in northern Sweden. Marvánek (2010) discussed the distribution of cryogenic periglacial landforms in the Krumgampen Valley (Ötztal Alps). Křížek (2007) and Křížek, Treml and Engel (2007) defined the spatial distribution of cryogenic landforms above the alpine timberline in the High Sudetes (*Vysoké Sudety*) and in the Giant Mountains (also known as the Krkonoše Mountains). The references described were used from the viewpoint of methodological approach and to evaluate the spatial distribution of the research data obtained for comparison with other areas.

This paper discusses the distribution of geomorphological landforms in the area studied and its dependencies on the characteristics of relief and subsoil geology. The results obtained can be compared with similar areas that developed on granite rocky relief (Migoń 2004b) and can help in the study of complex solutions to problems in the structural control of evolution in granite landforms.

2 Study area

Late Variscan migmatites of the Central Moldanubian Pluton prevail in the area (represented by several types: Weinsberg granite, Freistadt granodiorite, and Mrákotín granite), being partially overlaid by cordierite gneisses and migmatites representing remnants of the pluton's mantle (Pavlíček 2004).

The prevailing relief of the Pohořská Mountains has characteristic elements of a fault-block mountain range with delimitations strongly marked by erosion, and it is also polygenetic. Here is possible to find recent forms (rounded blocks of various sizes, alcoves, and grooves) and also fossil forms that are conserved in granite rock, such as exfoliation joints, tors, and frost-riven cliffs (Demek 1964).

Tables 1 through 4 show the percentage quotient in relation to all mapped categories of relief (lithology, slope, slope orientation, and elevation) in the Pohořská Mountains.

Table 1: Percentage quotient representation of lithology.

Lithology	Granite	Gneiss and migmatite	Sediments	Residue
Percentage quotient	56.84	30.61	11.52	1.03

Table 2: Percentage quotient representation of slope.

Slope	0–2°	2.1–5°	5.1–10°	10.1–20°	above 20.1°
Percentage quotient	9.77	19.73	48.28	20.71	1.51

Table 3: Percentage quotient representation of slope orientation.

Slope orientation	N	NE	E	SE	S	SW	W	NW	Plain
Percentage quotient	14.54	15.01	9.67	5.47	7.15	12.44	14.14	13.07	8.51

Table 4: Percentage quotient representation of elevation.

Elevation (m)	560–600	601–700	701–800	801–900	901–1,000	1,001–1,072
Percentage quotient	0.87	14.82	36.85	31.98	14.57	0.91

There are also granite areas with spectacular landforms in the Czech Republic. The Jizera Mountains (*Jizerské hory*, Figure 1) are among granite areas with extensive protection as a protected landscape area. The Giant Mountains and the Podyjí area (Figure 1) are also among granite areas with extensive protection as national parks. Although the Nové Hrady Mountains are an area with well-preserved spectacular granite landforms in the Czech Republic, there is no appropriate protection of the Nové Hrady Mountains today.

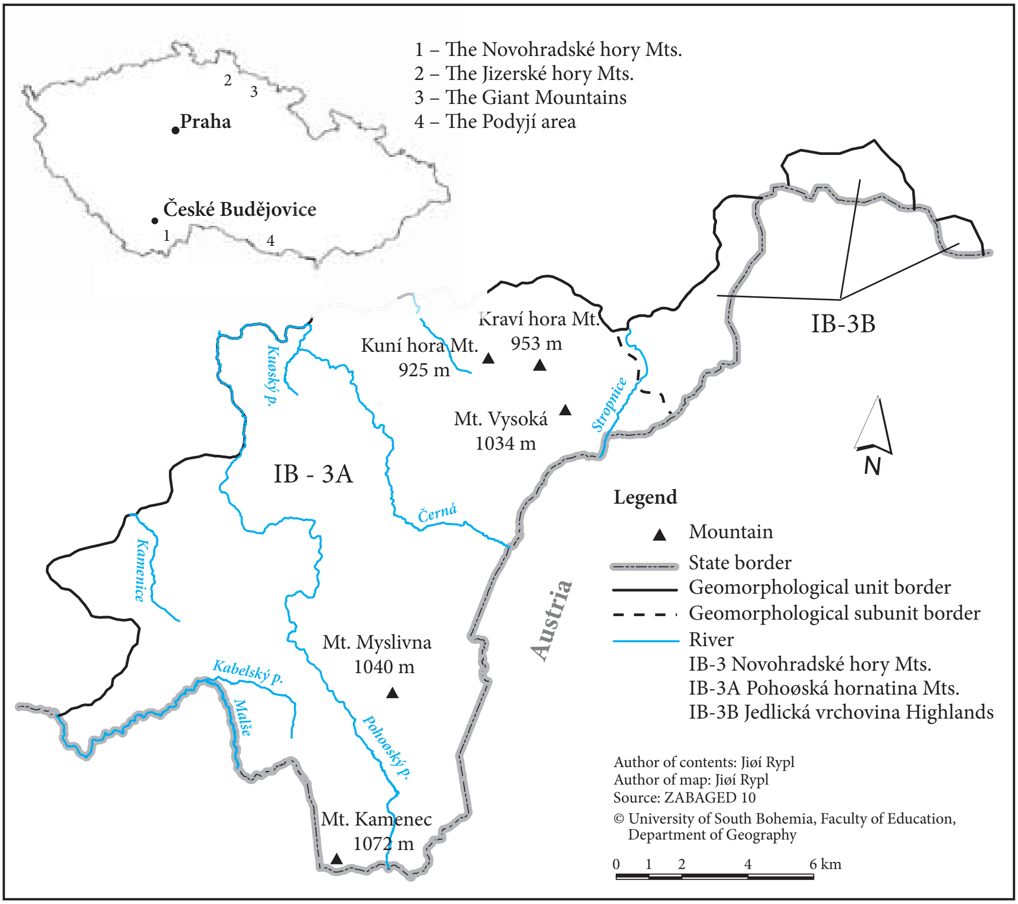

Figure 1: Location of the Nové Hrady Mountains, the Jizera Mountains, the Giant Mountains, and the Podyjí area in the Czech Republic and the basic geomorphological regionalization of the Nové Hrady Mountains.

3 Methods

Investigation of the spatial distribution of rock landforms in relation to geomorphological characteristics (lithology, slope inclination, orientation of slope, and elevation) may be based on division of the territory into discrete areas (e.g., squares). Dependence in the discrete area is examined using multiple statistical methods (e.g., CART, or classification and regression trees; Breiman et al. 1984) or generalized linear models such as GLM (Nelder and Wedderburn 1972). This article used another methodological approach, in which the study area is divided into categories according to its geomorphological characteristics and links to them are investigated. This method was successfully tested earlier in a similar Bohemian mountain range of the Giant Mountains (Křížek, Treml and Engel 2007).

Geomorphological mapping and GPS mapping were carried out in the Pohořská Mountains following the methodology described by Condorachi (2011), Smith, Paron and Griffiths (2011), and Voženílek et al. (2001). Mapping focused on rock relief landforms, and spatial data concerning their localization were acquired during the mapping. These spatial data were then processed using ArcGIS 9.1. Every geolocated landform was overlaid with a digital elevation model of the area studied and every feature was associated with data concerning lithology, slope, slope orientation, and elevation. Spatial statistics were calculated and it was possible to obtain the spatial distribution of rock landforms in all these categories. The spatial distribution of rock landforms was detected using the index of distribution *Wij = Xi / Yj*, where *Xi* is the percentage representation of the landform in the relevant category of the characteristic studied (e.g., in the case of slope characteristic, five categories of slopes were studied: 0–2.0°, 2.1–5.0°, 5.1–10.0°, 10.1–20.0°, and > 20.1°). *Yj* is the percentage quotient of this category on the surface of the entire area studied; this means that the percentage of surface was calculated where the relevant category of slope was identified. The example of tors is explicit: 52.5% of tors were found on slopes between 0° and 2°, and this category of slope is located on 9.7% of the area studied. The index of distribution *Wij* of tors was calculated as 52.49 / 9.79, which yields *Wij* =5.41. The index of distribution was calibrated using the sum (distribution sum) of arithmetic mean and average deviation:

$$\frac{1}{n}\sum_{i=1}^{n}\left|W_{ij}-\bar{W}_{ij}\right|$$

The distribution sum was calculated using the indices of the spatial distribution *Wij* of all rated landforms in the appropriate category of the characteristic investigated (e.g., slope 0–2° in the case of slope characteristic), its arithmetic mean, and its average deviation. From these indicators it is possible to obtain the formula:

$$Sumj=\bar{W}_{ij}+\frac{1}{n}\sum_{i=1}^{n}\left|W_{ij}-\bar{W}_{ij}\right|$$

where *n* represents the number of all landforms rated (the sum of tors, frost-riven cliffs, castle koppies, and blockfields). If the index of distribution *Wij* is equal to 1, the percentage representation of the landform in the category is equal to the proportional surface of this category in the total area studied. If the value of *Wij* is above 1, the landform has more significant representation in the relevant category. This means that the presence of this rock landform is related to the relevant category of the observed characteristic. If the value *Wij* is below 1, the occurrence of the landform in question is less significant in the relevant category and there is no clear dependence of landform localization with the relevant category. Landforms were estimated as dependent landforms based on two statistical conditions. First, the index of distribution *Wij* must be greater than 1. Second, the index of distribution must be greater than the sum of the arithmetic mean and average deviation in the category of the characteristic studied (Křížek, Treml and Engel 2007; Křížek 2007).

4 Results

Thirty-four tors were mapped in the Pohořská Mountains (see Figure 2), as well as 153 frost-riven cliffs (see Figure 3), thirty-six castle koppies, ninety-nine areas of blockfields, and a significant number of cryoplanation surfaces and terraces. This landforms are defined in global research as cryogenic landforms (Traczyk and Migoń 2000). According to Demek et al. (2006), the territory of what is now the Czech Republic was located not far from the frontal part of a continental glacier in Pleistocene sequence, where the climate

Figure 2: Tor on Mount Kamenec.

Figure 3: Frost-riven cliff on Mount Kuní.

was cold and cryogenic processes took place. This geomorphological processes formed cryoplanation terraces with frost-riven cliffs, tors, castle koppies, and blockfields (Demek et al. 2006). These landforms also developed in the Pohořská Mountains. They stand next to the Bohemian Forest (*Šumava*), a mountain range covered by an alpine glacier in the late Pleistocene sequence (Demek et al. 2006). Tors and castle koppies were formed during the same process (Migoń 2006) and they are mainly distinguished by their shape and proportions. Landforms with height greater than length were mapped as tors, and landforms with length greater than height were defined as castle koppies.

The cryoplanation terraces in the study area were not included in the analysis due to the scale of the maps used (1:25,000; the maps used covered the entire study area) and due to the size of cryoplanation terraces, which was smaller than other rock landforms. The thickness of the regolith was not considered in the research because the regolith was removed by etching during Saxon tectogenesis and a planation surface with a stripped etchplain was created (Migoń 2004a; Demek et al. 2006). The study area is practically without regolith originating from chemical weathering in the Paleogene. The percentage occurrence of cryogenic landforms in relation to various categories of relief is shown in Figures 4 through 7. The index of distribution, the arithmetic mean, the average deviation, and the distribution sum are shown in Tables 5 through 8.

Table 5: Index of distribution, arithmetic mean, average deviation, and distribution sum in relation to lithology.

Lithology	Tors	Frost-riven cliffs	Castle koppies	Blockfields	Arithmetic mean	Average deviation	Distribution sum
Granite	1.71	1.53	1.71	1.51	1.62	0.09	1.71
Gneiss	0.10	0.13	0.00	0.33	0.14	0.06	0.20

Table 6: Index of distribution, arithmetic mean, average deviation, and distribution sum in relation to slope.

Slope	Tors	Frost-riven cliffs	Castle koppies	Blockfields	Arithmetic mean	Average deviation	Distribution sum
0.0–2.0°	5.41	0.40	2.27	0.10	2.05	1.80	3.85
2.1–5.0°	0.15	0.17	0.42	0.05	0.20	0.11	0.31
5.1–10.0°	0.24	0.39	0.23	0.75	0.40	0.17	0.57
10.1–20.0°	1.28	2.68	1.60	2.15	1.93	0.49	2.42
> 20.1°	3.89	12.11	16.56	11.30	10.97	3.54	14.51

Table 7: Index of distribution, arithmetic mean, average deviation, and distribution sum in relation to slope orientation.

Slope orientation	Tors	Frost-riven cliffs	Castle koppies	Blockfields	Arithmetic mean	Average deviation	Distribution sum
N	0.20	0.90	1.15	0.76	0.75	0.28	1.03
NE	0.19	0.70	0.74	0.81	0.61	0.21	0.82
E	1.22	0.42	0.86	1.15	0.91	0.27	1.18
SE	1.61	2.27	1.52	1.48	1.72	0.27	1.99
S	0.00	2.10	0.39	1.70	1.05	0.85	1.90
SW	0.95	0.95	0.89	1.62	1.11	0.26	1.37
W	0.00	1.20	0.98	0.93	0.78	0.39	1.17
NW	0.67	0.75	0.43	0.85	0.68	0.13	0.81
plain	6.22	0.38	2.61	0.19	2.35	2.07	4.42

Table 8: Index of distribution, arithmetic mean, average deviation, and distribution sum in relation to elevation.

Elevation (m)	Tors	Frost- riven cliffs	Castle koppies	Blockfields	Arithmetic mean	Average deviation	Distribution sum
560–600	0.00	0.00	0.00	0.00	0.00	0.00	0.00
601–700	0.00	0.04	0.00	0.20	0.06	0.04	0.10
701–800	0.16	0.50	0.15	0.90	0.43	0.27	0.70
801–900	1.11	0.94	0.96	1.45	1.12	0.17	1.29
901–1,000	2.42	2.74	3.24	1.04	2.35	0.67	3.02
above 1,001	25.86	12.21	18.31	2.21	12.76	7.44	20.20

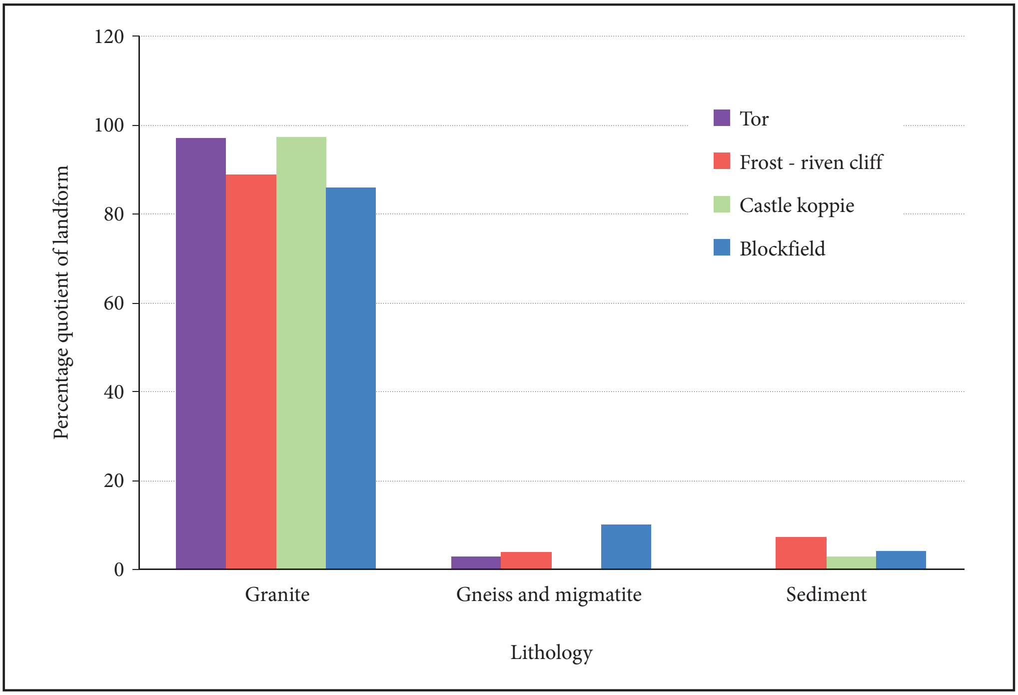

Figure 4: Occurrence of rock landforms in relation to lithology.

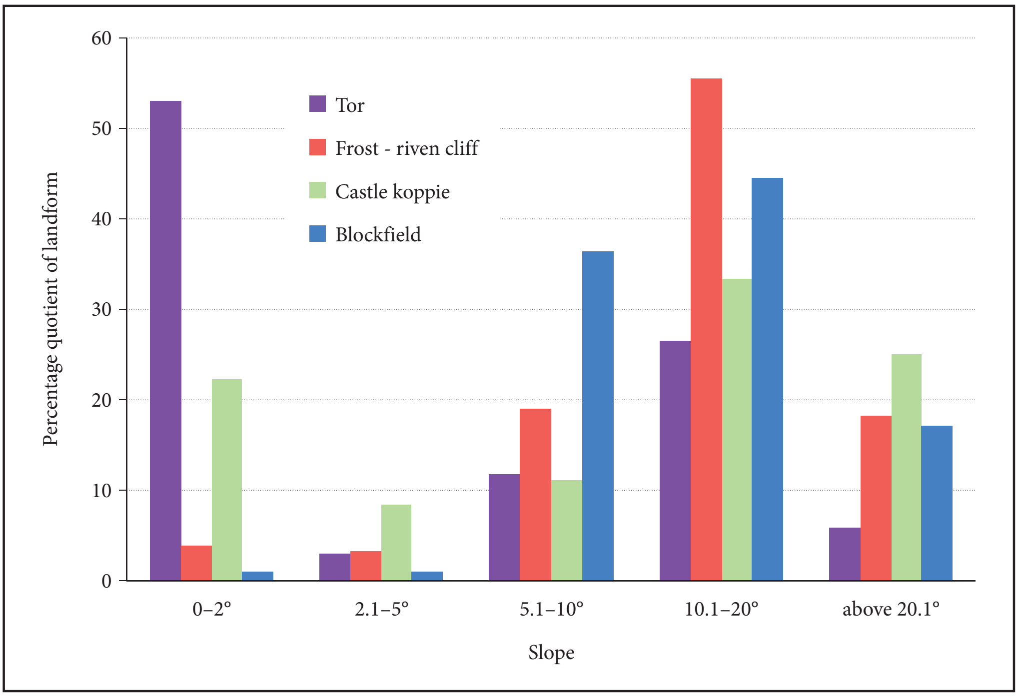

Figure 5: Occurrence of rock landforms in relation to slope.

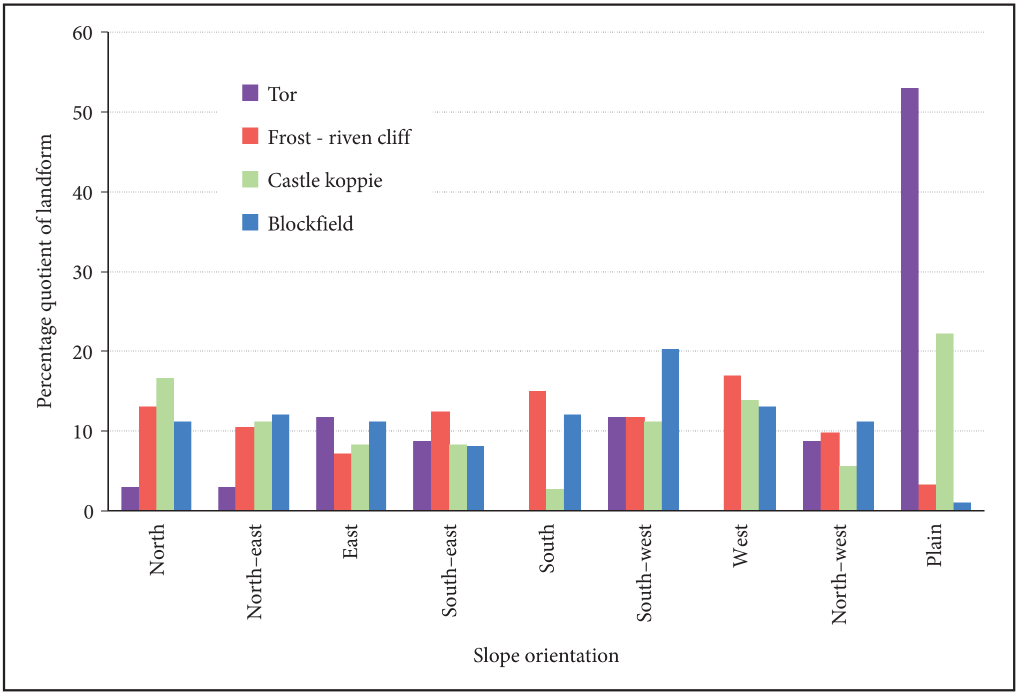

Figure 6: Occurrence of rock landforms in relation to slope orientation.

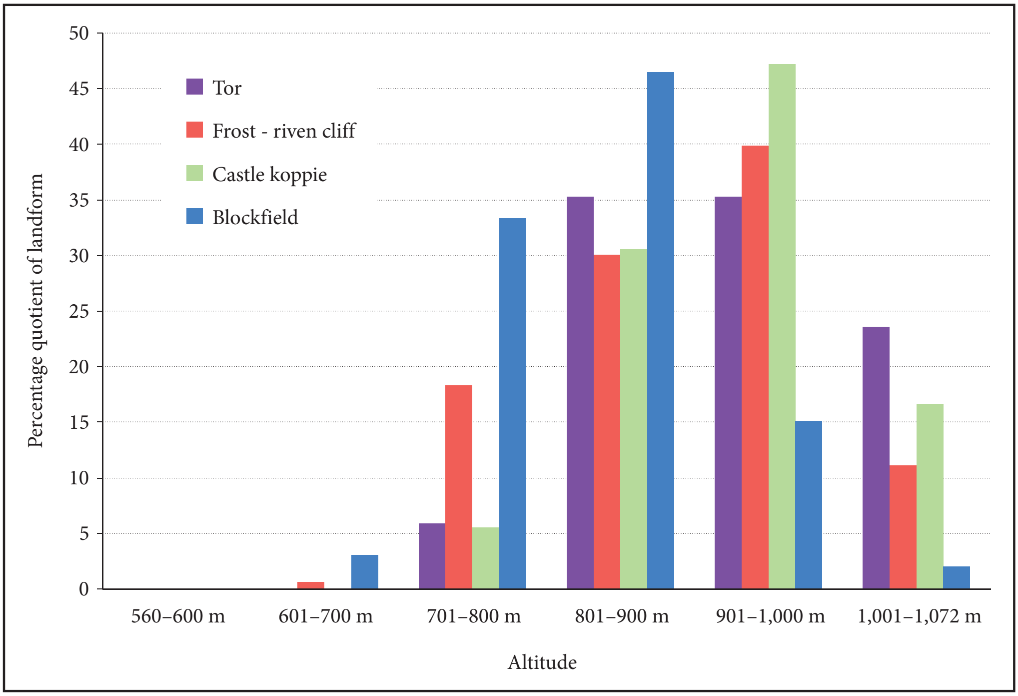

Figure 7: Occurrence of rock landforms in relation to elevation.

5 Discussion and conclusion

The determination of regularities in the spatial distribution of rock landforms is based on a comparison of the indices of distribution and arithmetic averages, or corresponding distribution sums. Each value of the index of distribution that is greater than the corresponding arithmetic mean of all the indices of distribution of the category shows that the occurrence of the specific type of rock landform is above average with regard to the mean. The data in Tables 5 through 8 show that the criterion related to the distribution sum is more stringent. This is because the criterion corresponds to only some values of the distribution indices that belong to the set of values greater than the arithmetic mean of the corresponding indices.

The elimination of a number of values is caused by calculating the variability of all rock landforms in the category, which also involves the error of minimalization potentially caused by variance in irregularly distributed values (Křížek, Treml and Engel 2007; Křížek 2007).

The spatial analysis of cryogenic landforms shows that all rock landforms are related to the presence of granite in all cases in which $Wij > 1$ (Table 5). The analysis did not prove dependence on another type of rock from the area studied. The dependence of cryogenic landforms on granite results from its easier conservation as solid rock (French 2007; Migoń 2006; Summerfield 1991) and was also studied in the Giant Mountains (Křížek, Treml and Engel 2007).

With regard to slope (Table 6), the dependence between tors and a slope of 0 to 2° was confirmed. This dependence is primarily based on the genesis of these cryogenic landforms (French 2007; Migoń 2006; Summerfield 1991). An above-average occurrence on slopes with an inclination of 0 to 2° was also discovered for castle koppies. The dependence of castle koppies and relief with a slope greater than 20.1° is interesting. This dependence is mainly explained by the low percentage quotient of occurrence of this landform in the area studied. The dependence of occurrence of frost-riven cliffs was proved for relief with a slope of 10.1 to 20° and an above-average occurrence of such cliffs was identified for relief with a slope of 20.1° and greater. This dependence and the above-average occurrence can be explained by the genesis of these cryogenic landforms (French 2007; Migoń 2006; Summerfield 1991). In the case of blockfields, no dependence was found, but only an above-average occurrence for two slope categories: 10.1–20° and > 20.1°. It is not possible to compare the dependence and above-average occurrence of landforms with the results of this relief category in the Giant Mountains because Křížek, Treml and Engel (2007) specified different slope categories in their work.

With regard to slope orientation (Table 7), the dependence of tors and the above-average occurrence of castle koppies on plains was confirmed. This dependence and above-average occurrence is connected to the genesis of cryogenic landforms (French 2007; Migoń 2006; Summerfield 1991). The dependence of tors extends to the eastern slope orientation, and the dependence of castle koppies to the northern slope orientation. Frost-riven cliffs are mainly distributed on slopes with a warm exposure (W, S, SE) owing to the intensive dynamics of cryogenic processes (Czudek 2005). This is why the blockfields also depend on slopes with a warm exposure, especially on slopes with a south (S) and southwest (SW) aspect. In this case, it is also difficult to compare the dependency and above-average occurrence of landforms with the results of this relief category in the Giant Mountains because Křížek, Treml and Engel (2007) specify four principal orientations in their work (N, E, S, W).

Above-average occurrences (Table 8) of destructive landforms (tors, frost riven cliffs, and castle koppies) were found at elevations above 901 m (climate conditions at this elevation are favorable for the significant expansion of tors; this is cold climatic zone CH7, based on Quitt 1971). Dependences and above-average occurrences of accumulation landforms (blockfields) were found at elevations between 801 and 900 meters (Table 8). Dependences and above-average occurrences with relation to elevations are a result of the genesis of these cryogenic landforms (French 2007; Migoń 2006; Summerfield 1991). In the Giant Mountains dependences and above-average occurrences of destructive cryogenic landforms depend on higher elevations (1,400–1,500 m), whereas in the case of accumulation landforms this dependence was found for relatively lower elevations (1,100–1,300 m; Křížek, Treml and Engel 2007).

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THE EFFECT OF NATURAL AND HUMAN-INDUCED HABITAT CONDITIONS ON NUMBER OF ROE DEER: CASE STUDY OF VOJVODINA, SERBIA

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Roe deer in natural habitat.

The effect of natural and human-induced habitat conditions on number of roe deer: case study of Vojvodina, Serbia

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ABSTRACT: Roe deer (*Capreolus capreolus L.*) have greatly expanded in both distribution and abundance during the last few decades, and are the most abundant cervids in Europe today. The aim of this paper is to determine the factors that have the most considerable impact on roe deer numbers in the Vojvodina region (North Serbia). Environmental (area in ha, total area of forest and total area of meadows and pastures in hunting ground) and anthropogenic (number of registered hunters, number of hunting sections, number of gamekeepers and roads in km on 1,000 ha) factors had been shown to influence the number of roe deer in Vojvodina region. A multiple regression analysis was carried out as the main statistical approach. The mapping of certain parameters was done using ArcGIS 9.2 software in order to establish the relation between the roe deer population and the different environmental and anthropogenic conditions. The results signify that the roe deer number dependency in the Vojvodina region is a very complex and multi-factorial phenomenon, strongly influenced by human induced modifications.

KEY WORDS: geography, environmental protection, roe deer number, habitat, hunting, regression model, GIS, Vojvodina, Serbia

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1 Introduction

During the last few decades, roe deer (*Capreolus capreolus L.*) have greatly expanded in both distribution and abundance, and today they are the most abundant cervids in Europe (Andersen, Duncan and Linnel 1998; Mysterud and Østbye 2004; Apollonio, Andersen and Putman 2010; Torres et al. 2011) as well as the most extensively studied ungulates (Andersen, Duncan and Linnell 1998).

Although generally considered as a typical forest specie, recent studies proved roe deer's ability to inhabit physically diverse areas and could be found in almost all European landscapes (Hewison et al. 2001; Jepsen and Topping 2004, Torres et al. 2011).

The Vojvodina region (North Serbia) is characterised by vast areas of steppe, wetlands, ponds and forests, which are favourable habi-tats for numerous and diverse game species (Ristić, Marković and Dević 2009). The number of roe deer within the investigated area varies among hunting associations. According to the data from 2000, the average number of roe deer in Vojvodina is 17.6 heads on 1,000 ha. The long-term hunting development plan 2001–2010 (Hunting association … 2000), predicted a 49.03% rise in the number of roe deer, which should bring the number of roe deer to 26.2 heads on 1,000 ha in 2010. The data from 2010 are not currently available, but according to the last available data, from 2009, the number has raised to 25.4 heads on 1,000 ha. The aim of this paper is to determine the factors with the most considerable impact on the number of roe deer in the investigated area. Although this species' habitat is widely influenced by a range of biogeographical factors operating at different scales (Torres et al. 2011), recent researches have determined that available food (Virgós and Telléria 1998) and land cover (Mysterud and Østbye 1999; Borkowski 2004; Borkowski and Ukalska 2008; Melis et al. 2009) are two essential factors. These factors play a critical part in shaping this species' habitat selection, which in turn affects the number of roe deer. However, Torres et al. (2011) consider several other factors that could also affect its population, including human interference and disturbance (Aragón, Braza and San José 1995; Hewison et al. 2001), topography (Mysterud and Østbye 1999), and climatic factors (Brewka and Kossak 1994). This research combines quantitative data on certain factors suggested to have the biggest impact on roe deer habitat suitability in order to determine the most influential ones. Environmental (area in ha, total area of forest and total area of meadows and pastures in hunting ground) and anthropogenic (number of registered hunters, number of hunting sections, number of gamekeepers and roads in km on 1,000 ha) factors influence the number of roe deer in Vojvodina region.

2 Materials and methods

2.1 Method

2.1.1 Sample

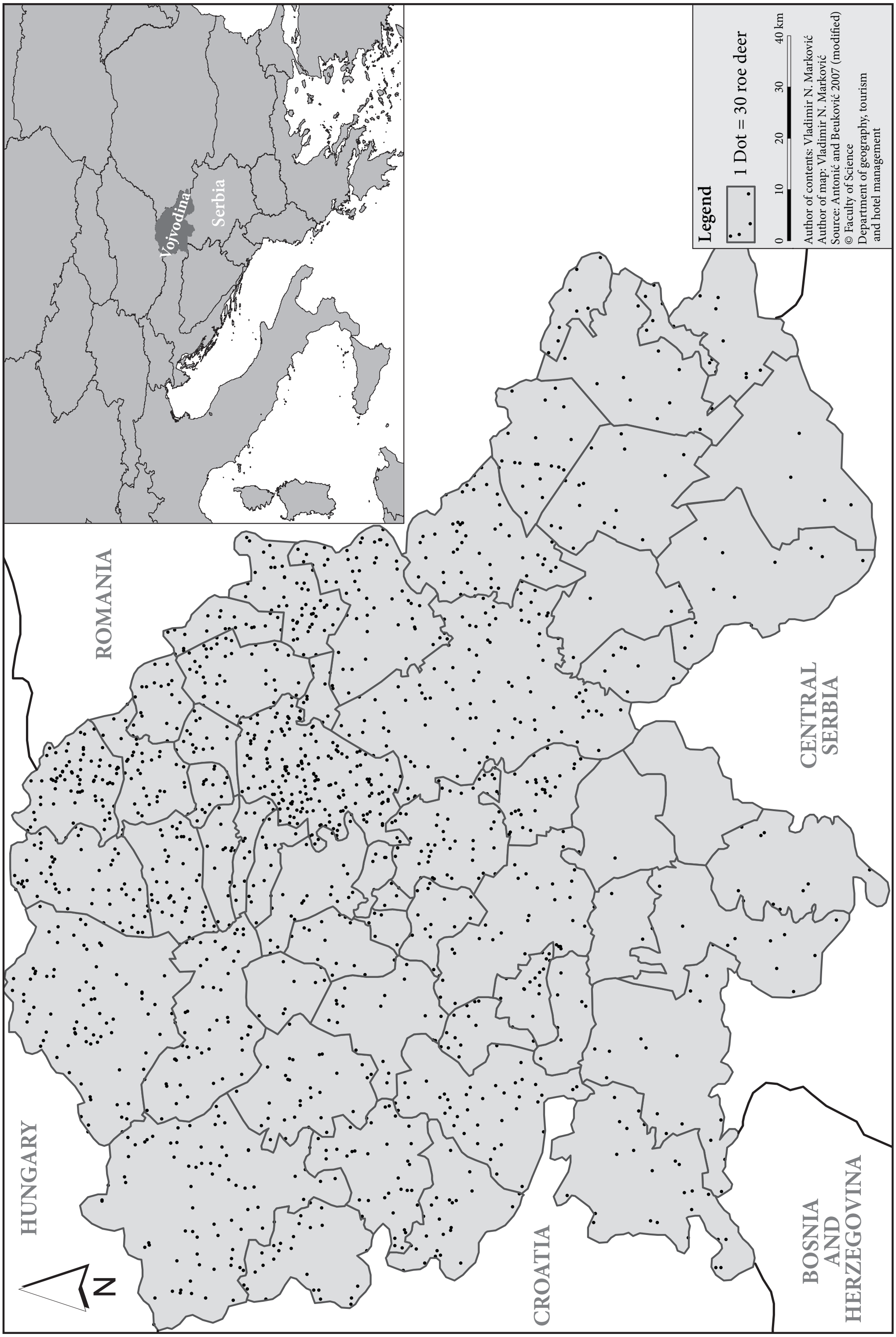
The study area includes 57 hunting grounds (Figure 1) that correspond with the municipality areas – except for the Kikinda, Vršac, Srbobran and Ada municipalities with more than one hunting ground on their area. The hunting grounds are unfenced and managed by the Provincial Secretariat for Agriculture, Forestry and Water Management. The game on these hunting grounds is self-reliant and only influenced by human induced environmental improvements. The following hunting grounds were excluded from the study because they are fenced off and supports different habitat conditions: The hunting grounds of National Park »Fruška gora«; hunting grounds in possession of military of Serbia; Public Company »Vojvodina šume«; and hunting grounds owned by agricultural and fish ponds companies.

2.1.2 Hypotheses

The following hypotheses were postulated:

1) The number of roe deer is influenced by natural factors: Total area of hunting ground in hectares; total area of forest on hunting ground in hectares; and total area of meadows and pastures on hunting ground in hectares.

Figure 1: The map of roe deer dissemination in the Vojvodina region (Antonić and Beuković 2007; modified). ►



Legend
1 Dot = 30 roe deer
0 10 20 30 40 km
Author of contents: Vladimir N. Marković
Author of map: Vladimir N. Marković
Source: Antonić and Beuković 2007 (modified)
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All above listed natural factors positively influence the number of roe deer. Numerous researches (e.g. Mysterud, Lian and Hermann 1999); Bokalo 2001; Partl 2001; Partl 2002; Borkowski 2004; Hemani, Watkinson and Dolman 2005; Toïgo et al. 2008; Popović et al. 2009; Reimosera et al. 2009) support this claim.

2) The number of roe deer is influenced by human induced factors: Number of registered hunters; number of hunting sections; number of gamekeepers; and roads in km on 1,000 ha of hunting ground.

The number of registered hunters, number of hunting sections, number of residents in the municipality and roads in km on 1,000 ha of hunting ground have a negative influence on the number of roe deer. The number of gamekeepers correlates positively with the number of roe deer. Many researchers have examined these factors and their impact on the number of game (e.g. Stedman et al. 2004; Blumstein et al. 2005; Borkowski and Ukalska 2008; Jayakody et al. 2008; Stankowich 2008; Torres et al. 2011).

2.1.3 Procedure

This study used data on the condition and number of game (including roe deer) obtained from the laboratory of Hunting Association of Vojvodina. Beside the number of game, the data also include: vegetation structure variability; infrastructure changes; various demographic data (hunters' number, age, gender); and other variables that could influence the game habitat and number. In order to establish the relation between roe deer population and different environmental and anthropogenic conditions, mapping of certain parameters was done using ArcGIS 9.2 software.

2.1.4 Statistical approach

A multiple regression analysis was carried out using SPSS 17 software for statistical computing. Before the analysis, three hunting grounds were excluded because their number of roe deer was either too small or two large in comparison with the other hunting grounds (± 2 standard deviations). A log-transformation of the dependent variable number of roe deer was performed in order to normalise its distribution. Predictor variables were: Total area of hunting ground in hectares; number of registered hunters; number of hunting sections; number of gamekeepers; total area of forest on hunting ground in hectares; total area of meadows and pastures on hunting ground in hectares; and roads in km on 1,000 ha of hunting ground. The criterion variable was the log-transformed number of roe deer.

3 Results

The results of the above mentioned multiple regression analysis are shown in table 1. The analysis of the results shows that the overall regression model is significant ($r = 0.648$; $r2 = 0.420$; $F(6.47) = 4.071$; $p < 0.01$). Only the *area in ha, number of registered hunters* and *number of hunting sections* show a statistically significant influence. The area of the hunting ground and number of registered hunters has a significant *positive* impact on the number of roe deer. However, the number of hunting sections has a significant *negative* impact on the number of roe deer. No effect of a multicollinearity problem is detected in the model as all the VIF scores are smaller than 10 and Tolerance values are larger than 0.1 (Figure 2).

4 Discussion

The results show that a larger surface area has a larger number of roe deer (Table 1). The smaller the area, the more negatively it affects game habitat in terms of seasonality, lack of shelters, and uniformed food supplies – all of which contribute to the decrease in the number of roe deer. According to Law on Game and Hunting (Zakon o divljači i lovstvu 2010), a minimum of 20% of each hunting ground must be protected as reserves, where all human activities related to hunting and animal disturbance are prohibited. This ensures safer reproducing conditions and protection of the roe deer offspring. Larger hunting ground (HG) will evidently have larger reserves. Commonly, each of the hunting grounds in the Vojvodina region is within only one municipality and is managed by its hunting association (Figure 3).

As there is no universal management model, each hunting ground operates independently, resulting in temporal and spatial discordance. Hunters' ethical behaviour is under question because there is no integral and internal control – it varies between sections and could lead to increased poaching and illegal hunting. This has all been proven in the regression model (Table 1).

Table 1: The regression model of certain factors influencing the number of roe deer of the investigated area.

	β (weight)	t-test	p (significance)	Tolerance	VIF
Total hunting ground area in ha	0.488	2.498	0.02	0.337	2.96
Number of registered hunters without hunter-tourists	0.543	2.778	0.01	0.337	2.97
Number of semi-independent hunting clubs within the hunting associations	-0.524	-2.46	0.02	0.284	3.52
Number of gamekeepers without volunteers	0.05	0.299	0.77	0.466	2.15
roads in km on 1,000 ha of hunting ground	-0.018	-0.13	0.9	0.665	1.5
total area of meadows and pastures on hunting ground in hectares	0.135	1.117	0.27	0.884	1.13
total area of forest on the hunting ground in hectares	-0.04	-0.3	0.77	0.712	1.4

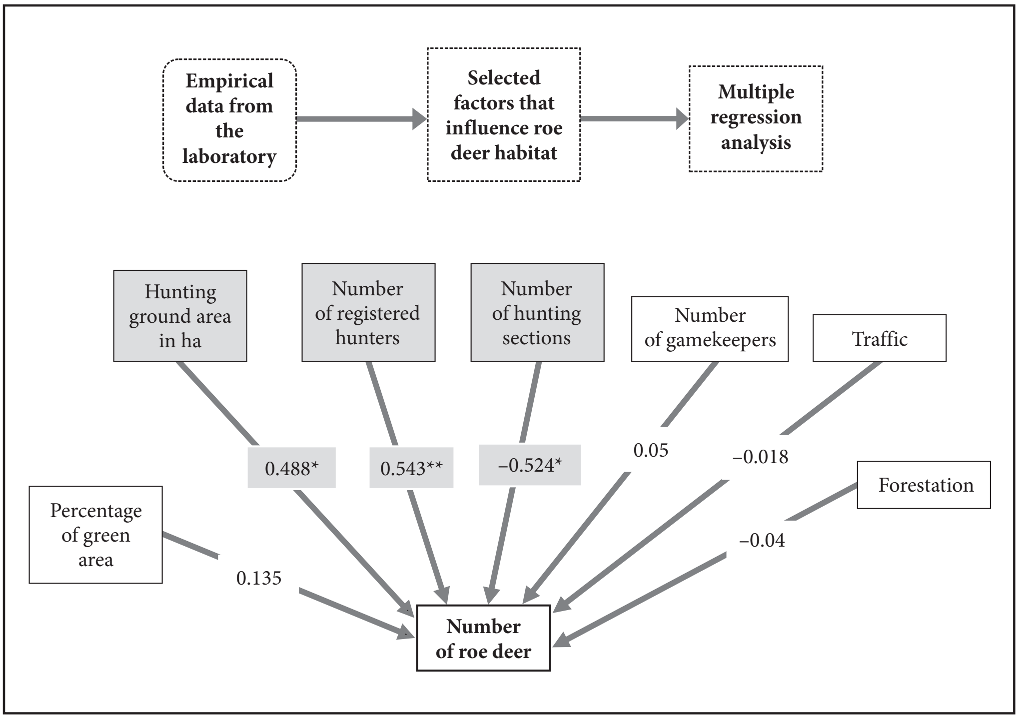
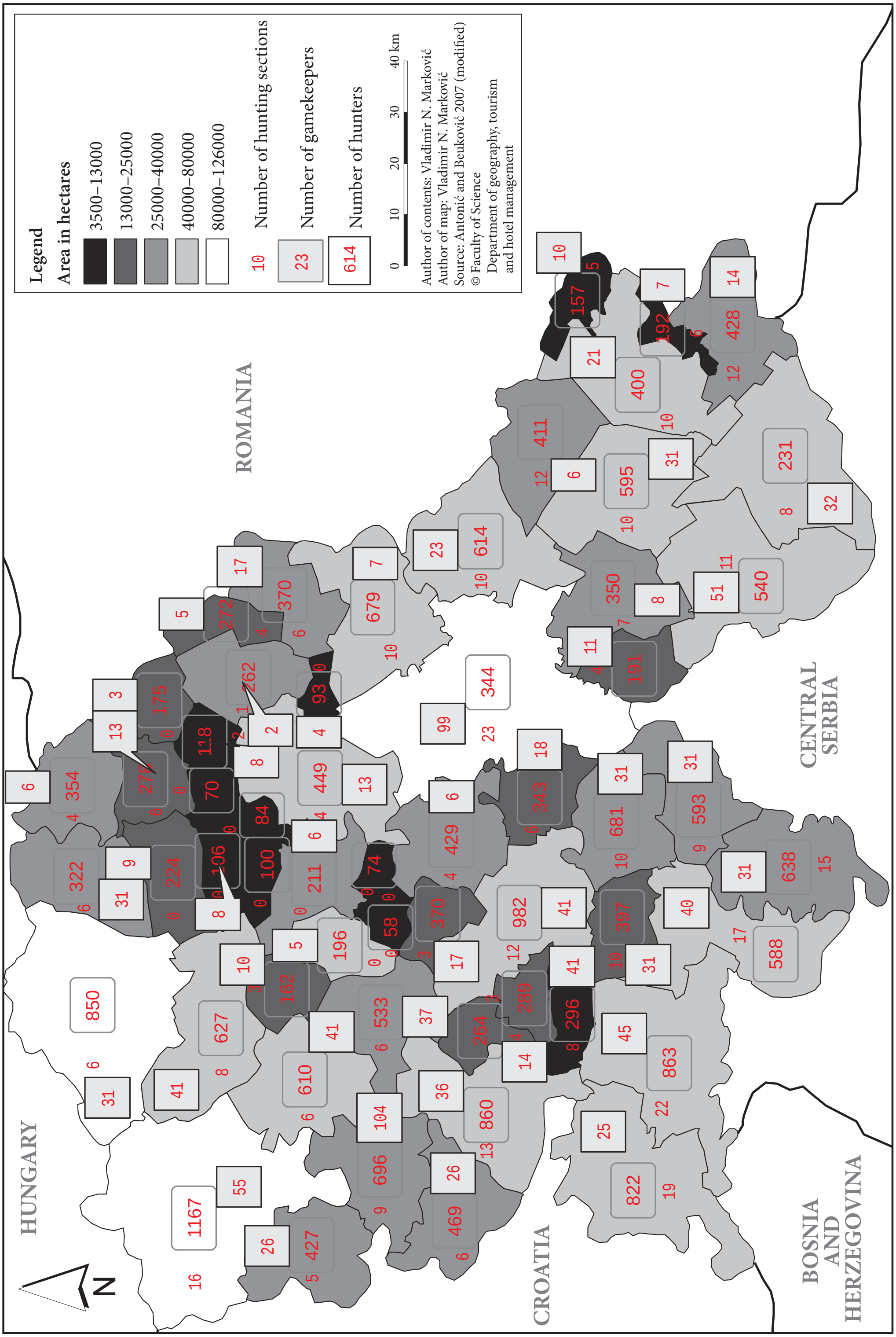


Figure 2: Graphic presentation of regression model.

Figure 3: Quantification of hunting factors by hunting grounds (Antonić and Beuković 2007; modified). ➤ p. 64
Figure 4: Traffic network density (km/1,000 ha) by hunting grounds in the Vojvodina region (Source: Statistical Office of the Republic of Serbia 2008; modified) ➤ p. 65
Figure 5: Forestation and area of meadows and pastures of hunting grounds in the Vojvodina region (Statistical Office of the Republic of Serbia 2008; modified). ➤ p. 66


Legend
Area in hectares
3500–13000
13000–25000
25000–40000
40000–80000
80000–126000
10 Number of hunting sections
23 Number of gamekeepers
614 Number of hunters
0 10 20 30 40 km
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Author of map: Vladimir N. Marković
Source: Antonić and Beuković 2007 (modified)
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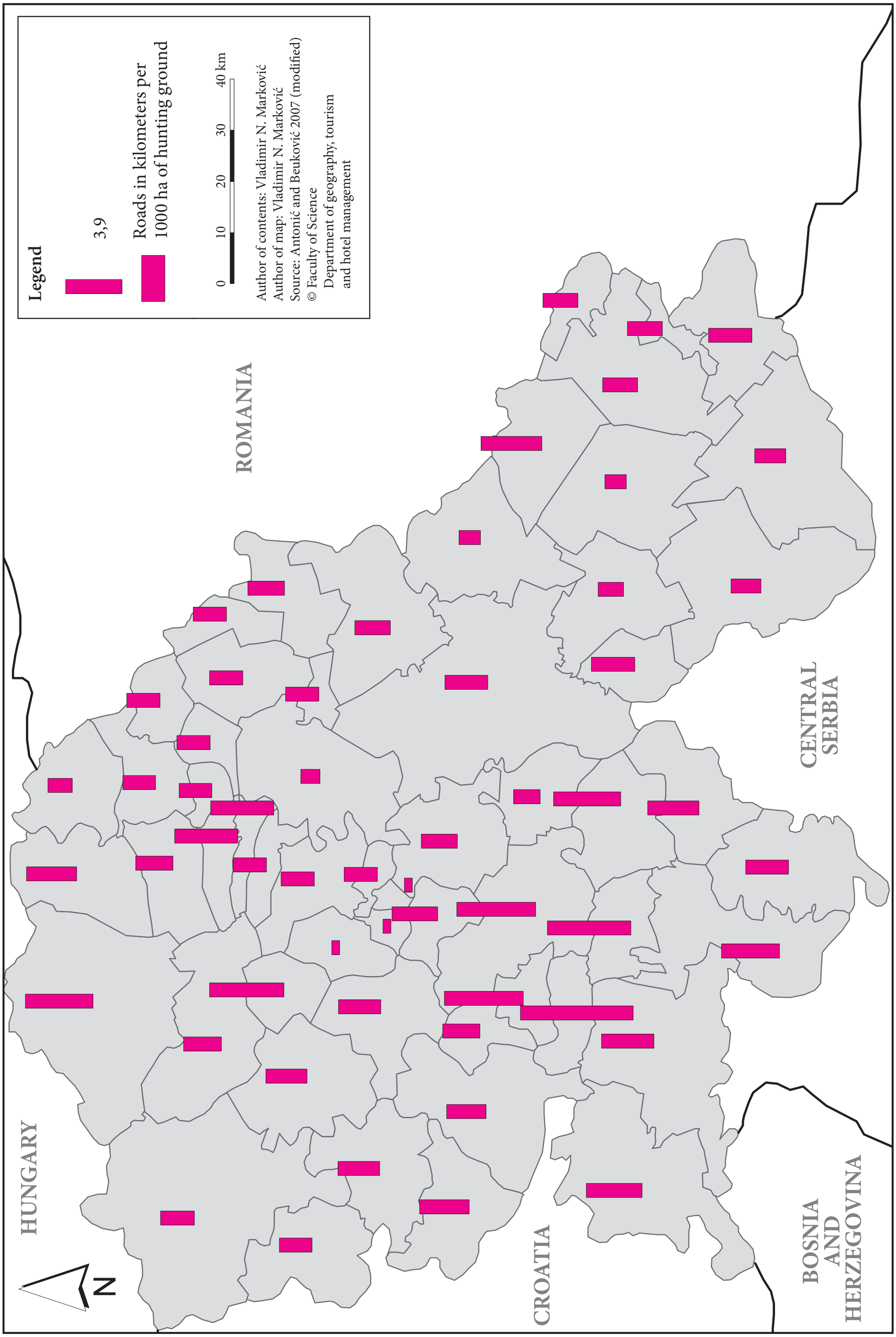
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3,9
Roads in kilometers per 1000 ha of hunting ground
0 10 20 30 40 km
Author of contents: Vladimir N. Marković
Author of map: Vladimir N. Marković
Source: Antonić and Beuković 2007 (modified)
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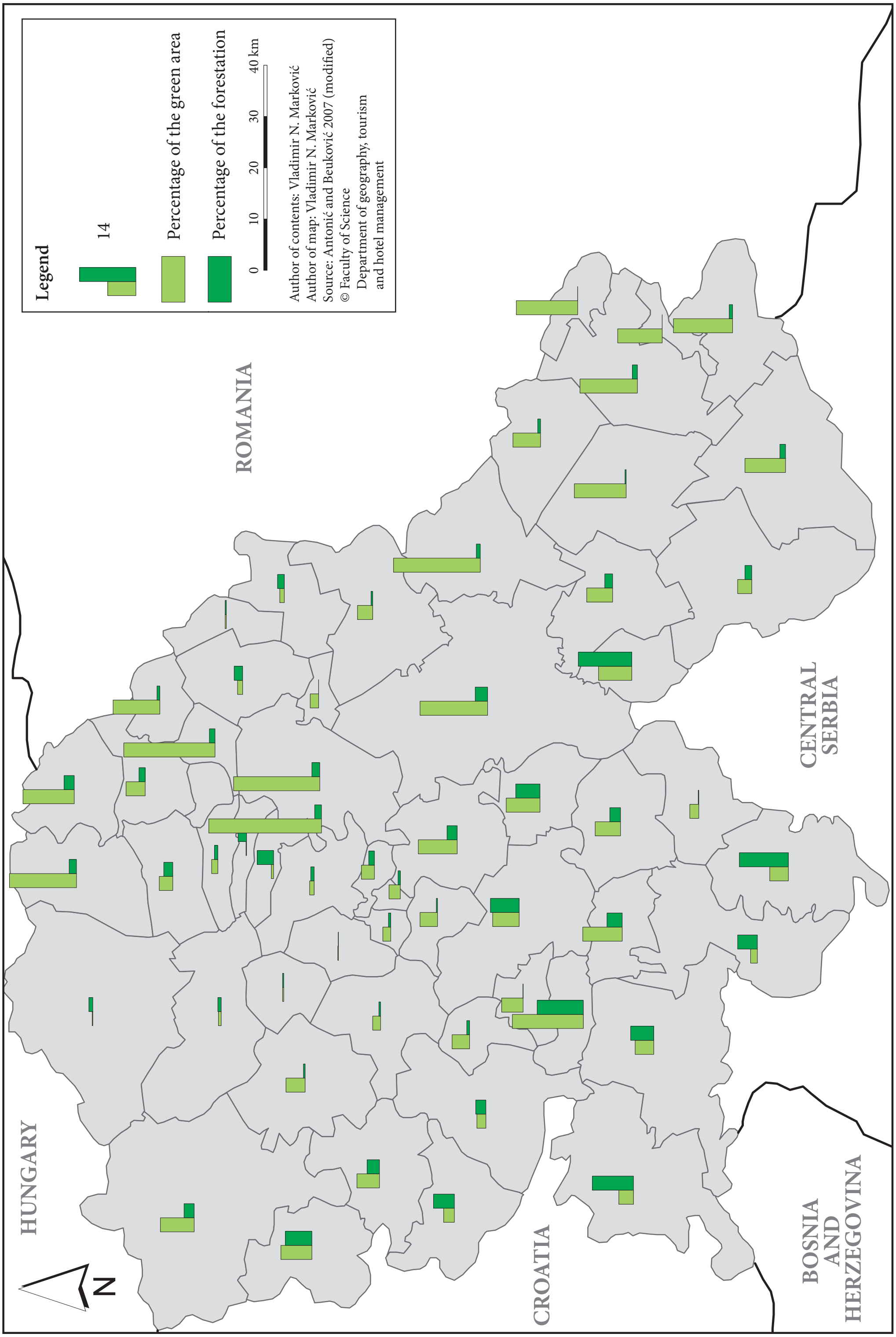
Legend
14
Percentage of the green area
Percentage of the forestation
0 10 20 30 40 km
Author of contents: Vladimir N. Marković
Author of map: Vladimir N. Marković
Source: Antonić and Beuković 2007 (modified)
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Roe deer generally avoid areas that are intensively used by humans (Mysterud, Lian and Hermann 1999). However, this study found that the number of registered hunters is directly proportional to the number of roe deer game. This might be due to increased income generated by the hunter's membership fees that is used for game food and medicaments, breeding and feeding facilities. Also, larger hunter numbers result in better and more efficient care of game, especially concerning annual procedures such as game counting, feeder and salt lick instalment, maintenance and repair of breeding and feeding facilities, or even game rescue during natural hazards (floods, fires, snow, etc.). The role of hunters in these situations is crucial, as hunting ground quality depends on their assistance. According to Marković et al. (2011), most of the registered hunters in Vojvodina (46.7%) have stated that linking with nature is the primary motive for engaging in hunting.

In contrast to number of hunters, number of gamekeepers does not affect the number of roe deer game. We believe that this is mostly the case because in the investigated area most of the gamekeepers work voluntarily and thus their commitment to duty could be questionable. Consequently, the latest Law on Game and Hunting (Zakon o divljači i lovstvu 2010) enacted by Ministry of Agriculture, Trade, Forestry and Water Management of the Republic of Serbia, revoked the title gamekeeper-volunteer. According to Marković (2010), the level of gamekeeper-volunteers' adequate expertise and knowledge in Vojvodina has shown considerable variability.

The length of roads in the investigated area has no effect on roe deer number, although it was expected to have a negative influence (e.g. Mysterud 1999; Hewison et al. 2001; Torres et al. 2011). This could be justified by the fact that average traffic network density in the Vojvodina region is only 2.93 km/1,000 ha (of hunting ground) (Figure 4).

The total area of meadows and pastures on hunting ground in hectares, and total area of forest on hunting ground in hectares are insignificant parameters (Table 1), unlike in the findings of previous researches (e.g. Reimoser and Zandl 1993; Partl 2001 and 2002; Bokalo 2001; Borkowski and Ukalska 2008; Reimosera et al. 2009). Vojvodina is one of the European regions with poorest forest areas (only 5.5% of the territory is covered by forest) (Figure 5). Furthermore, most of the forests are located within nature reserves (outside of hunting grounds), which leaves investigated area with average forestation of only 1.7% (Marković 2010). On the other hand, comparing three forest management models – no harvest, single tree selection and clear-cut – the clear cut gives the best habitat quality for roe deer, which indicate that forestation is not necessarily an essential parameter for roe deer habitat (Vospernik and Reimoser 2008). We also believe that the area of meadows and pastures is an insignificant predictor for the number of roe deer, mostly due to vast areas under agricultural crops with addition of feeding facilities that provide sufficient food supply for roe deer population.

5 Conclusion

This study's results and discussions signify that the roe deer number dependency in the Vojvodina region is a very complex and multi-factorial phenomenon, but strongly influenced by human-induced modifications of habitat. Unfortunately, as a typical Pannonian landscape with a high level of cultivation (Antonić and Beuković 2007), the Vojvodina region offers limited conditions for wildlife habitat (Suchant, Baritz and Braunisch 2003).

These agricultural regions, or »agroecosystems« (Knoche and Lupi 2004) present the most important and pervasive type of managed ecosystem (Antle and Capalbo 2002). It is located on the most productive land, covering 30% of the earth's land area, and 80% in the Vojvodina region (Antonić and Beuković 2007). Consequently, the establishment of agriculture and hunting grounds could influence natural habitats (Knoche and Lupi 2004), with certain conflicts arising between wildlife management and protection on the one hand, and the utilisation of the land for tourism and economic exploitation on the other (Suchant, Baritz and Braunisch 2003).

Inevitably, there is a formal opinion that (particularly in Vojvodina region) roe deer and ungulates in general, with habitats outside protected areas, could not survive in those numbers if there were no hunting grounds. A great danger to the roe deer population could emerge with uncontrolled hunting, cold and dry periods with poor land cover, food and water supplies, increased cultivated areas, etc. All of these factors are generally prevented by the efficient and devoted work of hunting associations with the application of adequate biogeographical surveys and strategies.

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SPECIAL ISSUE
Terraced landscapes

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TERRACED LANDSCAPES: AN INCREASINGLY PROMINENT CULTURAL LANDSCAPE TYPE

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SHUTTERSTOCK

Terraced paddy fields in Vietnam.

Terraced landscapes: an increasingly prominent cultural landscape type

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ABSTRACT: Over the past decades, attractive terraced landscapes composed of cultivated terraces have been increasingly dealt with in studies in geography, landscape architecture, ethnology, rural sociology, agronomy, pedology, and other spatial disciplines. Around 2000, several important research projects were carried out. The Terraced Landscapes Alliance (ITLA) was established, and terraced landscapes have also obtained their place within the European Geosciences Union (EGU) and EUCALAND. During this period, research on terraced landscapes has also intensified in Slovenia. All five articles featured in this special thematic issue of *Acta geographica Slovenica* are also briefly presented.

KEY WORDS: geography, cultural landscape, terraced landscape, terraces, cultural heritage, terraced landscapes bibliography

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1 Introduction

Terraced landscapes are constructed cultural landscapes with special value, and an exceptional physiognomy, in which terraces are the most important element (Ažman Momirski and Kladnik 2015b). Terraces can be found across the entire globe. In some areas, they were created by developed civilizations over millennia, whereas elsewhere they developed completely spontaneously as people adapted to the natural conditions and improved their ability to make a living. They reflect a harmony between man and nature, and in many cases also between people themselves (Kladnik et al. 2016b), which is expressed through the appearance and numerous functions of terraced landscapes. In many areas cultivated terraces provide food and have incomparable scientific, cultural, historical, ecological, and aesthetic value, and even psychological, philosophical, and religious value (Kladnik et al. 2016b). The terraces facilitate the lives of the people and they safeguard the environment by protecting the land and water (Junchao 2015). Their aesthetic value (Smrekar, Polajnar Horvat and Erhartič 2016) is defined by a repeating pattern of terrace platforms and slopes, or hill slope geometrization (Ažman Momirski and Radikon 2008; Ažman Momirski and Kladnik 2015b).

The EU has included cultivated terraced landscapes in its 2007–2013 rural development plan, its agricultural biodiversity action plan (to improve or maintain biodiversity through the abandonment or change of agricultural activities), its thematic strategy for soil protection (Lasanta et al. 2013), and numerous research projects and civic movements (Varotto 2015).

This special issue of *Acta geographica Slovenica* presents some of the latest research achievements in examining cultivated terraces and terraced landscapes connected with investigation of some more important elements of the modern transformation of terraced landscapes in Slovenia, neighboring Croatia, and nearby Slovakia.

2 International research on terraced landscapes

2.1 Main research topics

Terraces consist of flat or slightly inclined platforms of various widths used for cultivation separated by steeper embankments. These embankments differ in their type of material, which determines the solidness of the terraces, and in their height and individual slope (Kladnik et al. 2016b). They reduce the overall slope gradient and length, facilitating cultivation on steep slopes, and increase the infiltration of water in areas with moderate to low soil permeability, with positive effects on agricultural activities (Tarolli et al. 2015).

As an agricultural system, terracing has been known and used since the Neolithic (Agnoletti et al. 2015). One can find agricultural terraces in different topographic conditions, e.g., coastal areas, hilly areas, and steeply sloping mountain landscapes (Tarolli et al. 2015).

Agricultural terraces are among the most evident and extensive human signatures on various landscapes of the world. Accordingly, they have been the focus of a wide variety of studies, especially over the past two decades. The studies concentrate on their origins and time of creation, exploring their shapes and main types. A significant body of research is dedicated to their geographical distribution and the related natural conditions, primarily involving studies of relief elements and soil degradation. Terraces are built to retain more soil and water, to use sun exploitation and the reflection of the warmer temperature from the steep. Furthermore to reduce both hydrological connectivity and erosion, and to support irrigation. This is dealt with in studies of the numerous terrace functions, comprising the economic approaches mentioned above, studies in the humanities, and entirely geomechanical examinations of terraces' contribution to slope stability. Connected with this are studies of the processes and factors related to rural transformation, such as changes in land use and its intensity, and analyses of the impact of ownership and accessibility on the extent of terracing in the landscape. It can be argued that, due to a large number of influential factors, terraced landscapes are a sensitive indicator of rural development or transformation. This is what their significant social role (crop, fruit and wine production) was based on in the past. With the increasing importance of tourism, this role is now gaining new dimensions (Peters and Junchao 2012; Tillmann and Bueno de Mesquita 2015).

On the other hand, agricultural terracing introduced critical issues: increases in slope failures and hydraulic erosion processes with consequent loss of nutrients and redistribution of chemicals. Perhaps the most important topic related to cultural terraces (especially in developed countries) is that of land abandonment. Industrialization was associated with people moving from the countryside to towns and with fundamental demographic changes, especially shrinking and aging of the farming population and a resulting shortage of agricultural labor. Lack of irrigation equipment and poor road access to the land resulted in the abandonment of a significant number of traditional terraces in recent decades, especially in the Mediterranean area. Land abandonment has resulted in a progressive increase in various processes of land degradation in agricultural terraced landscapes (Tarolli et al. 2015). Terraces' sporadic and partial revitalization only took place in the last decade and can be ascribed to suburbanization, strengthening of the market economy and resulting increased demand, better road access to the land for farm machinery and emerging tourist flows.

2.2 A brief historical outline of studying cultivated terraces and terraced landscapes

Cultivated terraces were mentioned in research as early as the mid-nineteenth century (e.g., Kelly 1862). They attracted more attention after the Second World War, but organized research on terraced landscapes only intensified around 2000. Several important projects were carried out at the end of the twentieth century and during the first decade of the twenty-first century: the PROTERRA (1997–2001), RERTC (1997–2001), PATTER (1999–2001), TERRISC (2004–2006), and ALPTER project (2005–2008) (see Ažman Momirski and Berčič 2016 for details). The project team of the ALPTER project, founded in 2003 and 2004 based on university initiatives developed the methodological bases for evaluating terraced landscapes. Its results appeared in two publications: *Terraced Landscapes of the Alps: Atlas* (Scaramellini and Varotto 2008) and *Terraced Landscapes of the Alps: Projects in Progress* (Fontanari and Patassini 2008). The first one features one Slovenian article (Ažman Momirski 2008) and the second features two (Ažman Momirski, Škvarč and Kodrič 2008; Komac and Zorn 2008).

The international study of terraced landscapes reached its peak with international conferences on terraced landscapes. At the first one, which took place in China in the fall of 2010, the International Terraced Landscapes Alliance (ITLA) was established and the Honghe Declaration on the protection and development of terraces was adopted. Together with over one hundred conference papers on various aspects of terraced landscapes from around the globe, this declaration was published in an extensive volume in Chinese and English (Peters and Junchao 2012), which also includes one Slovenian contribution (Ažman Momirski and Kladnik 2012).

The second conference was held in Peru in May 2014. One of its results is an extensive volume of conference proceedings (Tillmann and Bueno de Mesquita 2015), which also features two Slovenian papers (Ažman Momirski and Kladnik 2015a; Ažman Momirski 2015a).

The third conference (Terraced Landscapes: Choosing the Future 2016) was held in Italy in October 2016, right at the time when this editorial was being written. In line with the rich Italian tradition of studying terraced landscapes (e.g., Barbera et al. 2010; Tarolli, Preti and Romano 2014; Agnoletti et al. 2015), pre-conference meetings were held in ten areas, each one highlighting a specific topic.

In connection with the third world conference, a special edition of the Slovenian journal *Annales, Series Historia et Sociologia* dedicated to terraced landscapes was issued. Among its seventeen articles, fourteen of which deal with cultivated terraces or terraced landscapes, four focus on the findings of detailed studies of Slovenian terraced landscapes (Kladnik et al. 2016a; Ažman Momirski and Berčič 2016; Berčič 2016; Guštin 2016).

Research is also taking place as part of the European Geosciences Union (EGU). One of its sections, titled »Agricultural terraces of the world: Their pedological, geomorphological and hydrological role« (Tarolli et al. 2015), dedicates special attention not only to the topics highlighted in its title, but also to the use of technological applications for field data analysis and topographic surveys (i.e., remote sensing), empirical and modeling approaches, and advances in environmental planning strategies for agricultural terrace management. In 2015 and 2016, when this section was active, a series of papers exploring terraced landscapes were presented, including three Slovenian ones (Ažman Momirski 2015b; Kokalj 2015; Komac and Zorn 2015).

Since 2015, systematic research on terraced landscapes has also been carried out as part of the nongovernmental organization of European experts, EUCALAND (European Culture Expressed in Agricultural Landscapes), which promotes the systematic study of typical European landscape types. It is closely connected with the activities of the Permanent European Conference on the Study of the Rural Landscape (PECSRL). Wooden pastures were the first to be studied as part of EUCALAND; they comprise pastures in traditional rural orchards, fruit-tree and cork-oak plantations, olive groves, and farmland that is already being overgrown by shrubs or trees. In addition, research on water meadows and enclosed fields is still ongoing.

3 Studying cultivated terraces and terraced landscapes in Slovenia

Although Slovenia does not have terraces that rank among the best-known such landscapes in the world (i.e., those that are irrigated for rice production), Slovenian terraced landscapes are sufficiently diverse that they deserve special treatment. We seek to reveal their inner structure and to highlight the elements by which they differ from one another. Their diversity is also a consequence of the fact that Slovenia has a great variety of natural landscape types (Ciglič and Perko 2013; Perko, Hrvatin and Ciglič 2015).

For a long time, Slovenian geographers failed to treat terraces as an important landscape phenomenon. There were only individual regional studies, among which Titl's (1965) was the most notable. His study relies at least partly on Melik's rather in-depth discussion on cultivated terraces in the countryside along the Slovenian coast (Melik 1960). Titl was also the first to develop a typology of terraces. Much later the terraces in the Koper Hills were dealt with in Drobnjak's article on the physiogeographic significance of cultivated terraces and typology (Drobnjak 1990) and in Kladnik's article on the possibilities of their intensification (Kladnik 1990). An in-depth study of the Gorizia Hills (Vrišer 1954) devotes only scant attention to cultivated terraces, mostly concerning field division and cultivated plants. In eastern Slovenia, in the monograph *Ljutomersko-Ormoške gorice* (The Ljutomer–Ormož Hills), the author (Belec 1968) mentions the completely altered landscape image caused by the terraces.

An exhaustive chronological overview of research on cultivated terraces and terraced landscapes in Slovenia and an outline of Slovenian terraced landscapes were only published a few years ago (Ažman Momirski and Kladnik 2009). Also noteworthy are an article about terraced landscape in the Brkini Hills (Ažman Momirski and Kladnik 2015b) and a comparative study of land-use changes in the Mediterranean terraced settlements of Krkavče in the Koper Hills and Ostrožno Brdo in the Brkini Hills (Ažman Momirski and Gabrovec 2014), a study created based on fieldwork in selected Slovenian terraced landscapes (Križaj Smrdel 2010a; Križaj Smrdel 2010b), and the in-depth volume *Terasirana pokrajina Goriških brd* (Terraced Landscapes of the Gorizia Hills; Ažman Momirski et al. 2008). It is an interdisciplinary, geographical, historical, ethnographic, and architectural study, which still remains the most in-depth study of a Slovenian terraced landscape. Another two studies from this time that should be mentioned address the threat that landslides pose to Slovenian terraced landscapes (Zorn and Komac 2007; Komac and Zorn 2008).

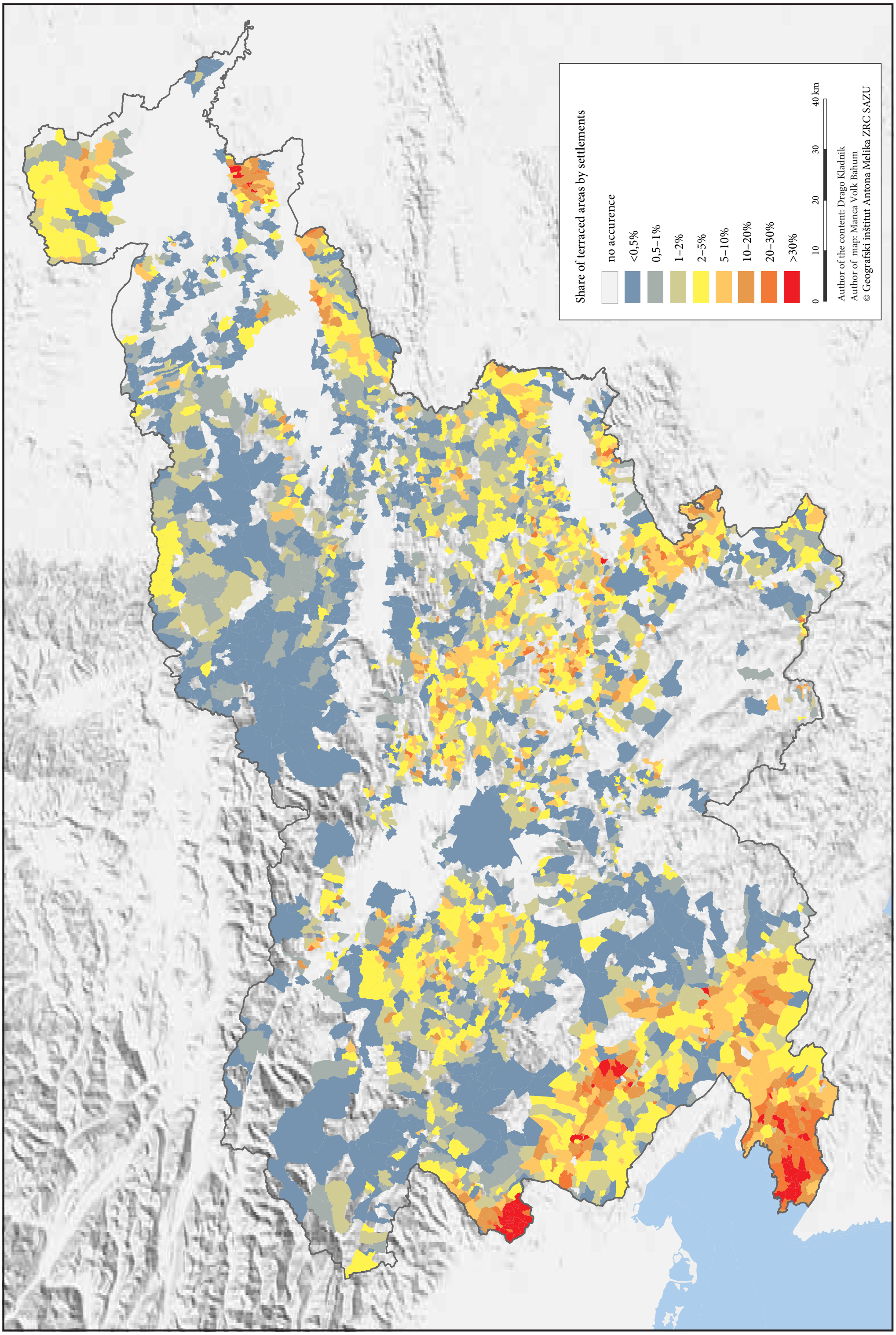
In one of the most recent articles (Kladnik et al. 2016a), the geographical distribution and characteristics of selected typical terraced landscapes in Slovenia are presented, based on analysis of the metric characteristics and the qualities of individual terraces and their components (terrace platforms and terrace slopes).

The extensive volume *Terasirane pokrajine* (Terraced Landscapes; Kladnik et al. 2016b) was published in April 2016 upon the seventieth anniversary of the ZRC SAZU Anton Melik Geographical Institute. It is an illustrated text that presents terraced landscapes around the world and Slovenian landscapes, as well as natural and manmade non-agricultural terraces. As far as we know, it is the first and only work of this type in the world.

4 The articles

The journal *Acta geographica Slovenica* has a long tradition in regional geography. With the articles in this special issue (volume 57, issue 2), we present the comprehensive and multidisciplinary nature of the geographical approach to the study of cultural terraces and terraced landscapes.

Figure 1: Share of terraced areas by settlement in Slovenia. The level of terracing in Slovenia reflects various natural conditions and cultivation trends associated with them. ➤ p. 78


Share of terraced areas by settlements
no accurence
<0,5%
0,5–1%
1–2%
2–5%
5–10%
10–20%
20–30%
>30%
0 10 20 30 40 km
Author of the content: Drago Kladnik
Author of map: Manca Volk Bahun
© Geografski inštitut Antona Melika ZRC SAZU

Following this introduction the special issue begins with the article *Cultivated terraces in Slovenian landscapes* (Šmid Hribar et al. 2017). Its authors study the characteristics of cultivated terraces and their use at selected pilot sites in various Slovenian landscape types. They report that one of the greatest problems for the continued existence of cultivated terraces is the abandonment of their use and subsequent overgrowth, highlighting the issue of land ownership and assuming that the share of privately owned overgrown terraced land is smaller than that of publicly owned land of this type. They also identify natural conditions as factors influencing the abandonment and overgrowth of terraced landscapes. In addition, they raise the issue of further maintenance and protection of aesthetically complete terraced landscapes, recognizing their significant tourism potential.

In the article *Terrraced landscapes in Slovakia* (Špulerová et al. 2017) its authors investigate the distribution of terraced landscapes and analyze their structural characteristics and land use. They found that traditional farming and terrace building as a part of agricultural intensification resulted in two main types of terraced landscapes: historical terraced landscapes and new terraced landscapes. The two types differ in size, structure of various elements, their management intensity, and the impact of these spatial structures on biodiversity. The preservation of such landscapes mostly depends on tradition and is highly dependent on the demgraphic situation. These areas are of great value, both from the perspective of nature and heritage conservation as well as with regard to landscape and aesthetic values.

In the article *Classifying the Mediterranean terraced landscape: The case of Adriatic Croatia* (Andlar, Šrajer and Trojanović 2017), the authors present the Croatian Adriatic terraced landscape classification, with the aim of highlighting its natural and cultural background and proposing a classification framework for further research. The proposed classification framework is based on the landscape pattern dimension whereby the extraction of the class is primarily based on the structure, but also interpreting the geomorphological, biophysical, and cultural-historical circumstances that affected its genesis. Nine classes of terraced landscapes are singled out, described, and referred to with example locations, and also clarified with illustrations and photos.

In the article *Terraced landscapes as protected cultural heritage sites* (Kladnik, Šmid Hribar and Geršič 2017), the authors present the current state of protection of terraced landscapes, both globally and in Slovenia. The UNESCO World Heritage List, the Satoyama Initiative list, and the Slovenian Register of Immovable Cultural Heritage are analyzed. The findings show that terraces rarely appear as a factor justifying protection, even though certain progress has been made in recent years. Intangible aspects of terraced landscapes (e.g., group work, celebrations, rituals) are already being recognized around the globe, but this does not apply to Slovenia. Slovenia shows both a lack of appropriate criteria for identifying terraced landscapes worth protecting and an insufficiently systematic treatment of heritage sites that are already being protected.

In the last article *Transformation of the Jeruzalem Hills cultural landscape with modern vineyard terraces* (Pipan and Kokalj 2017), the authors emphasize that the terraced landscape in the Jeruzalem Hills is the result of specific socioeconomic conditions under communism. Nowadays its appearance is drastically changing for the second time in the last fifty years. The authors examine the creation of a new landscape layer of modern cultivated terraces, study their disappearance, and discuss the return to a condition similar to the original state. It is determined that, despite the recognized aesthetic value of terraces, legal protection in the form of a nature park has not impacted their preservation. The analysis is based on interviews and visual interpretation of aerial laser scanning (lidar) data.

5 Conclusion

The articles in this special issue of *Acta geographica Slovenica* provide an interdisciplinary and comprehensive examination of terraced landscapes in three countries on the border between central and eastern Europe, combining the research potentials of geographers, landscape architects, and biologists. The geographers highlight the spatial, developmental, and protection aspects of terraced landscapes, the landscape architects develop the typology of cultivated terraces using detailed images of terrace structure in individual terraced landscapes, and the biologists explore the landscape ecology elements within the established typology of terraced landscapes.

Due to its comprehensive approach, fresh methods, and newly covered topics, this special issue of *Acta geographica Slovenica* dedicated to terraced landscapes and cultivated terraces is a significant contribution to a better understanding of the characteristics of terraced landscapes and their typology.

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CULTIVATED TERRACES IN SLOVENIAN LANDSCAPES

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A terraced olive grove in Krkavče.

Cultivated terraces in Slovenian landscapes

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ABSTRACT: Cultivated terraces distinctively mark the landscape and are a result of human adaptation to steep areas. Terraces were studied with regard to their morphometric qualities, ownership structure, and land use at eight pilot sites in various landscape types in Slovenia. Twenty-six detailed interviews were carried out with local residents and experts. In current agricultural practice, terraces mostly represent obstacles, and for owners they create a loss rather than profit; however, they represented an advantage in the past, when they were cultivated manually. Land use is intensifying on economically profitable terraces. Among those examined, the Jeruzalem terraces stand out because these are the youngest ones (created in socialist Yugoslavia around 1965). Because of their aesthetic value, they are the best known among the public. Profitability in particular will be an important driving force for the future maintenance of terraces.

KEYWORDS: geography, terraces, cultural landscape, terraced landscape, cultural heritage, Slovenia

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1 Introduction

Cultivated terraces are step-shaped relief forms on inclined land (Križaj Smrdel 2010), which ranks them among the distinctive elements of cultural landscapes. They are a response to human adaptation to natural conditions in steep areas. A distinction is made between irrigated and dry terraces (Rivera 2012). Generations of people invested enormous amounts of labor in their construction, and in many places they completely changed the appearance of the landscape. In places, in developed civilizations they appeared in an organized manner over millennia, and in others they were created spontaneously. Slovenia is crisscrossed by terraces to an extent rarely found in other European countries. In certain places they are so important that one can speak of terraced landscapes, whereas in others they are less distinct and can only be discerned through detailed studies (Kladnik et al. 2016).

As a unique landscape system terraced landscapes were recognized at the global level at the conference on terraced landscapes held in Mengzi, China, where the Honghe declaration on the protection and development of global terraced civilizations was adopted (Peters and Junchao 2012). The terraced landscapes of eastern, southeast, and southern Asia have been discussed by various authors: for example, Liu et al. (2004) studied water flow on terraces, and Min and Zhiyong (2012) wrote about the role of women in working terraced areas among the Hani people. Classification of terraced landscapes in Africa was carried out by Rose (2008), and in South America manmade terraces in the Andes were studied by Goodman Elgar (2002) and Kendall (2012), among others; Kendall dedicated special attention to terraces as a method of adapting the land for food production. In Europe, there is a predominance of studies on terrace management (e.g., Stanchi et al. 2012; Tarolli, Preti and Romano 2014) and the consequences of their overgrowth (e.g., Höchtl, Lehringer and Konold 2005). The economic role of cultivating land in terraces in the Alpine countries has been dealt with in Italy (Scaramelini and Varoto 2008), Switzerland (Lavaux 2007), and France (Jeddou et al. 2008). Špulerová et al. (2017) described the qualities of terraced landscapes in Slovakia. Andlar, Šrajer and Trojanović (2017) studied solutions for avoiding the deterioration of the terraced cultural landscape, which is occurring in Croatia due to accelerated deagrarization and rapid tourism development. In Slovenia, cultivated terraces have long been a marginal topic, and they were only investigated in detail in Istria by Titl (1965). The first detailed analyses were made of the Gorizia Hills (*Goriška Brda*) (Ažman Momirski et al. 2008) and the Brkini Hills (Ažman Momirski and Kladnik 2015). Terracing across all of Slovenia was studied by Ažman Momirski and Kladnik (2009) and Križaj Smrdel (2010). Kladnik et al. (2016) offered detailed data on terraced landscapes in Slovenia.

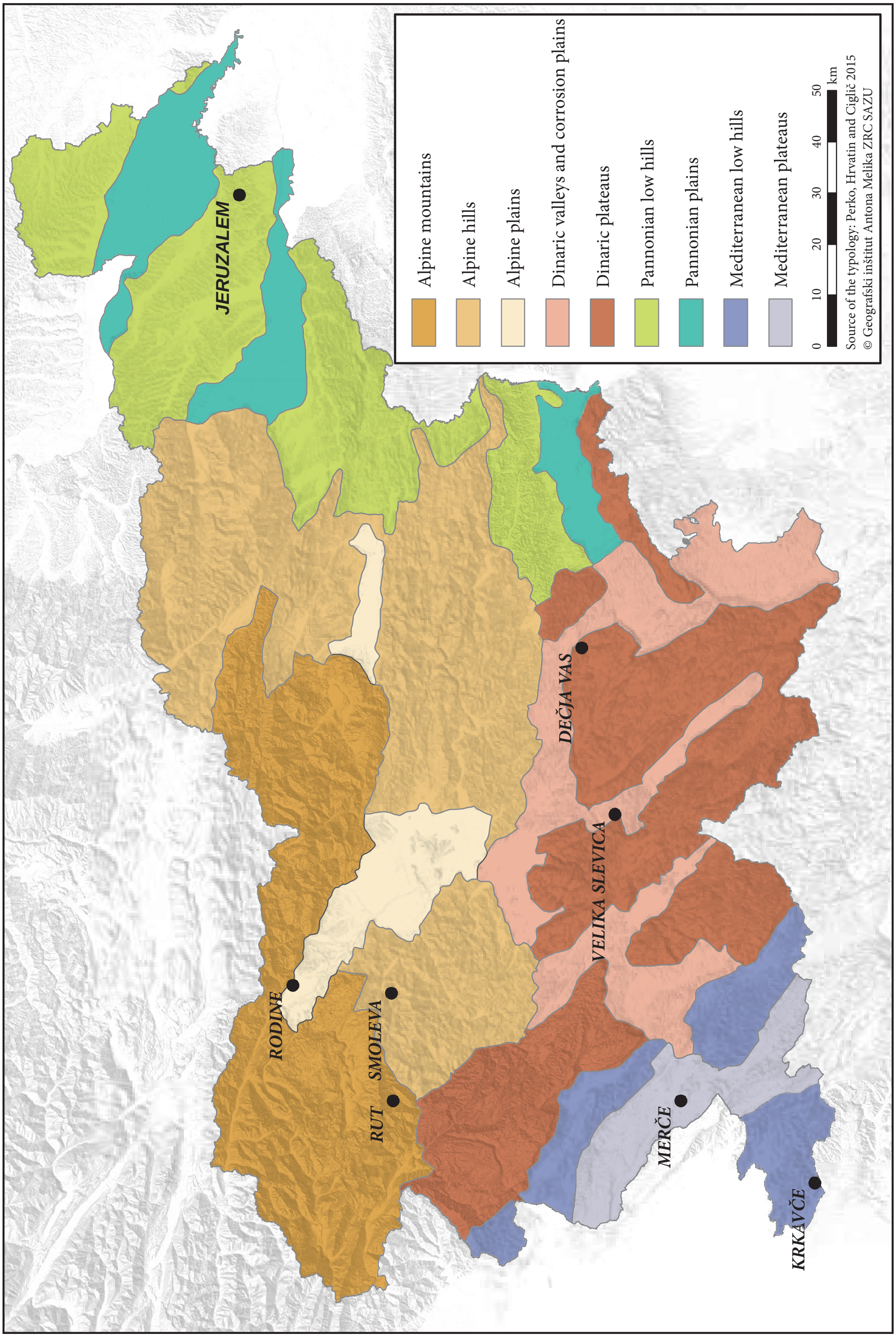
Despite the important role of terraced landscapes in the Slovenian economy and their landscape function, there is still no detailed study at the national level that 1) presents the attitude of owners and experts toward terraces, and 2) examines their multiple importance. This article studies the characteristics of cultivated terraces and their use at selected pilot sites in various Slovenian landscape types. It is hypothesized that the share of privately owned overgrown terraced land is smaller than that of publicly owned land of this type.

2 Methods

Eight pilot sites or settlements were selected (Figure 1) within eight of the nine landscape types according to Perko's (1998, 2007, 2015) classification of Slovenia. The pilot sites have an above-average share of terraced land in comparison to the proportion of terraces in individual landscape types. The final selection was made based on the morphometric characteristics of the terraces (inclination, aspect, and elevation), the researchers' own judgement of their aesthetic value (visual impact), and public awareness of them. No pilot site was selected in the Pannonian plains landscape type, where only 0.05% of the land is terraced.

The pilot sites were studied using a combination of desk work and fieldwork. The sites were first studied using digital orthophotos (Digitalni ortofoto posnetek 2015), and then shaded relief, which was created with the help of laser scanning data (LIDAR 2015). Because laser scanning can also detect relief formations if the site is covered by vegetation, it can provide data for very accurate digital elevation model (DEM)

Figure 1: Map of landscape types and pilot sites. ➤


Alpine mountains
Alpine hills
Alpine plains
Dinaric valleys and corrosion plains
Dinaric plateaus
Pannonian low hills
Pannonian plains
Mediterranean low hills
Mediterranean plateaus
0 10 20 30 40 50 km
Source of the typology: Perko, Hrvatin and Ciglič 2015
© Geografski inštitut Antona Melika ZRC SAZU
JERUZALEM
DEČJA VAS
VELIKA SLEVICA
RODINE
SMOLEVA
RUT
MERČE
KRKAVČE

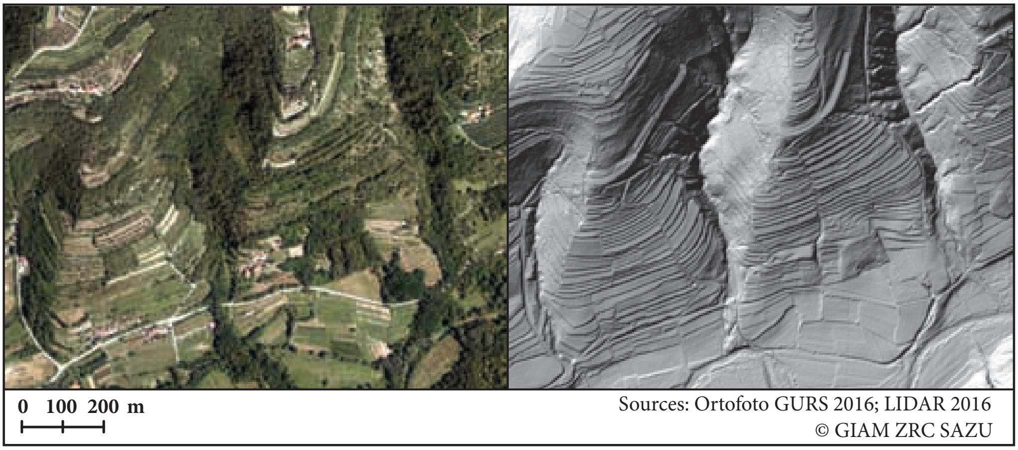


Figure 2: Comparison of a digital orthophoto (left) and shaded relief based on laser scanning (right) for the Krkavče site. Shaded relief makes it possible to also identify terraces under vegetation.

generation. This is very important in determining the layout of terraced landscapes because it makes it possible to register terraces that are overgrown or even covered by forest (Figure 2). The terraces that were identified were then digitized, and overlapping data layers were used to study their morphometric properties (elevation, inclination, and aspect), ownership structure, and land use.

A DEM (with a resolution of 1 × 1 m) derived from laser scanning data was used to analyze the pilot sites. For the land use analysis, data from Ministry of Agriculture, Forestry and Food (Grafični podatki RABA … 2015) were used. Information on the owners of individual parcels was obtained from the Land cadastre (Zemljiški kataster 2014). Owners were sorted into ten different categories (private individuals, legal entities, the state, the Slovenian Farmland and Forest Fund, agriculture communities, municipalities, parishes, property in public domain, general-use public property, and unknown), and the influence of ownership structure on land use was analyzed.

The fieldwork was based on observations and 26 structured interviews that were carried out at the pilot sites in 2014 with 16 local residents that owned terraced land, 5 residents that were not owners, and 5 experts in nature conservation, cultural heritage protection, history, archaeology, and agriculture, respectively. The questionnaire for owners contained 22 questions about the influence of terraces on the settlement, their use, their significance, and their preservation. Non-owners were asked about the same issues, except for questions connected with cultivating and maintaining the terraces. Experts were asked 10 questions regarding challenges connected with terraces, their possible protection and future development, and 1 specific question connected to their field of expertise. The audio recordings and transcriptions of the interviews are kept at the Archives of the ZRC SAZU Anton Melik Geographical Institute.

3 Results

The history, time, and reason connected with the creation of the terraces, and their position, appearance, current status, and dominant processes differed greatly between landscapes. Some cultivated terraces were shaped centuries ago, and the most recent were created in the 1960s. The characteristics of the terraced landscape are connected with the shape of the terrain, as well as lithological, pedological, climatological, and other natural and social characteristics of the landscape. In order to highlight their variety, the pilot sites, which were selected based on the criteria in Chapter 2, are briefly presented. Their basic characteristics were identified with the help of spatial analyses, in-depth interviews, and field visits (Figures 3, 4, and 5; Table 1).

At the **Rut** site (Alpine mountains) the terraces were created following the settlement of Tyrolean farmers from the vicinity of San Candido (Germ. *Innichen*) in the Puster Valley in the 13th century (Torkar 1994).

Near the village, cleared stones were laid into dry walls that support the terraces. Originally they contained small cultivated fields, known as *flančniki*, or seedling plots, and *repniki*, or plots for turnips and other vegetables. The former fields are now predominantly meadows and pastures, and the small plots have fallen into disrepair and are overgrown. All of the non-terraced land in Rut is being intensively overgrown, but the terraced land is not. Therefore in a few decades the terrace site in Rut will be the only land that has not undergone afforestation.

In **Smoleva** (Alpine hills) the terraces were created during medieval colonization of hilly areas (Blaznik 1928; Ilešič 1938). The steep slopes and the bottoms of two ravines that open to the southwest were terraced in order to facilitate cultivation of fields and reduce soil erosion. In the past, they contained fields with all sorts of cultivars for subsistence farming, but they have now been replaced by meadows. Because of the strong incline of the slope, the terraces are narrow and have high earthen embankments. Their maintenance is encumbered by the landslide-prone slopes.

In **Rodine** (Alpine plains) the terraces are in a warm zone at the foot of the hills. The terrace platforms are several dozen meters long and at least five meters wide, and the embankments are low, gently sloping, made of earth, and overgrown with grass. A special feature among the embankments is two relatively well-preserved dry stone walls. In the past, more than half of the terraces were used as cultivated fields, whereas today meadows and pastures predominate.

In **Jeruzalem** (Pannonian low hills), the information gathered in the interviews indicates that vineyard terraces were created around 1965 on land that had been nationalized after the Second World War (Pipan and Kokalj 2017). Due to the lack of manual labor, the terraces were built to accommodate the mechanical cultivation available at the time. The terracing was so intense that it was carried out all the way to the houses at the top of the ridge. In 2015, 89.8% of the terraced land was used for vineyards.

In **Dečja vas** (Dinaric plateaus) the terraces are characterized by reddish-brown soil. Terraced land is surrounded by the clustered village on all sides. The terraces in Dečja vas are marked by a predominance of cultivated fields, which cover more than half (51%) of all terraced land, which is noteworthy not only among Slovenian terraced landscapes, but also among agricultural landscapes in general.

The terraces in **Velika Slevica** (Dinaric valleys and corrosion plains) represent the Lower Carniolan type of terraces (Križaj Smrdel 2010). Old agricultural terraces extend along the full length of slopes, especially those facing the southeast. They have recently been subject to grass overgrowth. All of the embankments are earthen and overgrown with grass, and in places one can notice the first signs of overgrowth with bushes. The greatest danger threatening their long-term existence is ownership fragmentation, which encumbers economical and intensive cultivation.

The terraces in **Krkavče** (Mediterranean low hills) are believed to date back to Antiquity (Gaspari 1998). In the past they were used to cultivate vineyards, fruit trees, and vegetables, but today olive groves predominate because of their profitability and mechanical cultivation. Nearly one-third of the terraces are already afforested. The trend of overgrowth is continuing, whereby the terraces where olives do not thrive are being abandoned first. An important factor in their abandonment is the protected status of the Dragonja River region, which is an obstacle to use. Dry stone walls have largely been replaced by earthen embankments.

In **Merče** (Mediterranean plateaus) there are no terraces at all on karstified soil (Jurkovšek et al. 1996; Jurkovšek, Cvetko Tešović and Kolar-Jurkovšek 2013); they are found on dolomite and are laid out concentrically around the central village depression. They are bordered by multifunctional dry stone walls (Panjek 2015). Once cultivated fields predominated on the terraces, and there were also many meadows and pastures. Today these are in the majority, one-fourth of the terraces are afforested, and overgrowth continues to be intense.

The pilot areas also differ in terms of land use (Figures 4 and 5). Vineyards are almost exclusively found in Jeruzalem, where they account for 89.8% of the terraces, and a very small portion can also be found in Krkavče (6.8%). Olive groves are found only in Krkavče and account for 30.7% of terraced land. There are few orchards; the largest share (9.5%) is found in Velika Slevica. In Dečja vas there is a mix of cultivated fields (51%) and meadows and pastures (40.7%), whereas meadows and pastures dominate in Merče (64.9%), Rodine (83.5%), Rut (83.2%), Smoleva (59.4%), and Velika Slevica (85.4%). One of the basic characteristics of land use on agricultural terraces is the abandonment of intensive use for cultivated fields or meadows,

Figure 3: Eight selected pilot sites that reflect the diversity of Slovenian terraced landscapes by various landscape types. ➤ p. 88

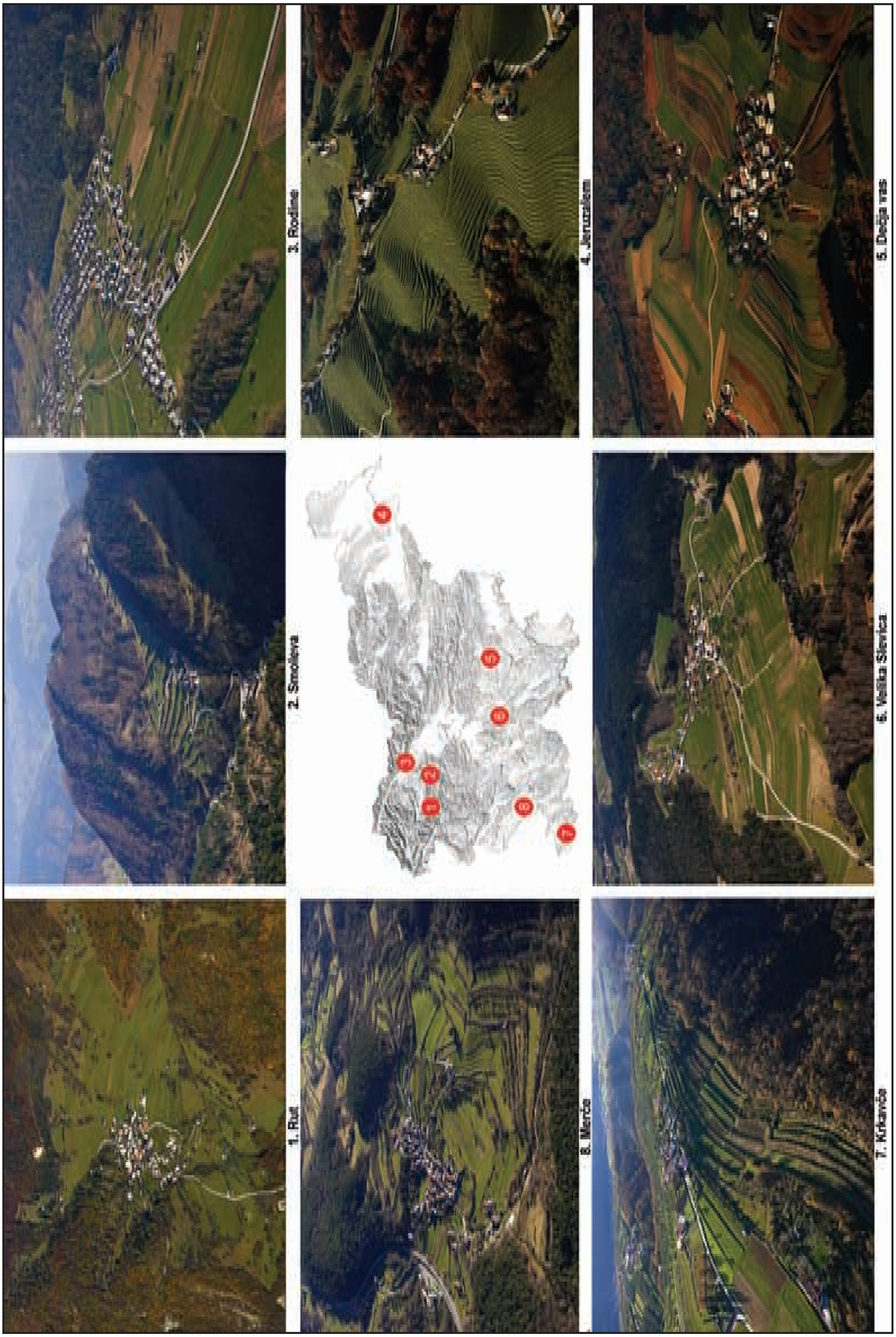
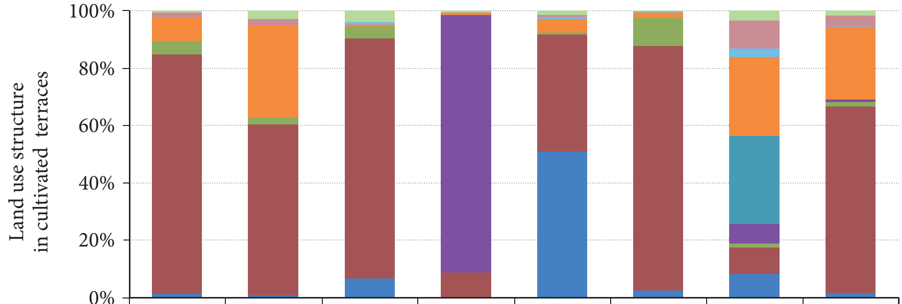

1. Rut
2. Smoleva
3. Rodine
4. Jeruzalem
5. Dečja vas
6. Velika Slevica
7. Krkavče
8. Merče

Table 1: A comparison of terrace characteristics at eight pilot sites (Source: Grafični podatki RABA … 2015; Register prostorskih enot 2016; interviews; field inspections).

Pilot site	Area (ha)	Share of terraced land in settlement (%)	Predominant use (> 20%)	Predominant embankment type	Special features	Difficulties/challenges
Rut (1)	43.8	4.3	Meadow and pasture	Dry wall	Dry walls	Clearing overgrown embankments
Smoleva (2)	20.2	11.0	Meadow and pasture, woods	Earthen	The terraces have their own microtoponyms, which are generally known by local residents; the embankments often have fruit trees on them	Landslide-prone area; potential abandonment of mowing and brush removal on small farms
Rodine (3)	22.3	12.4	Meadow and pasture	Earthen	Two dry-wall embankments	Land use change from cultivated fields to meadows and pastures; removal of dry walls
Jeruzalem (4)	24.4	40.9	Vineyard	Earthen	The terraces undulate along the contours of small hills	Landslide-prone area
Dečja vas (5)	61.0	20.0	Cultivated field, meadow, and pasture	Earthen	Reddish-brown loamy soil; mix of cultivated fields and meadows	Owners' negative attitude to terraces; need to conserve arable land
Velika Slevica (6)	27.1	23.9	Meadow and pasture	Earthen	The terraces extend along the entire slopes following the contours	Overgrowth of individual embankments; smallness and spatial dispersion of land ownership; owners' negative attitude to terraces
Krkavče (7)	231.3	35.9	Olive grove, woods	Earthen	Few dry walls; olive groves have not only economic value but also distinctive aesthetic value	Dry walls not maintained; overgrowth due to abandonment of farming and unsettled ownership
Merče (8)	52.0	13.3	Meadow and pasture, woods	Dry wall	Dry-wall system; concentric arrangement of terraces around a central depression where the village houses stand	Overgrowth; mowing only on terraces where farmers receive subsidies



	Rut	Smoleva	Rodine	Jeruzalem	Dečja vas	Velika Slevica	Krkavče	Merče
Built area	0,5	2,9	4,1	0,6	1,5	0,3	3,3	1,7
Overgrown	1,8	2,2	0	0,2	0,8	0,1	9,7	3,7
Non cultivated farmland	0	0	0,7	0	0,4	0,1	3,2	0,3
Woods	8,1	32	0,7	0,6	4,9	2,1	27,3	25,2
Olive grove	0	0	0	0	0	0	30,7	0
Vineyard	0	0	0	89,8	0	0	6,8	0,8
Orchard	5	2,7	4,1	0	0,7	9,5	1,3	1,8
Meadow and pasture	83,2	59,4	83,5	8,7	40,7	85,4	9,5	64,9
Cultivated field	1,4	0,8	6,9	0,1	51	2,5	8,2	1,6

Figure 4: A comparison of terraced land use at pilot sites in % (Grafični podatki RABA . . . 2015).

which is best seen in afforestation and farmland that is being overgrown. Overgrowth is seen at all pilot sites except Rodine; it is greatest in Krkavče (9.7%) and Merče (3.7%). In general, it is true for all pilot sites that northern orientations are being overgrown more that southern ones, and that slopes with an inclination greater than 27° (50%) are being overgrown more than those with less of an incline. The greatest share of woods is in Smoleva (32%), and just under this in Krkavče (27.3%) and Merče (25.2%).

Based on information from the Land cadastre (Zemljiški kataster 2014), the largest number of parcel owners in terraced areas is in Krkavče, followed by Merče, and the smallest number is in Smoleva. Comparing the number of owners with the size of the terraced areas, the greatest fragmentation of property is in Rodine and the least in Velika Slevica. With the exception of Jeruzalem, the highest share of owners in terraced areas are private individuals, followed by the state (especially in Krkavče at 34.4%), and the remainder of other categories is negligible. For a total of 6% of land in the register the owner is unknown. In Jeruzalem the largest ownership share is held by the Farmland and Forest Fund (58.4%). The smallest ownership shares are held by agriculture communities, municipalities, legal entities, and parishes. In terms of ownership, the majority of land that is being overgrown is privately owned (Figure 6). The largest share of such land is found in Krkavče (9.7%), Merče (3.7%), and Smoleva (2.2%). Elsewhere overgrown land accounts for less than 2%.

4 Discussion

One of the greatest problems for the continued existence of cultivated terraces is abandonment of their use and subsequent overgrowth, which is especially the case in Krkavče, Smoleva, and Merče. Although overgrowth of steep slopes is readily apparent at most of the pilot sites, the overgrowth of land by aspect varies much more. One reason for this is also the fact that certain pilot sites have very little or almost no land with particular aspects (Figure 4). The same is true regarding the influence of elevation and relative elevation differences within the pilot site: overgrowth of higher-elevation areas is characteristic of pilot sites with greater elevation and greater relative elevation differences (e.g., Smoleva and Rut), whereas elsewhere this tendency is not observable. It was also surprising that land that is being overgrown, especially in Smoleva, Merče, and to some extent in Krkavče, is largely privately owned and not state-owned, as was first expected. It is likely that more meaningful reasons for the overgrowth of cultivated terraces should

Figure 5: Overgrowth of cultivated terraces at individual pilot areas by aspect in % (Grafični podatki RABA . . . 2015; LIDAR 2015).

	Rut				Smoleva				Rodine				Jeruzalem				Dečja vas				Velika Slevica				Krkavče				Merče			
	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT
S, SE, SW	82,7	8,9	2,1	89,0	60,9	18,0	2,9	79,1	82,9	0,4	0,0	99,6	61,1	0,7	0,3	99,0	41,1	3,4	1,0	95,6	54,6	1,3	0,2	98,5	61,0	17,2	9,9	72,9	30,0	27,8	4,5	67,7
E	4,6	5,9	0,3	93,8	8,6	98,5	0,0	1,5	1,0	6,2	0,0	93,8	22,9	0,5	0,1	99,4	12,9	4,0	1,1	94,9	27,5	2,4	0,0	97,6	6,8	22,4	8,5	69,1	20,7	27,9	4,7	67,4
W	12,1	3,2	0,5	96,3	14,8	7,9	2,5	89,6	12,3	0,6	0,0	99,4	5,1	0,7	0,1	99,2	8,7	4,2	0,0	95,8	0,7	16,9	0,0	83,1	12,3	46,1	10,1	43,8	8,8	15,3	2,3	82,4
N, NE, NW	0,6	14,6	1,1	84,3	15,7	73,1	0,6	26,3	3,8	4,0	0,0	96,0	10,9	0,5	0,0	99,5	37,3	7,0	0,8	92,2	17,2	3,5	0,0	96,5	19,9	48,1	9,2	42,7	40,5	24,1	2,8	73,1

S – share (in %) of aspect categories; W – woods (in %); OVG – overgrown farmland (in %); OT – other (in %)

Figure 6: Share of terraced land at pilot sites by ownership type, with an emphasis on wooded land and farmland being overgrown (Zemljiški kataster 2014).

Pilot site	Rut				Smoleva				Rodine				Jeruzalem				Dečja vas				Velika Slevica				Krkavče				Merče			
Number of owners	54				13				37				16				39				29				213				84			
	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT	S	W	OVG	OT
Private individual	91,4	6,1	3,5	90,4	98,2	30,9	3,6	65,5	75,6	0,8	0,1	99,1	38,9	0,4	1,6	98,0	89,8	5,0	1,1	93,9	88,0	1,1	1,2	97,7	57,2	18,4	18,0	63,6	95,1	16,5	12,9	70,6
Legal entity	–	–	–	–	–	–	–	–	–	–	–	–	0,0	–	–	100,0	–	–	–	–	–	–	–	–	0,8	3,2	13,2	83,6	–	–	–	–
Republic of Slovenia	1,2	69,2	2,9	27,9	–	–	–	–	0,2	–	–	100,0	0,0	–	–	100,0	–	–	–	–	–	–	–	–	34,4	26,8	22,5	50,7	0,1	7,7	36,6	55,7
The Slovenian Farmland and Forest Fund	–	–	–	–	0,1	100,0	–	–	–	–	–	–	58,4	0,1	0,0	0,1	2,7	1,8	2,4	95,8	–	–	–	–	1,5	51,6	23,3	25,1	–	–	–	–
Agriculture community	–	–	–	–	–	–	–	–	0,0	–	–	100,0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Municipality	–	–	–	–	0,6	5,6	4,6	89,8	0,0	–	–	100,0	–	–	–	–	–	–	–	–	–	–	–	–	0,1	21,5	32,4	46,1	–	–	–	–
Parish	4,7	0,0	4,5	95,5	–	–	–	–	0,0	–	–	100,0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0,3	32,0	22,3	45,7
Property in public domain	1,0	3,5	9,9	86,6	0,9	12,0	29,6	58,4	0,3	–	–	100,0	–	–	–	–	1,2	11,9	0,4	87,7	–	–	–	–	1,2	15,6	23,9	60,5	–	–	–	–
General-use public property	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,0	1,1	4,8	94,1	–	–	–	–	2,3	21,0	17,6	61,4
Unknown	1,7	0,0	0,1	99,9	0,2	–	–	100,0	23,9	–	–	100,0	2,7	–	–	100,0	6,3	0,1	0,5	99,4	10,0	0,1	0,2	99,7	4,8	0,2	12,2	87,6	2,2	–	4,1	95,9

0,0 category exists, but its value is less than 0.05 %; – category does not exist; S – share (in %) of owners; W – woods (in %); OVG – overgrown farmland (in %); OT – other (in %)

be sought in the socioeconomic development of the pilot areas: in unfavorable demographic development and deagrarization of a large part of the rural population and the related abandonment of intensive cultivation, in the growing market orientation of farming, and, especially in eastern Slovenia, in the planned construction of new vineyard terraces for easier and better cultivation. Based on interviews and fieldwork, it has been established that the abandonment of terraced land results from the following:

- Aging of the population and younger generations moving away (Krkavče, Merče, and Rut);
- Redirection of residents from farming to other activities (Krkavče, Merče, Rodine, Smoleva, and Velika Slevica);
- Fragmented and small holdings, which often impede or completely prevent mechanical cultivation (Smoleva and Velika Slevica); and
- Conflicts arising from joint ownership and incapacity for uniform management (Merče).

In some cases, these reasons for abandoning terraces are comparable to those in other terraced areas in Europe. In the Alps these especially include natural limiting factors (Höchtl, Lehringer and Konold 2005), in southern Europe poor accessibility to these areas and socioeconomic changes (Stanchi et al. 2012), in Slovakia a lack of successors and young people moving away (Špulerová et al. 2017), and in Croatia decline of traditional agricultural production and diversification in modern agriculture techniques, which rarely include terracing (Andlar, Šrajer and Trojanović 2017). Abandonment due to the expansion of construction areas if terraces are located near large settlements was not observed in Slovenia, as Špulerová et al. (2017) reported for Slovakia. In individual areas, the continued existence of terraces is also threatened by other factors. One of these is the transformation of terraces into vertical vineyards – for example, in the broader area of the Jeruzalem Hills – which allows a greater number of grape vines per area unit (Urbanc 2002; Pipan and Kokalj 2017). Terraces are also indirectly threatened by changes in land use from cultivated fields to meadows and pastures because grazing livestock gradually level terraced land, as has started to occur in Velika Slevica. The preservation of terraces is also impeded by the lack of special subsidies for maintaining them. Subsidies are available only for cultivating farmland and cultivating areas with »limited agricultural potential«, and so narrow terraces on large slopes are deteriorating, and in places the embankments are becoming overgrown (e.g., in Velika Slevica) because the steep incline necessitates mowing by hand. In contrast to the past, terraces represent more of an obstacle than an advantage to modern agriculture.

In addition to the Jeruzalem terraces, only the terraces in Krkavče are also officially recognized as cultural heritage (Register nepremične kulturne … 2015; Kladnik, Šmid Hribar and Geršič 2017). Among the local residents, terraces as cultural heritage or as part of tradition that must be respected, are also recognized in Merče, and by their owners also in Smoleva and to some extent in Velika Slevica.

One of the more important qualities of terraces is their aesthetic value, which is also cited by UNESCO as one of the criteria for defining world heritage (Internet 1). Despite the subjective judgment, perhaps precisely aesthetic attractiveness is a key quality that can aid terrace preservation. Aesthetic value is further added to terraces by an evenly structured, harmonious, orderly, and cultivated surface, along with individual elements such as trees and dry stone walls. As external observers, we can highlight the mix of terraced cultivated fields and meadows in Dečja vas, which, together with the reddish-brown color of the soil, create a unique landscape. More or less all of the local residents interviewed were aware of the aesthetic values of terraces–except, interestingly, for those in Dečja vas, where the farmers viewed terraces as merely time-consuming and demanding extra work. It is interesting that the locals ranked the Jeruzalem terraces highest in terms of aesthetic value; these are the youngest terraces and were created mechanically. They emphasized that terraces are more attractive than vertical plantations, and because of their colorfulness they are especially attractive in the autumn. This confirms Kant's point of view that beauty is the capacity to experience beauty, which is created in the subjective experience of the observer, which is highlighted by Šmid Hribar (2011) with regard to the aesthetic evaluation of trees and by Smrekar, Polajnar Horvat, and Erhartič (2016) with regard to landscape forms.

In the case of the Jeruzalem terraces it turned out, similar to what Erhartič (2009) had already ascertained, that it is precisely the aesthetic value of the terraces that influenced the development of tourism as an important branch of the economy. This is well appreciated by both wine producers, who designated the wine from the area with the label *Terase (eng. terraces)*, as well as advertising campaigns, which use the Jeruzalem vineyard terraces to promote landscape beauty. Among the general Slovenian public, it is the Jeruzalem terraces that are best known among all of the pilot sites because of their picturesque character, which should also be taken into account in defining aesthetic criteria for assessing terraced landscapes.

In addition to all of this, due to difficult natural conditions in many steep landscapes, terraces must also be protected for the following reasons:

- Protecting soil fertility;
- Protection against erosion;
- Maintaining soil moisture; and
- Safeguarding traditional knowledge about terrace construction, especially regarding how and where it is possible to obtain flat areas on slopes in order to make farming possible (e.g., for vineyards, olive groves, cultivated fields, meadows, and pastures).

Based on the observations and interviews, it has been determined that only those terraces will be preserved that allow mechanical cultivation and that are economically profitable, similar to those in Alpine valleys in Italy (Scaramelini and Varoto 2008), Switzerland (Lavaux 2007), and France (Jeddou et al. 2008). In order to preserve other interesting terraces (but only to a smaller extent), it will be necessary to apply appropriate protection, new practices, and financial resources. This could, for example, prevent overgrowth near settlements in Istria by encouraging residents to engage in hobby production of fruit and vegetables. This should be put in place through systematic measures and setting up appropriate shared places for tool storage. This would also encourage socialization and the exchange of knowledge and experience.

5 Conclusion

Construction and maintenance of cultivated terraces is a demanding task. In the past, terraces were connected with subsistence farming and represented an advantage, but with modern machinery they mostly hinder owners and generate a loss for them. This leads to two opposing trends. On the one hand, terraces are being abandoned and overgrown on a large scale, but where production on them has proven to be economically attractive modern farm equipment is being used to convert them into land adapted for mechanical cultivation. This has intensified their use; for example, in Jeruzalem and Krkavče. Both of these contribute to fundamental changes to traditional terraced landscapes. It is therefore concluded that primarily profit will be an important driver for the future maintenance of terraces.

Because of the steep inclines in Jeruzalem, despite the greater production costs in comparison with vertical vineyards, the terraces have maintained their original viticultural function. The reason for this also lies in their majority ownership by the Farmland and Forest Fund, which rents the land to a large wine-producing company. These terraces, in addition to their primary production function, also promote the development of tourism and other activities. The high profile of the terraces there and their aesthetic importance for tourism will also be important driving forces for their maintenance in the future. In Krkavče, which ranks second among the pilot sites studied in terms of the share of cultivated terraces, the main driver of their preservation in recent times has been the economically profitable production of olive oil. At other pilot sites studied, terraces are preserved solely where the only (flat) farmland can be found on terraces.

In addition to economic value, many terraces also have heritage value, with an emphasis on their aesthetic importance and traditional knowledge and practices used for making a living in a particular landscape. In this respect as well, the Jeruzalem terraces stand out: even though they are the youngest, having been created around 1965 in socialist Yugoslavia, their aesthetic value makes them the best known among the general public.

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TERRACED LANDSCAPES IN SLOVAKIA

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Terraces in the Low Tatras, Slovakia

Terraced landscapes in Slovakia

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ABSTRACT: This study investigates the distribution of terraced landscapes in Slovakia and analyzes their structural characteristics and land use. We found that traditional farming and terrace building as a part of agricultural intensification resulted in two types of terraced landscapes: historical terraced landscapes and new terraced landscapes. The two types differ in size, structure of various elements, their management intensity, and the impact of these spatial structures on biodiversity. Historical terraced landscapes in Slovakia have been partially preserved in vineyard regions, but they are mainly found in mountainous areas. New terraced landscapes are mainly linked to vineyard landscapes. The plant species composition on the mapped terraced landscapes shows a high diversity of habitats and terraces as agrarian relief forms create islands of species diversity in extensively managed agricultural landscapes.

KEY WORDS: terraced landscape, traditional agricultural landscape, agrarian relief forms, terraces, collectivization, Slovakia

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1 Introduction

Due to natural conditions, such as mild climate and varied topography agriculture represents the most dominant activity of its inhabitants since the earliest colonization of Slovakia (Špulerová et al. 2014b). The south Slovakia – namely, the productive Danubian Lowland (*Podunajská nížina*) and the Eastern Slovak Lowland (*Východoslovenská nížina*) were settled first, whereas the mountains and border regions were settled and colonized later. In order to improve relief and soil quality, and to decrease both erosion and surface runoff on sloping terrain in less-suitable areas, terraces were built for cultivation. Terraced landscapes developed in various places around the world as a result of terraced farming (Agnoletti et al. 2011; Fischer et al. 2012). They have many environmental effects and often create specific habitats for biota (Babai et al. 2015). The construction and function of the various elements of terraced landscapes and their interactions were the particular focus of this article. Because terraces are the result of long-term utilization of parallel plateaus and grassy slopes, we consider them historical terraced landscapes. The importance of terracing systems in different traditional landscapes is highlighted as one of the most relevant traditional elements in the rural landscape (Barbera and Cullotta 2012), and we consider terraces to be agrarian relief forms. Current studies indicate that naturally less-fertile soils were improved by terracing and long-term cultivation (Slámová et al. 2015). Dry stone walls were used as retaining structures (Petit, Konold and Höchtl 2012). Because gully erosion in traditional agricultural landscapes is controlled by the course of anthropogenic linear features such as unpaved field and forest roads and balks in arable land, terracing usually mitigates erosion (Saksa and Minar 2012). The distribution of terraced landscapes is also related to the geological substrate and slope processes (Barančoková and Barančok 2015). Because large parts of the agricultural landscape were transformed by intensification of agriculture in the second half of the twentieth century, agrarian terraces as the oldest relics of traditional agricultural land use remained only in remote, less-accessible, and less-fertile localities or in areas with significant slope inclination (Štefunková and Dobrovodská 2009; Ivanova et al. 2011; Lieskovský et al. 2014).

In the second half of the twentieth century, new terraced landscapes were created through agricultural intensification. These terraces were built as terrain stages on an originally continuous slope in order to mitigate water erosion and allow more efficient mechanical cultivation on the flat part of the terrace (Štefunková and Hanušin 2016).

Traditional and new terraced landscapes are extraordinary landscaping that was used by man to deliberately reshape the landscape for his needs. They are also witnesses to technological and economic evolution in a particular historical period.

This study investigates the distribution of terraced landscapes in Slovakia and analyzes their structural characteristics, which may indicate differences between types of terraces and their role for man and the landscape.

2 Methods

The spatial distribution of historical terraced landscapes in Slovakia was acquired from a rural inventory of traditional agricultural landscapes (Špulerová et al. 2011), using visual interpretation of aerial photos and a field survey. As a result of this inventory we classified four types of traditional agricultural landscape with occurrence of terraces.

- I. Traditional agricultural landscapes with dispersed settlements;
- II. Traditional agricultural landscapes with vineyards;
- III. Traditional agricultural landscapes with arable land, grassland, and orchards; and
- IV. Traditional agricultural landscapes with arable land and grassland.

The presence of terraces and other agrarian relief forms was identified and studied in detail as part of the field survey.

Altogether, above 626 landscape sites of traditional agricultural landscapes recorded during the fieldwork, out of which 480 entries include terraced landscape. Regarding the manner of cultivation, content of the soil skeleton, and configuration of relief, we distinguished four agrarian relief forms of terraced landscape (Figure 1):

- Relief forms as a result of improvement of relief and soil quality: terraces or banked fields (historical or new terraces). Terraces were created in the course of long-term utilization of parallel plateaus and grassy slopes (balks). Banked fields were created through ploughing, without flattening the relief of arable fields;

Figure 1: Agrarian relief forms of terraced landscape (A: terraces, B: banked fields, C: dry stone walls, D: slope mounds and heaps on terraces).

- Relief forms that are a result of soil-skeleton removal: dry stone walls were built from stones as supporting walls for vineyard terraces;
- Relief forms that are the result of both manners of soil cultivation: slope mounds and heaps occur on terraces or on banked fields, where stones from soil were removed and heaped onto the slope of the terraces or banked fields during yearly ploughing.

The agrarian relief forms were further characterized by the following features which were recorded in the field:

- Skeleton and soil content: 1) muddy, 2) muddy-rocky, 3) loamified rocky, 4) rocky (Figure 2);
- Width: average width of the soil/stone features by categories: 1) < 1 m, 2) 1.1–3 m, 3) > 3 m;
- Height: average height of soil/stone features by categories: 1) < 0.5 m, 2) 0.5–1 m, 3) 1.1–3 m, 4) > 3 m;
- Length: span length of soil/stone features (minimum and maximum of length) in meters;
- Continuity of banks: 1) continuous, 2) interrupted; interruptions are shorter than the fragments of a bank, 3) disconnected; interruptions are longer than fragments of a bank;
- Habitat: species richness on mapped agrarian relief form, species community belonging to the list of habitats with reference to the national habitat catalogue (Ružičková et al. 1996; Stanová and Valachovič 2002).
- Continuity of wood cover: 1) continuous; interruption of width is less than one time the vegetation height, 2) interrupted; interruption of width is two to four times the vegetation height, 3) disconnected; interruption of width is more than five times the vegetation height.

In order to determine the spatial distribution of new terraced landscapes in Slovakia, we used the CORINE Land Cover database (Pazur, Otaheľ and Maretta 2015) and land cover data from the national Basic Geographic Information System (ZBGIS) by Maretta (Cadastre, Cartography and Land Surveying Office of the Slovak Republic, 2015). Terraces were identified by using visual interpretations of aerial photos. We divided them into three groups: 1) terraced vineyards, 2) abandoned terraced vineyards, and 3) other new terraced landscapes, usually covered by grassland or orchards.

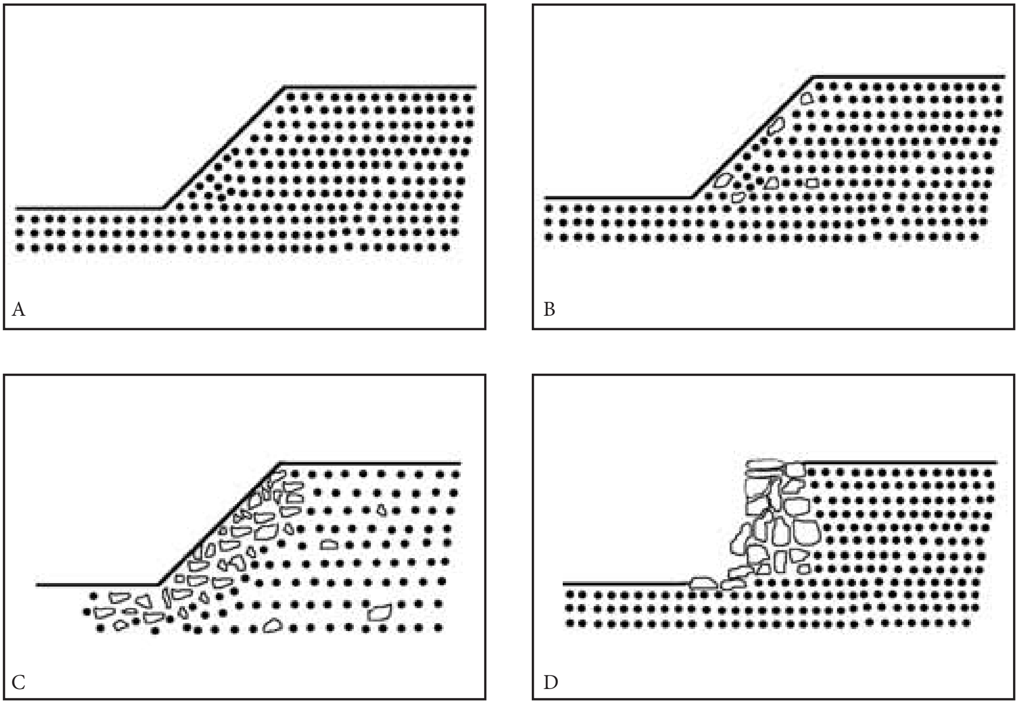

Figure 2: Skeleton and soil content of agrarian relief forms of terraced landscapes (A: muddy, B: muddy-rocky, C: loamified rocky, D: rocky).

3 Results

3.1 Land use of terraced landscapes

The terraced landscapes in Slovakia are a result of two different ways of land management focused on improving soil and relief condition. Long-term traditional farming has caused the origin of historical terraced landscapes. The terrace building as a part of agricultural intensification resulted in new terraced landscapes.

Historical terraced landscapes are usually extensively managed and consist of a patchwork of unique small-scale arable fields and permanent agricultural cultivations such as grassland, vineyards, and orchards.

Historical terraced landscapes have also been partially preserved in vineyard regions with a warmer climate (type II, traditional agricultural landscape of vineyards), but are mainly found in mountain areas with a cold climate on steep slopes and on shallow and skeletal soils (other types of traditional agricultural landscapes).

Historical terraced landscapes with vineyards create a patchwork of vineyards, often combined with orchards, grassland, and occasionally arable fields. They are mostly used for viticulture, or for other crops such as vegetables, fruit, potatoes, and cereals. They are distributed in southern Slovakia in the following natural – settlement nodal regions (*regióny*) (Miklós 2002): Lower Hron–Lower Ipeľ (Hont) (*Dolnohronsko-Dolnoipeľský (Hontský) región*), Lower Zemplín (*Dolnozemplínsky región*), Gemer–Novohrad (*Gemersko-Novohradský región*), Košice (*Košický región*), Danube (*Podunajský regón*), Nitra (*Ponitriansky región*), Trnava (*Trnavský región*), and Záhorie (*Záhorský región*). Infrastructure and buildings such as vineyard houses, cellars with vacation houses, and cottages are also a significant element of this small-scale structures because their presence is correlated with their management intensity. Where buildings are present, the patterns of agricultural mosaic are usually regularly managed and this management directly supports maintenance of the traditional landscape. Wine taverns and wine cellars are typical small architectural elements for the vineyard landscapes; however these were often expanded and rebuilt into weekend houses.

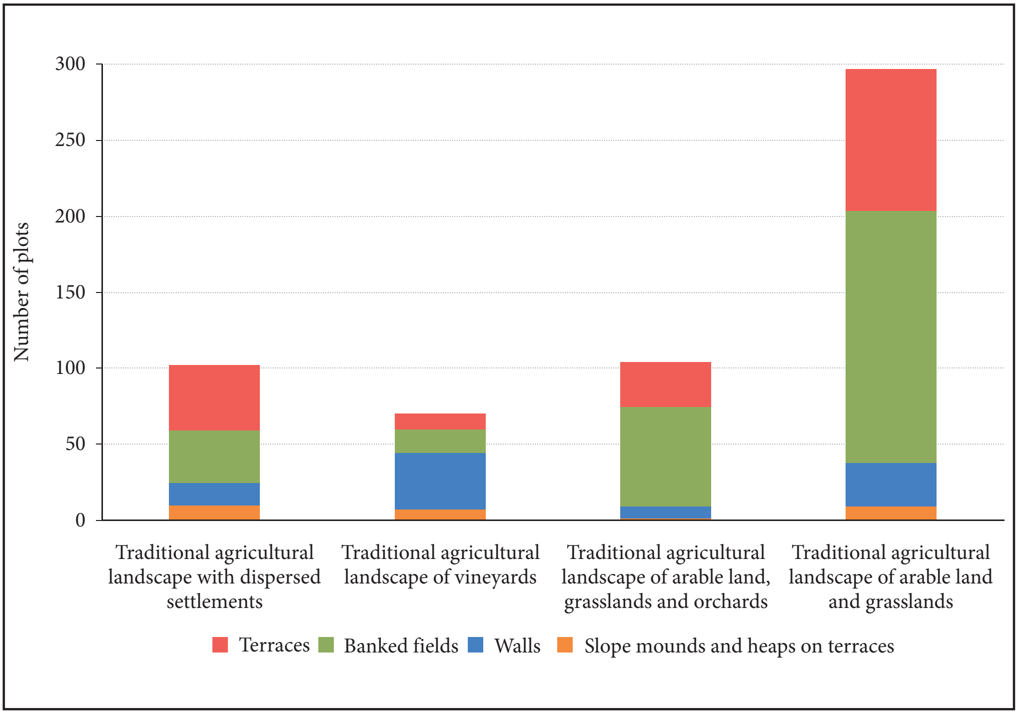

Figure 3: The presence of agrarian relief forms in traditional agricultural landscapes of Slovakia.

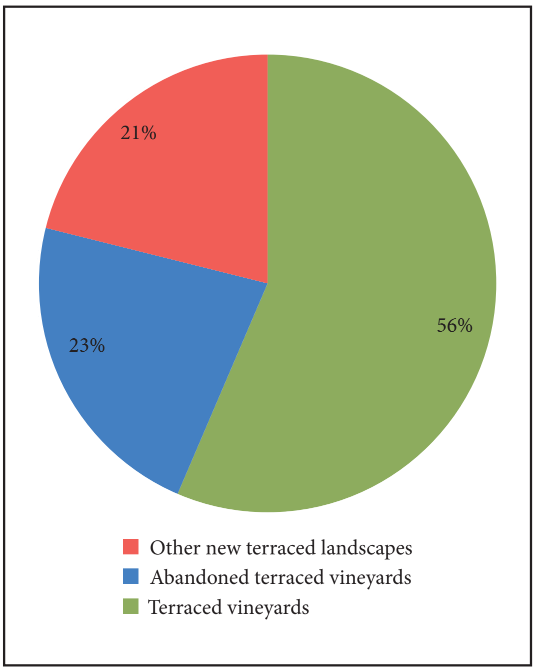

Figure 4: The area (in hectares) and share of characteristic types of new terraced landscapes.

The mountain terraced landscapes occur in other three types of traditional agricultural landscapes (with dispersed settlement – type I, with orchards – type III or with arable land and grassland – type IV). They are characterized by a cold climate, steep slopes, and less-fertile soil, and therefore they are not very suitable for intensive agriculture. They consist of a patchwork of arable land, orchards, and grassland. They are primarily used for producing hay, vegetables, fruit, potatoes, and cereals. Due to declining management, they have often been transformed into grassland and their heterogeneous patterns are becoming rare. They are threatened by abandonment or construction. Hay barns, springs, and shelters have rarely remained in the traditional agricultural landscape of arable land and grassland.

New terraced landscapes are mainly linked to vineyard landscapes and rarely to other agricultural production. New terraces were created in the second half of the twentieth century and are intensively managed. They usually consist of a vineyard monoculture, and some of them were abandoned and overgrown with grass after 1990 (Figure 4). They are prevalent in the Little Carpathian Mountains (*Malé Karpaty*) and in south-central Slovakia on slopes with an incline greater than 6°. The new terraced landscape with orchards and/or grassland were mapped in Spiš region (*Spišský región*).

3.2 Main features of terraced landscapes

The largest group of agrarian relief forms are banked fields and terraces, which mainly occur in the traditional agricultural landscape of arable land, grassland, and orchards (type IV). The most valuable terraced landscapes feature dry stone walls, which are mainly found in the traditional agricultural landscape of vineyards (type II) and less frequently in the traditional agricultural landscape with dispersed settlements (type I) (Figure 3).

We differentiated agrarian relief forms in terms of the proportion of rocky material in the substrate, size parameters (width, height, and length), and plant species composition (Figures 5, 6). The terraces and banked fields were gradually formed on the edge of the plot through ploughing, and they are characterized by muddy or muddy-rocky skeleton content. Rocky content is typical for two other agrarian relief forms: walls and slope mounds/heaps on terraces. The height of agrarian relief forms ranges at most from 1.1 to 3 m, and the width mostly exceeds 3 m.

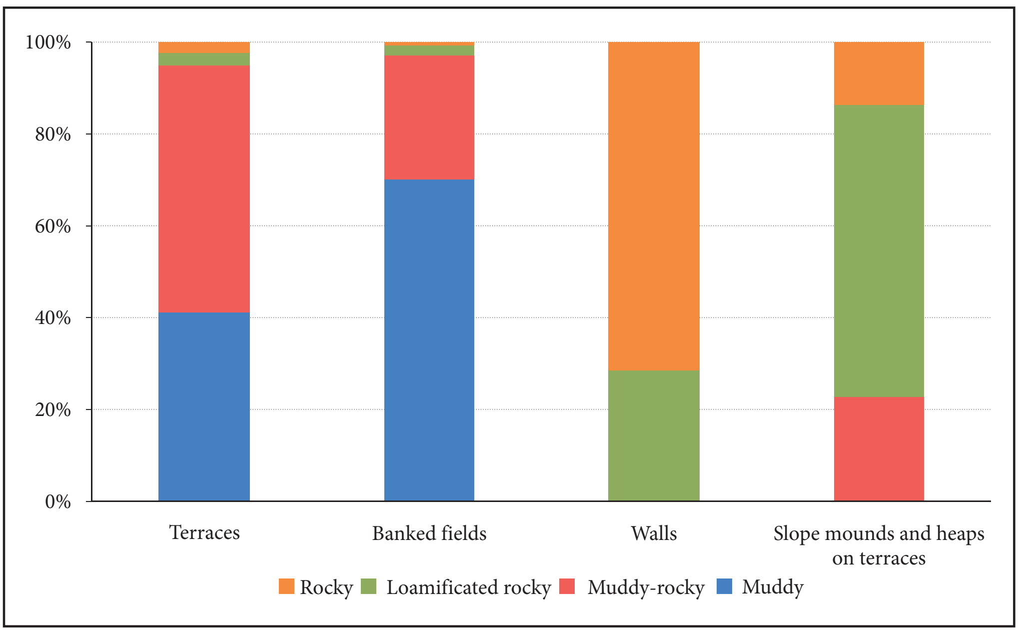

Figure 5: Skeleton content of agrarian relief forms in historical terraced landscapes.

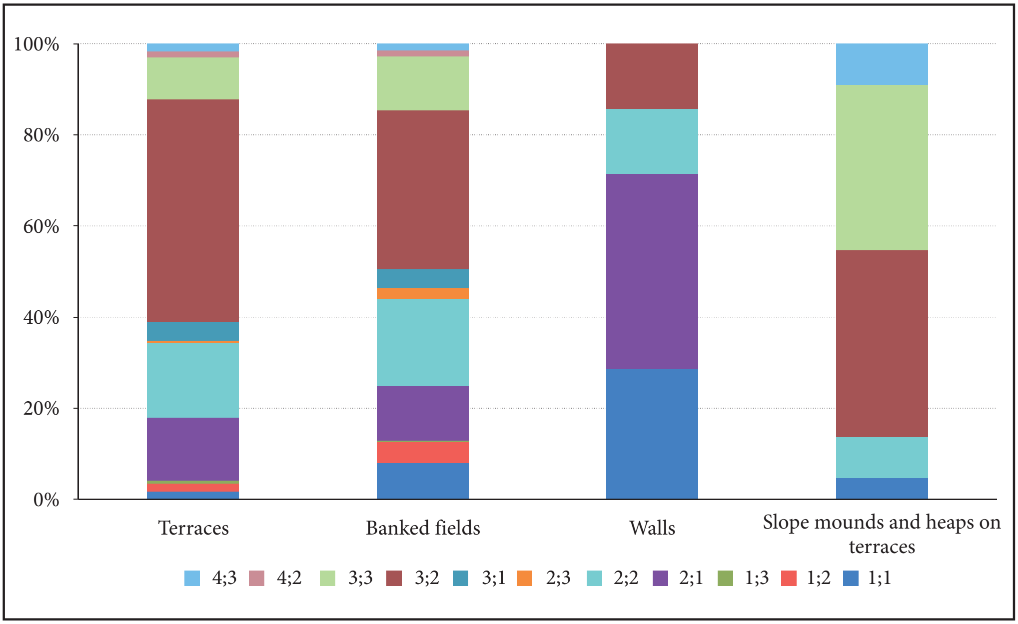

Figure 6: Parameters of historical terraced landscapes.
Legend: First number: height category: 1) < 0.5 m, 2) 0.5–1 m, 3) 1.1–3 m, 4) > 3 m; second number: width category: 1) < 1 m, 2) 1.1–3 m, 3) > 3 m).

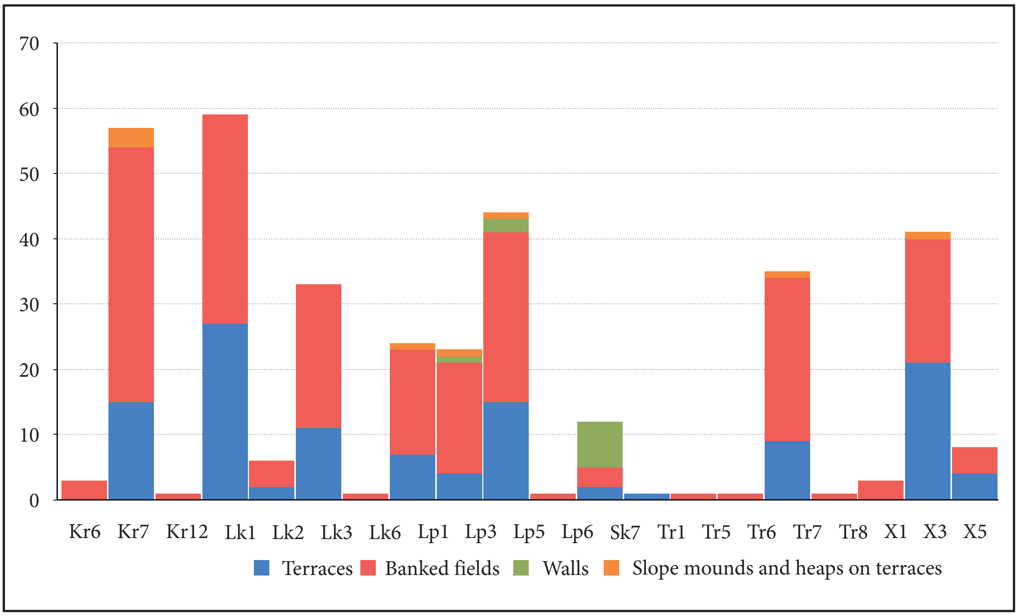

Figure 7: Vegetation on terraced agrarian relief forms.
Legend: Habitats: Kr6 Continental deciduous thickets, Kr7 Temperate thickets and scrub, Lk1 Lowland hay meadows, Lk2 Mountain hay meadows, Lk3 Mesophile pastures, Lk6 Eutrophic humid grassland, Lp1 Lines of planted fruit trees, Lp3 Lines of domestic deciduous trees, Lp5 Lines/remnants of mixed succession wood species, Lp6 Line/remnants of invasive woody species (*Ailanthus altissima, Negundo aceroides*, and others), Sk7 Secondary rocky habitats, Tr6 Xeri-thermophile fringes, Tr7 Mesophile fringes, Tr8 Mat-grass swards, X1 Herbaceous clearings, X3 Ruderal communities, X5 Field margin cropland.

Previous studies show that agrarian relief forms create islands of species diversity in extensively managed traditional agricultural landscapes (Ružičková et al. 1996; Imrichová 2006; Aavik and Liira 2009; Špulerová et al. 2014a). The plant species composition on the mapped terraced landscapes shows a high diversity of habitats, from open secondary screes and rocky habitats through ruderal communities and semi-natural grasslands to shrubby habitats, lines of trees, or other small woody patches (Figure 7). Because some habitat relevés could not be assigned to a particular syntaxon, but are affected by human activities or various phases of succession development between grassland, scrubland, and forest, we did not include them in the figure.

Banked fields were most often formed by communities of temperate thickets and scrub (Kr7) or lines/remnants of mixed succession wood species (Lp5). If agrarian relief forms were managed, they were usually covered by lowland hay meadows (Lk1) or mesophile pastures (Lk3). The presence of arable land was often accompanied by the occurrence of ruderal communities (X3). Species richness depends on complex factors and corresponds to certain abiotic factors, habitat types, aspects, and methods of cultivation.

The biodiversity of new terraced landscapes is generally lower due to intensive use of heavy machinery and intensive fertilization. However, in some areas landscape diversity has increased due to building new terraces during the communist era (Hanušin and Štefunková 2015).

4 Discussion and conclusion

Terraced landscapes were originally created mainly to protect and improve the soil quality and agricultural productivity in regions with unfavorable natural conditions. The ecosystem effects of such a specific landscape type have changed significantly. From the production point of view, they do not play an important role in sustaining food provision for local communities. In the case of terraced vineyards, their production and soil protection function remains an important issue. Today many terraced landscapes face two main threats: abandonment and subsequent succession (Gelencsér, Vona and Centeri 2012; Gellrich et al. 2007) or expansion of construction areas if they are located near large settlements.

Building various »steps« or terraces was the practice of cutting flat areas out of a hilly or mountainous landscape in order to grow crops. This type of farming influenced the development of various habitats. As a result of long-term utilization and management of the traditional agricultural landscape and extensive management practices, it can generally be concluded that traditional agrarian relief forms are overgrown by semi-natural or natural vegetation and that they increase the overall landscape ecological value of these landscapes. The biodiversity of newly created terraced landscapes is lower, but new terraced landscapes also increase overall landscape diversity and stability compared to intensified large block fields.

The preservation of such landscapes mostly depends on tradition and is highly dependent on the demographic situation. After decades of their utilization in changing social and economic conditions, the question is what their role and function would be today (Lipský 1995; Liquete et al. 2015). Stakeholders' preferences could significantly influence the preservation of these landscapes (Howley, Donoghue and Hynes 2012). The same landscape type could provide different services based on the context of preferences. From this perspective, it is important to focus future research on assessing how terraced landscapes affect the ecosystem and especially how they are changing in order to justify their preservation. It is also very important to involve social research to investigate social preferences for utilizing such landscapes.

This patchwork of agrarian relief forms and small-scale arable fields or permanent agricultural cultivations comprises areas that are defined as farmland with a high natural value in the European Union (Andersen et al. 2003; Ažman Momirski and Kladnik 2015). These areas are of great value, both from the perspective of nature and heritage conservation, as well as with regard to landscape and aesthetic values (Urbanc, Gašperič and Kozina 2015; Smrekar, Polajnar Horvat and Erhartič 2016; Smrekar, Zorn and Komac 2016). It is necessary to pay special attention to them, to develop strategies for their preservation, and to learn from good practices of the past and good examples from other countries (Stanchi et al. 2012; Kravchenko et al. 2016).

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CLASSIFYING THE MEDITERRANEAN TERRACED LANDSCAPE: THE CASE OF ADRIATIC CROATIA

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Terraces with dry walls on the island of Korčula.

Classifying the Mediterranean terraced landscape: The case of Adriatic Croatia

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ABSTRACT: This article presents a Croatian Adriatic terraced landscape classification, highlighting its natural and cultural background and proposing a classification framework for further research. The classification is based on the landscape level (i.e., the »landscape pattern level«), synthesizing its structural, biophysical, and cultural-historical dimensions. The interpretation of classes involves a combination of general land use, structure, geomorphology, local land use, crops, soil type, and historical aspects. Nine classes of terraced landscapes are identified and described, example locations are given, and they are substantiated with illustrations and photos.

KEYWORDS: landscape classification, cultural landscape, terraces, agricultural land use, Mediterranean, Adriatic, Croatia

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1 Introduction

Agriculture terracing involves leveling slopes in order to create accessible, flat, or sloped plots for agricultural, silvicultural, or pastoral use. The terraces allow the redistribution of soil and prevent soil erosion by controlling the quantity of existing soil and soil brought from the surroundings by man or controlled erosion (Countryman 2012). Terracing has many positive effects because it makes it possible for roots to penetrate hard ground and provides control of the water regime. It also contributes to protecting the ground from wind and ensures better insolation. The shape of terraces depends on various factors, such as their purpose, soil properties, lithology, and relief characteristics, and on construction craftsmanship and local agricultural practices.

Cultivated terraces are a prominent feature of the Mediterranean agricultural landscape, and due to their cultural, ecological, and aesthetic value they have had great importance for a range of academic disciplines (Titl 1965; Price and Nixon 2005; Asins-Velis 2006; Acovitsióti-Hameau 2008; Kale 2011; Sluis, Kizos and Pedroli 2014; Gadot et al. 2016). On the other hand, contribution by Croatian researchers and information on Croatia's terraced landscapes are scant and do not correspond to the variety of efforts invested in their protection (Gotthardi Pavlovsky 1972; Kladnik, Šmid Hribar and Geršič 2017) and interpretation (Gams 1987). These circumstances and the fact that rural exodus, tourism, and new agricultural techniques are increasingly endangering the integrity of terraced and other cultural landscapes (Andlar and Aničić 2017) necessitated an extensive study (Andlar 2012) to assess and evaluate Croatia's Adriatic cultural landscapes. The research showed the great diversity of agricultural terraced landscapes in the region and provided sufficient data to establish a classification of terraced landscapes and a framework for future research.

1.1 Natural and cultural-historical background

The Croatian Adriatic region extends across approximately one-third of Croatian territory (18,000 km²). This predominantly karst area is characterized by a Mediterranean climate, high complexity of relief forms, thin soil, sparse natural vegetation, lack of surface water (Filipčić 1998; Bognar 2001; Andlar 2012), and a Euro-Mediterranean cultural context. High and irregularly distributed precipitation, along with high soil erosivity, have resulted in high ecological sensitivity of the area (Cvijić 1918; McNeil 2003; Grove and Rackham 2001). Natural conditions are harsh but vary significantly due to the great diversity of environmental factors (Ciglič et al. 2012), which has led to a high diversity of human adaptation, in which terracing has played an important role in stabilizing resources on steep slopes and in valleys, dolines, and gullies (Andlar 2012).

The diversity of terraces can be observed from the cultural point of view. Many areas have a distinctive pattern of terraces that reflects cultural and economic influences, and local practices. Due to the high endurance of stone and slow modernization processes, agricultural landscapes still testify to the earliest times of human culture. Terracing has probably been present since the first agricultural activity in steep terrain. However, there is no clear evidence of the evolution of terracing techniques over time; it may have remained unchanged for thousands of years. Many researchers believe that terracing was already present in the Mediterranean in the Neolithic (Price and Nixon 2005; Hughes 2005), whereas other research shows that the first terraces were built during the Bronze Age (Countryman 2012; Grove and Rackham 2001). This was probably related to the spread of agriculture practices and the establishment of a Mediterranean polyculture with the introduction of new agricultural techniques, including terracing. In Croatia, some stone structures have been found in Neolithic settlements (Moore et al. 2007) and on the site of an Iron Age hill fort (Barbarić 2010) (it is rather certain that the terracing happened in the nineteenth or twentieth century), but no clearly prehistoric terraces could be confirmed. In the Greek and Roman period, terracing was clearly present in newly farmed land. For example, the ancient Greek geometrical system of land division has been preserved on the Stari Grad plain on the island of Hvar (Zaninović 2002), and it influenced the spatial organization of terraced fields.

The next indicative period was the High Middle Ages to Early Modern Age. The Euro-Mediterranean area had flourishing agricultural production from the eleventh to thirteenth century due to the agrarian revolution and economic development (Delort and Walter 2002). In the eastern Adriatic, the development of agricultural communities was fostered by the establishment of medieval statutes, which, in some cases, regulated how agricultural land and terraces were managed (e.g., the Dubrovnik Statute of 1272). From the early fifteenth century onward, some eastern Adriatic islands were targets of regional immigration after the Ottoman annexation of the Adriatic hinterland (sixteenth to eighteenth centuries), and the additional need for arable land was met by allocations (Latin *gratia*; Kasandrić 1978) of former communal land (mostly pastures) to the new settlers for cultivation (Carter 1992; Kovačić 1993; Tudor 2004; Dokoza 2009). Evidence of early terraced landscapes can be seen in a 1573 bird's eye view of the island of Korčula prepared by Simon Pinargenti (Marković 2001). The southern coastal slopes of Dingač on the Pelješac Peninsula were also cleared for growing grapes in the sixteenth century (Glavina 2008).

The last large-scale karst reclamation with extensive terrace construction took place in the late nineteenth and early twentieth centuries, and was caused by large-scale environmental and socio-political events such as the pandemics of grapevine diseases that first hit the leading winegrowing regions of France and Italy, the ease of international sale through established Austro-Hungarian trade links and the empire's large market, and the partial transfer of land ownership (or at least disposal rights) from large landlords, the state, or communes to the wider population (Trogrlić 1980; Kale 2006 and 2010; Kraljević 1994; Kulušić 2006; Žuvela-Doda 2008). This period of growth ended in a similar way: suddenly and as a result of larger events such as the First World War, the 1918 flu pandemic, and several others that led to a large-scale crisis that resulted in land abandonment and exodus (Kraljević 1994). Because the vast majority of extremely steep slopes, remote areas, and uninhabited islets have never been reclaimed again, it can be argued that labor-intensive terrace construction and maintenance were only possible under extraordinary socioeconomic conditions. Therefore, these large-scale landscape transformations were far from sustainable, as opposed to polyculture, which is common in the Mediterranean.

The most notable example of terrace construction soon after the Second World War is the creation of the terraced vineyards in the Primošten area, carried out in the first period of communist collectivization, when agricultural cooperatives were established (Kale 2006), similar to eastern Slovenia (Kladnik et al. 2016b; Pipan and Kokalj 2017). The vineyards were newly planned and designed, but they were inspired by landscape patterns from the surrounding area. This method proved to be successful and could be recommended for planning karst land reclamation in the future.

1.2 Classification of terraces

It can be observed that there is lack of standardized nomenclature and classification of terraces. For example, a constructive typology of terraces was given in the transnational project ALPTER (Internet 1) but its nomenclature was primarily based on Italian terms, such as balk (Italian *ciglioni)*, fanlight (Italian *lunette)*, step (Italian *gradoni*), terrace, and terrace construction (Scaramellini 2008). The terrace typology most often cited is probably that by Grove and Rackham (2001), who classified Mediterranean terraces based on their construction and structural characteristics: step terraces, pocket terraces, braided terraces, check-dam terraces, and terraced fields.

A terrace consists of three parts. The terrace wall is referred to as a *riser*, the flat planting surface is the *tread* or *platform*, and the soil in the interior of the terrace behind the riser is the *fill* (Countryman 2012; cf. Frederick and Krahtopoulou 2000, 80). The direction of the riser is usually parallel to the terrain contours.

Based on the type of riser, the following basic terrace types were distinguished in the research area:

- Terraces with built risers; a dry stone wall supporting the construction is the most common, and the riser is vertical, or gently sloped towards the terraced plot. Other forms of supporting structures are possible but are very rare, such as wattle.
- Terraces with a vegetation riser; hedges or trees are intentionally or spontaneously grown.
- Unwalled terraces; these are shaped intentionally or spontaneously due to ploughing longitudinally along the contour lines. This type of terrace is particularly associated with heavy textured soils.

2 Methods

The terraced landscapes in the Croatian Adriatic region have not yet been the subject of systematic investigation. General or site-specific interpretations of Croatian Adriatic karst land use, and terraced or dry stone landscapes from the archaeological, geographical, architectural, structural, biophysical, ethnological, or historical points of view are given by Aničić and Perica (2003), Borovičkić (2008), Buble (2009), Freudenreich (1962), Gams (1991), Kale (2006, 2008, 2010), Kulušić (1999, 2006), Lozić et al. (2013), Petrić (2008), Slapšak et al. (1998), Tudor (2004), Zaninović (2002), and Zupančič (2010). In neighboring Slovenia, the research project Terraced Landscapes in Slovenia as Cultural Values (2011–2015) produced a systematic inventory of terraces throughout the entire country. Characterization of terraces was carried out within Slovenian landscape types and based on construction techniques, purpose, metrics, biophysical features, and the history of terracing (Ažman Momirski and Kladnik 2008; Kladnik et al. 2016a; Šmid Hribar et al. 2017).

The first comprehensive study of the Croatian Adriatic cultural landscape was based on extensive research on land use and identity in agricultural, forestry, and salt-extraction landscapes. In order to identify outstanding cultural landscapes, landscape history and classification studies were carried out (Andlar 2012; Andlar and Aničić 2017):

- Research on rural landscape history provided a chronological outline of successive historical periods with common social and spatial patterns. Its purpose was to outline the history and identity of the present landscape and to understand the historical background on a regional level and at the particular locations observed .
- Landscape classification was based on the model of functional, structural, and cultural-historical aspects of landscape types, synthesizing several theoretical and practical approaches (e.g., Fairclough 2010). The classification consists of three levels: the first one is based on general land-use categories, the second revolves around the concept of land-use structure, and the third applies the concept of structural, functional, and cultural-historical landscape character.

These historical and classification studies, along with descriptions of outstanding landscapes (half of the sixty-three sites identified are terraced or partially terraced), were used in this article as a starting point for terraced landscape analysis and classification. Additional information was collected through a series of local landscape character assessments and a WebGIS public participatory database of Croatian Adriatic dry stone wall heritage (Suhozid … 2016). Creation of the register involved combined flyovers and fieldwork carried out since 2007, establishment of a geo-tagged photo register, and analysis of data from various available sources, such as historical and recent digital orthophoto images, topographic, soil, and historical maps, and CORINE land cover (CORINE … 2016), Google Earth (Google Earth 2016), and ARKOD data (ARKOD 2016).

3 Classification of terraced landscapes

The classification was based on the »landscape pattern scale,« which is defined as consecutive repetition of a similar anthropogenic structure in relation to particular natural and cultural features (Andlar and Aničić 2017). Identification of the terraced landscape class was based on a synthesis of structural, natural, and anthropogenic factors; namely, general land use, structure and geomorphology, local land use, crops and soil type, and historical aspects. Each class is presented with a sketch and an example location is given.

3.1 Terraced field landscapes

The following terraced landscape types are part of »field landscapes,« which are defined by the presence of natural cultivated soil, where cultivation is primarily achieved through ploughing. It is related to karst depressions with undulating bottoms that have been cultivated with shallow, non-consecutive, and wide terraced fields. The main types of such landscapes are the following:

(A) Wide regular-pattern terraced fields in landscapes with karst poljes and river valleys (Figure 1) are associated with large karst depressions with shallow terracing with mildly undulating bottoms. Due to their spaciousness and gentle slopes, regular (sometimes planned) patterns are common. The terraces are usually combined with fields and enclosures, forming a mixed crop system defined by the proximity of settlements and a complex history, such as Stari Grad on the island of Hvar.

(B) Wide irregular-pattern terraced fields in landscapes with karst uvalas and large dolines (Figure 1) are associated with moderate-sized karst depressions with pronounced relief and consequently irregular and organic terrace patterns. This type involves various land uses with mixed crops, and is related to small nucleated or scattered settlements and hamlets located above the field. This is a typical rural land pattern in the Adriatic hinterland.

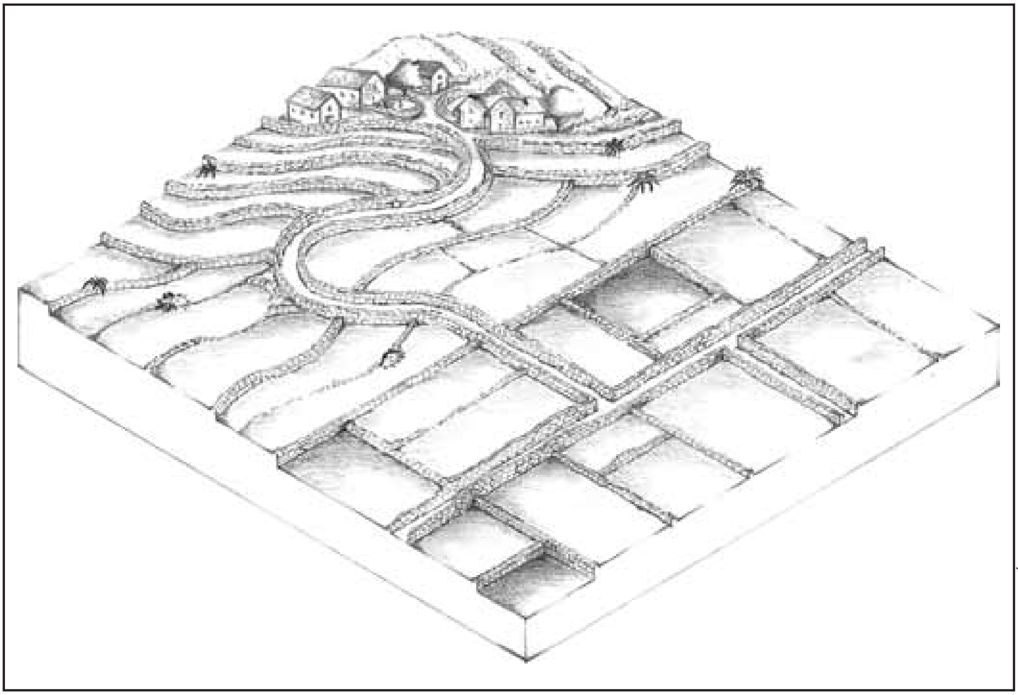


Figure 1: Irregular- and regular-pattern terraced fields (left to right).

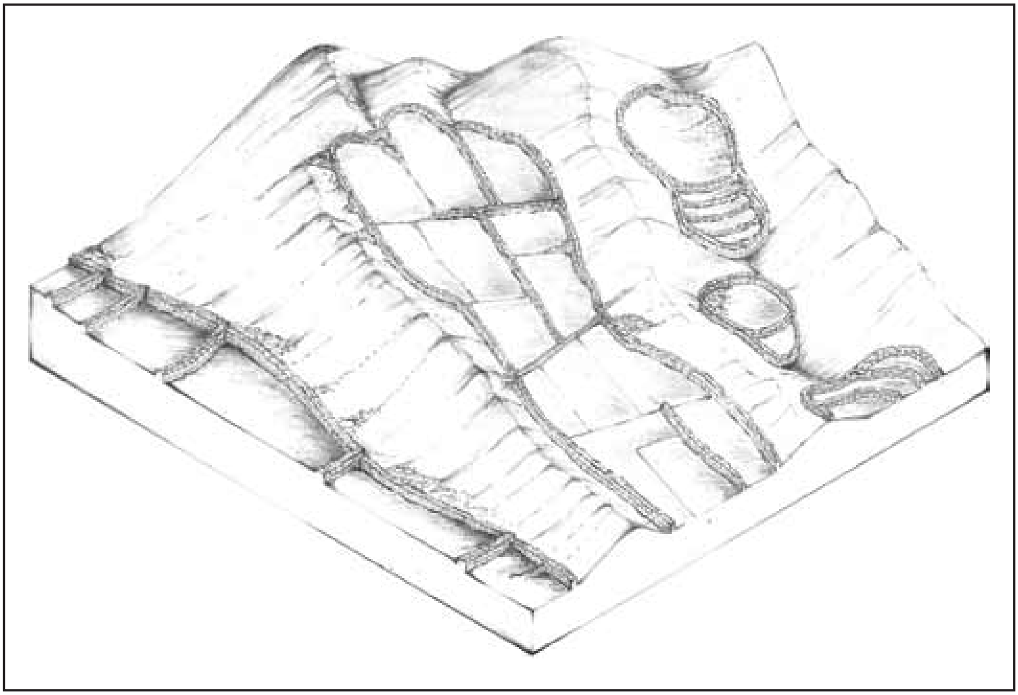
(C) Terraced fields in landscapes with shallow ravines and dry valleys (Figure 2). Sloping, narrow, elongated dry valleys and ravines create oases with arable soil that were enclosed by dry walls and terraced in order to preserve soil and control water flow during thunderstorms. Interesting examples can be found on the island of Brač, where narrow, winding valleys up to ten kilometers long with a single row of terraced fields with mixed or vineyard use can be observed. A variation of this class is seen on the island of Krk, where scattered terraced enclosures can be found in cultivated gullies.

(D) Terraces and terraced fields landscapes on colluvium (Figure 2). A particular type of terraces evolved on very steep colluvium (even exceeding 35°), where consecutive terracing is not common because of its physical characteristics and resistance to erosion. The inclination is unchanged or slightly flattened, and the risers are sporadic. Large, elongated deposit patches are completely cultivated and sometimes enclosed by dry stone walls. The fertile and porous soil is suitable for cultivating quality grape varieties. Such sites are located on southern coastal slopes of the island of Hvar and on the Pelješac Peninsula. The emergence of these terraces is likely to be associated with the first period of karst land reclamation.

(E) Unwalled terraced field landscapes (Figure 3). This type of terrace is associated with flysch areas such as »Gray« Istria (the flysch or clay central part of Istria) and the Ravni Kotari region, where built structures are not present (or are negligible) due to the lack of stone on the surface and the physical characteristics of the soil, whereas vegetation risers are common. It is characterized by a curved strip pattern. As opposed to neighboring karst areas, these areas have patches of fertile land, characteristic for mixed use with long continuity.

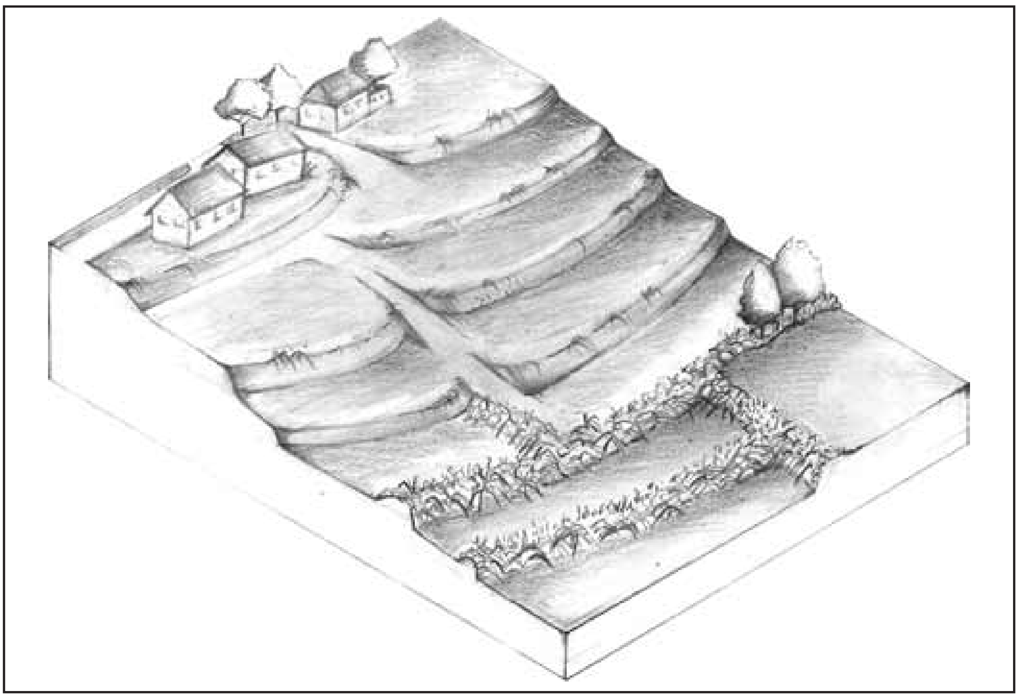
3.2 Hillside terraced landscapes

The following terraced landscape types are associated with consecutive terracing, dry stone wall risers, and narrow to moderate tread width, usually designed for one or several rows of cultivated plants (olives, grapes, lavender, etc.). Ploughing is absent or rare in these areas. Such terraced landscapes are common



ANITA TROJANOVIĆ

Figure 2: Terraced fields in a dry valley, terraces and terraced fields on colluvium, and a terraced shallow ravine (left to right).



ANITA TROJANOVIĆ

Figure 3: Unwalled terraced fields with and without vegetation risers.

in remote, steep areas outside settlements and were initially intended to be monocultural due to karst land reclamation. The main types of hillside terraced landscapes are the following:

(F) Regular-pattern step-terraced landscapes (Figure 4). They are typical for the upper parts of slopes. The dry stone walls are usually solid and well built, and are sometimes higher than the tread width. The connection between terraces is achieved by steps cut into the riser, protruding from the riser, and/or on the top of piles of stone and walls that run along the slope. The terrace patterns are regular, but can vary, depending on various factors. Groups of terraces are sometimes enclosed by stone walls in various forms. Regular enclosures usually indicate later colonization, with the distribution of land organized among new owners. Very narrow terraces were initially mostly intended for growing grapes. This type can be found in the southern part of the islands of Korčula and Hvar, and in the hinterland of Trogir.

(G) Irregular-pattern terraced landscapes (Figure 5). This type is associated with an irregular plot pattern with a non-continuous riser, often containing a ramp that links the upper and lower treads. A poor-quality wall structure is common in this type, which can be found in areas with sparse surface stone or where rock fragments or small pebbles are found in soils. It is also typical for areas with sandy soils; for instance, on the island of Susak, where terrace risers are overgrown with reeds. Various crops may be associated to this type, but, unlike the previous one, grains, vegetables, and mixed use are more common.

(H) Pocket-pattern terraced landscapes. This type is associated with semicircular or triangular parcels, either laid out individually or in a series in a honeycomb pattern, which may contain a dry stone wall riser (Figure 6), but the riser may also be completely absent (or »spontaneous«; Figure 7). The latter subtype can be found on slopes with large stone fragments where natural voids in the rocks were slightly reshaped and filled with soil usually in order to grow individual plants (olives or grapes). Individual pocket terraces are intended to grow one cultivar, but larger pockets were probably used for creating small arable plots (e.g., for growing tansy or grains, or for meadows).

(I) Off-contour terraced landscapes (Figure 8). These atypical terraces are characterized by supporting walls laid out at an angle, sometimes even perpendicular to the terrain contours, characterized by a narrow pattern.

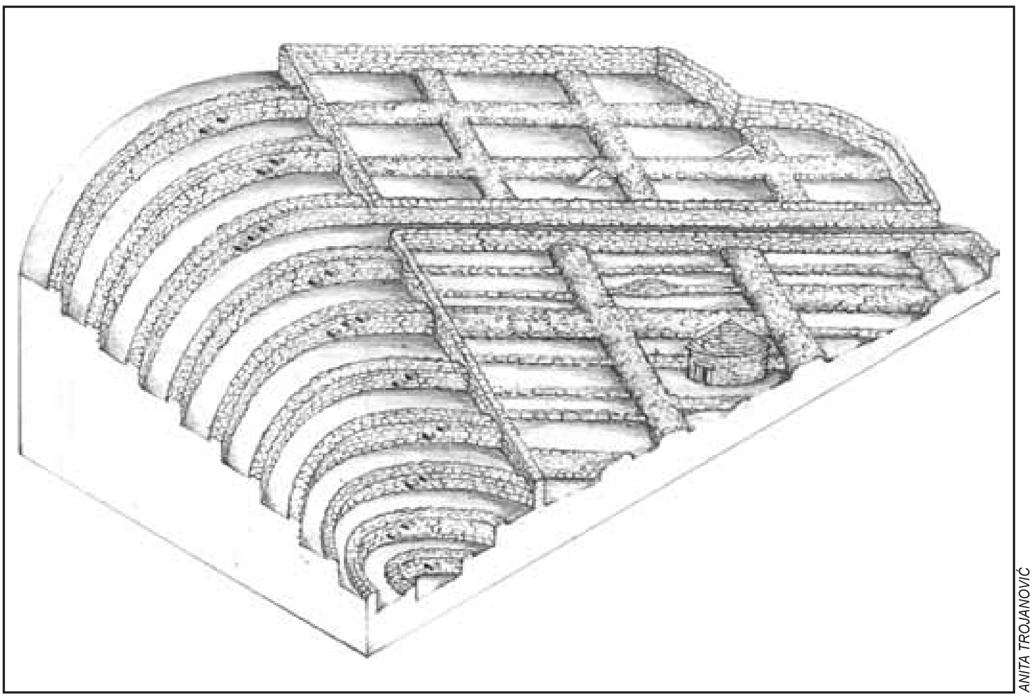
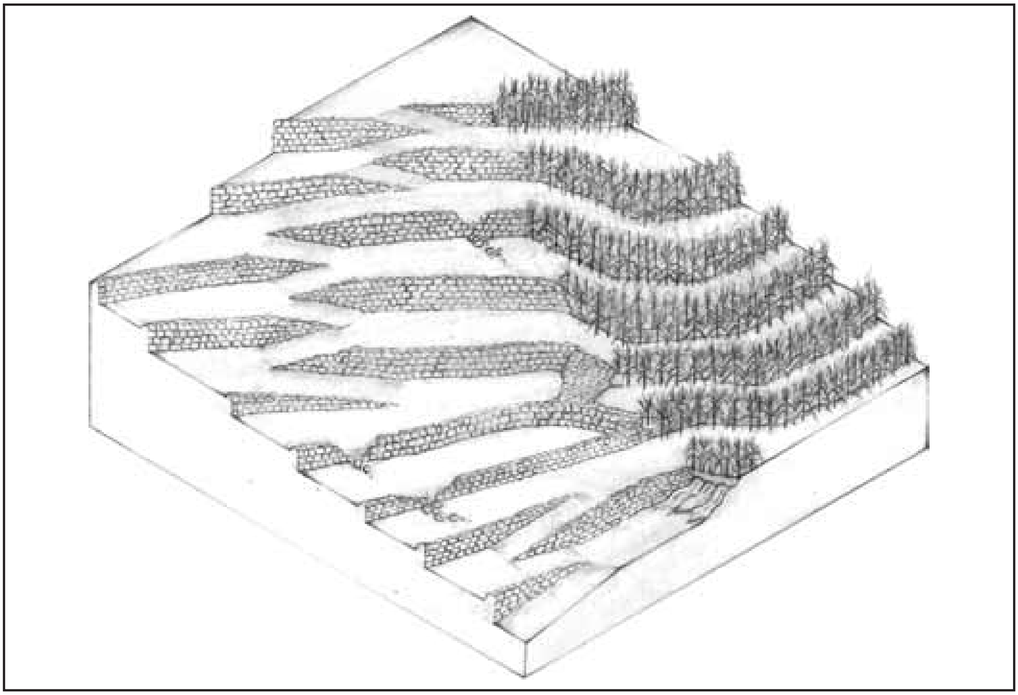


Figure 4: Variations of regular-pattern step terraces: a narrow organic pattern, a narrow vertically intersected pattern, and a wide rectangular pattern (left to right).



ANITA TROJANOVIĆ

Figure 5: Irregular-pattern terraces with dry stone wall and vegetation risers (left to right).

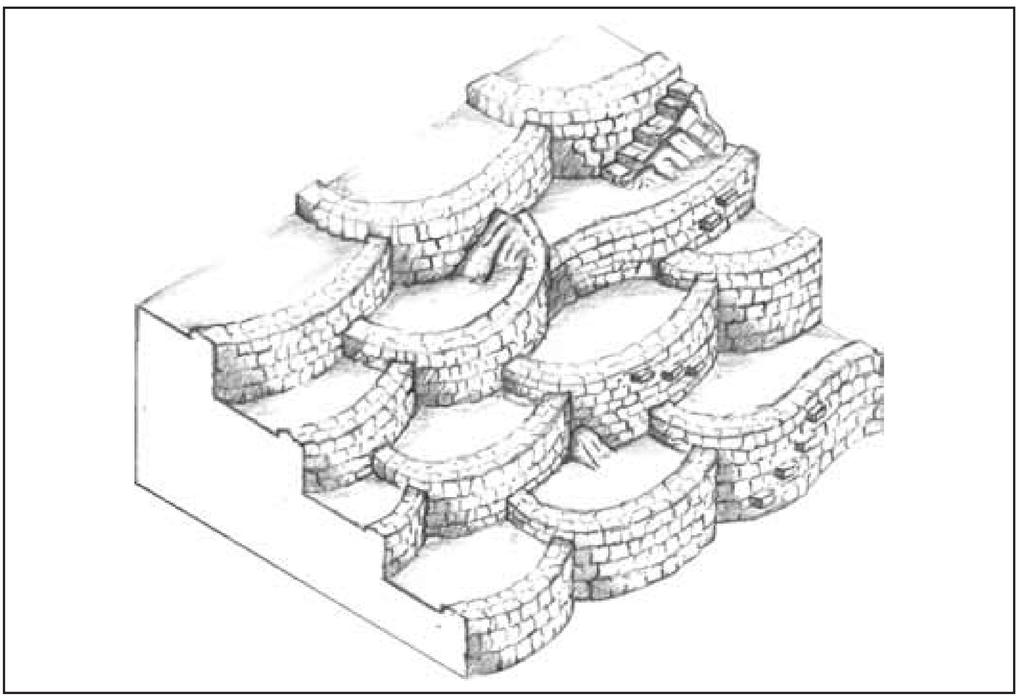


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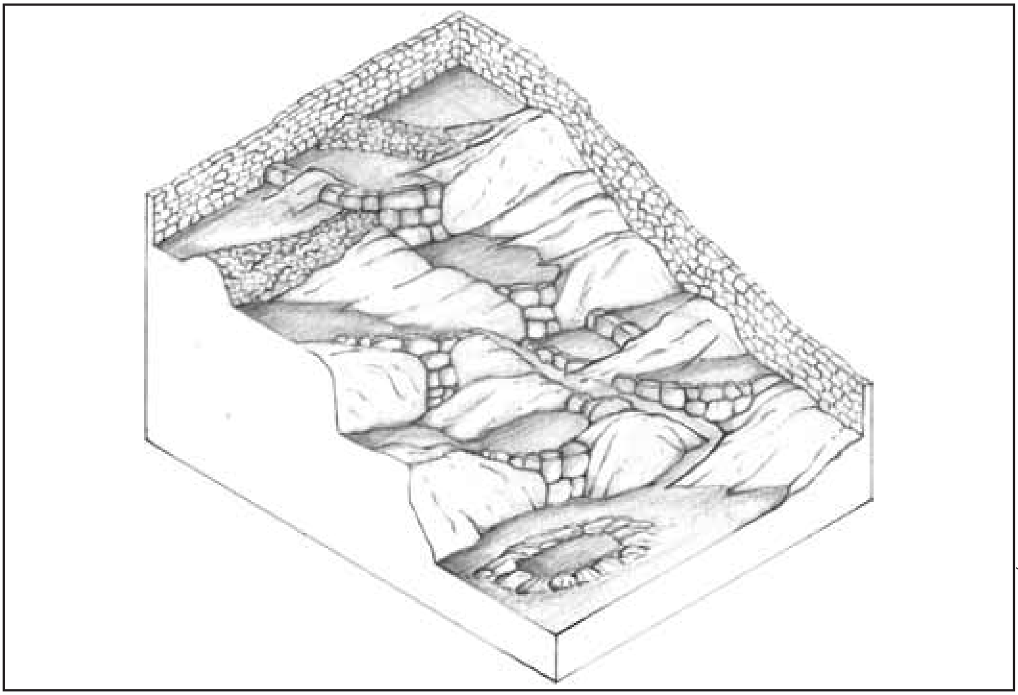
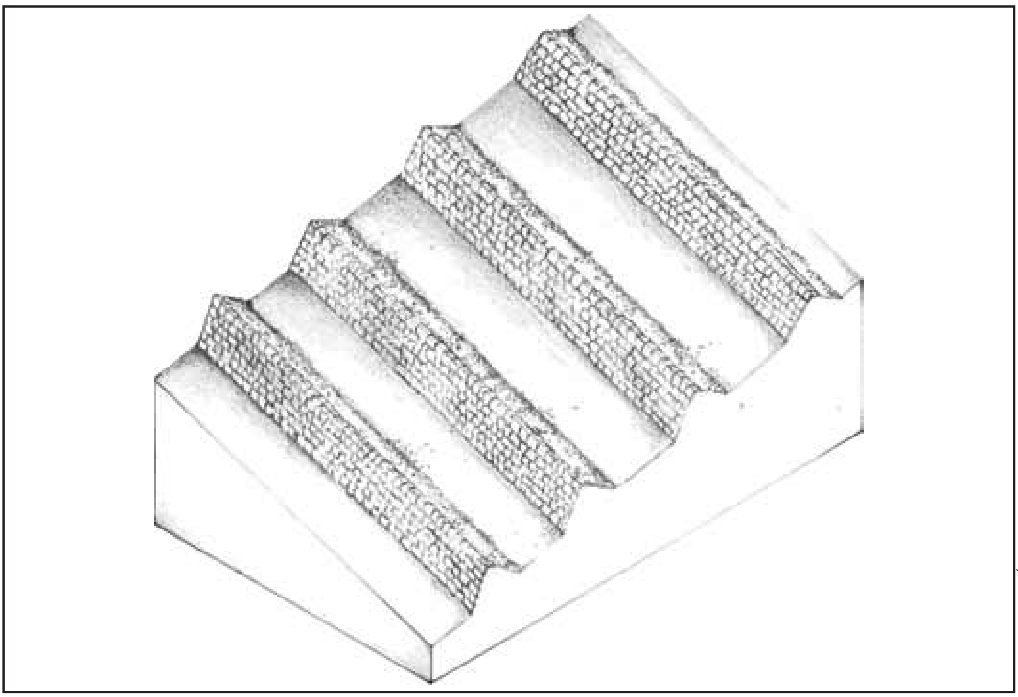
Figure 6: Pocket terraces.



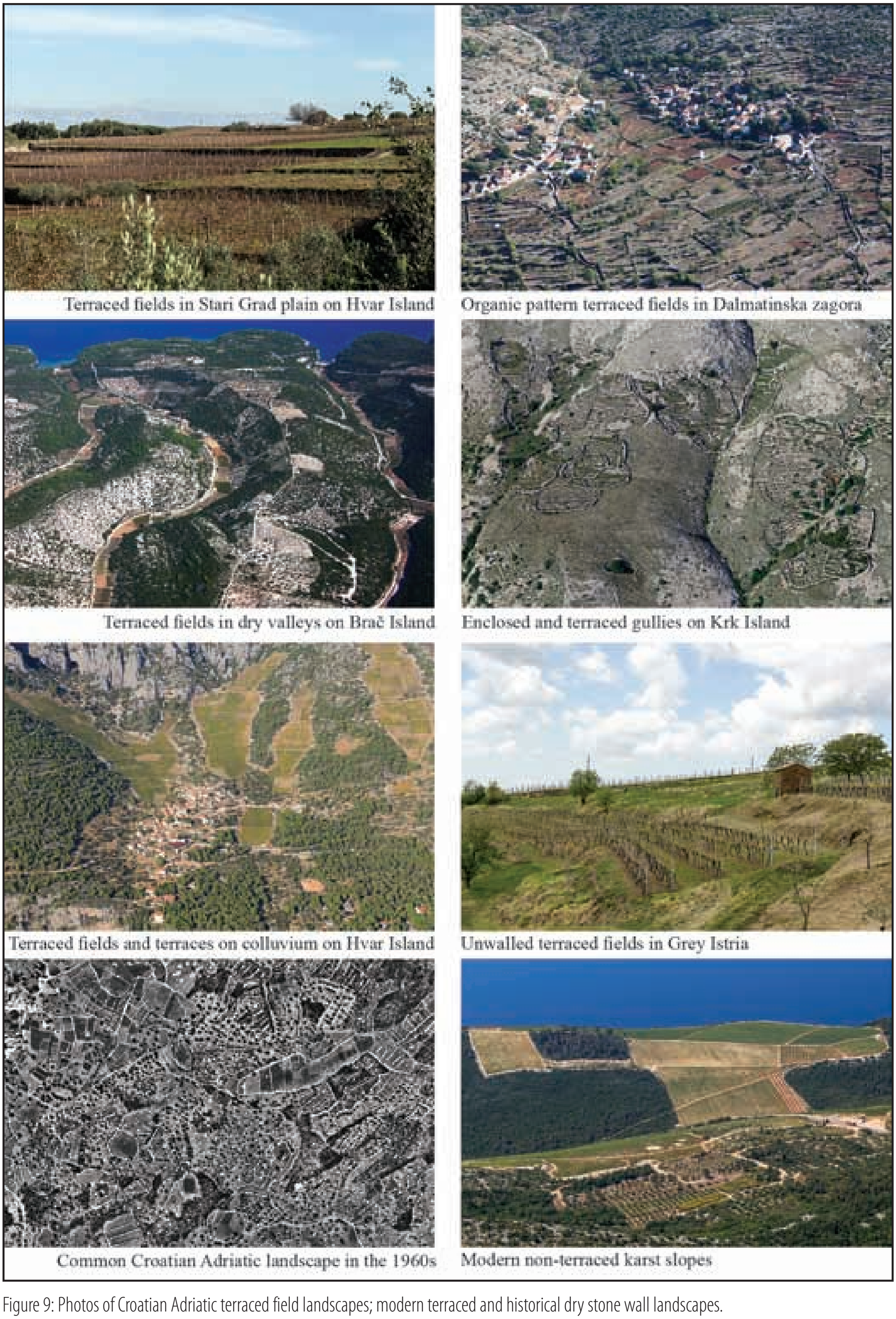
ANITA TROJANOVIĆ

Figure 7: »Spontaneous« pocket terraces.



ANITA TROJANOVIĆ

Figure 8: Off-contour terraces.



GORAN ANDLAR, BRANKA ANIČIĆ, INTERNET 2

Figure 9: Photos of Croatian Adriatic terraced field landscapes; modern terraced and historical dry stone wall landscapes.

GORAN ANDLAR

Figure 10: Korčula vineyards on narrow step terraces.

GORAN ANDLAR

Figure 11: Short and wide vineyard terraces in the hinterland of Trogir.


GORAN ANDLAR

Figure 12: Typical Hvar terraces with vertical intersections.


GORAN ANDLAR

Figure 13: Vineyard pocket terraces on the island of Hvar.

BRANKA ANIČIĆ

Figure 14: Vineyards on spontaneous pocket terraces in Kostanje near the Cetina River.

GORAN ANDLAR

Figure 15: Off-contour terraces on the island of Kaprije.


TONI MOSTAHINIĆ

Figure 16: Irregular and pocket terraces in Duba Konavoska.


GORAN ANDLAR

Figure 17: Abandoned reed-supported terraces on the island of Srakane.

The layout of these terraces might be a consequence of a need for protection from the wind, but also an adaption to the direction of lithological layers. They are very rare and, as far as they are known, abandoned (e.g., small sites in the Senj-Jablanac area and on the islands of Kaprije, Baljenac, and Kakan). Gams (1987, 1991) pointed out an interesting type of the »box-like landscape« with an example of a site near Brusje, Hvar, where the terraced parcel stripes are divided by solid dry stone scarps (or sometimes simply elongated heaps of stone) perpendicular to the contours. Although they are visually impressive and similar to the off-contour terraces, these structures could not be classified as such because they are structurally a secondary feature (a boundary, path, or deposit of excess stone) in the otherwise regular horizontal terrace system.

4 Conclusion

The main contribution of this article is to present an original typology of terraced landscapes and to show their diversity based on the example of the Croatian Adriatic region, followed by standardized nomenclature that should facilitate further research.

We argue that standardized classifications are necessary for unifying the »language« among the various disciplines that deal with this interdisciplinary subject. They are also important for making possible comparisons between different case studies and for creating databases. We agree with the opinion that systematic quantitative techniques may expand the boundaries of historical landscape research and preservation, and that the typologies have yet to become common practice when studying historical landscapes (Kohr 2008). Using sketches (Figures 1–8) and photos (Figures 9–17), this article promotes the importance of visual presentation.

The proposed classification framework is based on landscape pattern dimensions, for which the definition of types is primarily based on structure and geomorphology, but includes other biophysical and cultural-historical circumstances. In this regard, this article is also a contribution to sociogeomorphology (Ashmore 2015).

In the proposed typology, links between the structure observed and the circumstances of its emergence can be followed up to a certain level. For every type, one can potentially know which crop it was initially intended for, what its biophysical context is, what »micro-cultural« area it belongs to, what its relation to the settlement is, and sometimes even which period or historical event it is part of. Further knowledge is needed to test the applicability of the suggested principle.

Such a generalized framework has some deficiencies. For example, certain types of terraced landscapes are sometimes connected with other types of land use.

Furthermore, the multidimensional approach of this work points to the fact that additional expertise and research is needed, especially in history and archaeology to support chronological dating and explain the socioeconomic context of the spatial structures observed.

Further research in the Croatian Adriatic region should be directed towards identifying representative sites for every terraced landscape; namely, to identify the construction materials, techniques, structures, soil characteristics, lithology, and relief that have formed the *terroir* (Jamšek Rupnik, Čuš and Šmuc 2016), and other associated local practices, cultures, and cultivars that may have evolved within the unique terraced landscape.

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TERRACED LANDSCAPES AS PROTECTED CULTURAL HERITAGE SITES

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Terraced rice paddies in Bali, a UNESCO world heritage site.

Terraced landscapes and protected cultural heritage sites

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ABSTRACT: This article presents the current state of protection of terraced landscapes as an important type of cultural landscape, both globally and in Slovenia. The UNESCO World Heritage List, the Satoyama Initiative list, and the Slovenian Register of Immovable Cultural Heritage are analyzed. The findings show that terraces rarely appear as a factor justifying protection, even though certain progress has been made in recent years. At least globally, this has clearly been contributed to by the 2010 adoption of the Honghe Declaration. Slovenia shows both a lack of appropriate criteria for identifying terraced landscapes worth protecting and an insufficiently systematic treatment of heritage sites that are already being protected.

KEY WORDS: geography, cultural landscape, terraces, UNESCO World Heritage, Satoyama Initiative, Slovenian heritage, Slovenia

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1 Introduction

Terraced landscapes are cultural landscapes with a special value, in which their aesthetic role is of great importance in addition to ecological, cultural, historical, research, psychological, philosophical, and religious aspects (Kladnik 2016a; Smrekar, Polajnar Horvat and Erhartič 2016). Therefore, it is not surprising that terraced landscapes are among the world's most picturesque landscapes found online (e.g., Amazing satellite … 2016; Incredible … 2014; Tremendous … 2011). They form a special agricultural and ecological system that can be found throughout the world. They are formed by diverse agricultural terraces, the main purpose of which is to produce food. However, if they are well maintained, they can have an added value in fighting erosion and the negative effects of natural disasters (Komac and Zorn 2008) and in case of extensively management they also ensure biodiversity (Špulerová et al. 2017). However, if terraces are not maintained, this only exacerbates the effects of natural degradation. Unfortunately, due to the restructuring of social strata, maladaptation to mechanized farming, and increasingly pronounced globalization effects, in many places terraces are being abandoned, overgrown, or left to deteriorate in large numbers, while traditional terraced landscapes are becoming neglected (Kladnik 2016a).

Only well-maintained terraced landscapes can present an attractive image that not only makes the locals that live with terraces from one generation to the next proud, but can also prove to be an important part of cultural heritage with developmental potential (Kladnik 2016b). This is true both globally and in Slovenia, and accordingly the awareness that terraced landscapes are worth protecting as an invaluable part of cultural landscapes is gradually strengthening (Erhartič 2009). Various protective initiatives and strategies (Ažman Momirski and Kladnik 2015) have sprung up, which in and of themselves do not automatically guarantee appropriate further maintenance and conservation of terraced landscapes, but they do clearly play an important role in the perception, awareness, discovery, and evaluation of these landscapes. If protection is well thought out and the values of terraced landscapes are suitably promoted, the protection itself can provide an exceptional developmental impulse (Geršič et al. 2016). Together with their increased profile, this makes possible not only further maintenance of an attractive cultural landscape, but also generates new jobs in activities related to the growing number of incoming tourists (Ažman Momirski and Kladnik 2015).

Terraced landscapes belong to cultural landscapes that are the result of the interaction between the natural environment and human life and work in this environment (Urbanc 2002). The expression »cultural landscape« was introduced by the American geographer Carl Sauer, who defined it as follows: »*The cultural landscape is fashioned out of the natural landscape by a culture group. Culture is the agent, the natural area is the medium, the cultural landscape is the result*« (Sauer 1925, 46). Cultural landscapes are already indirectly mentioned in the 1972 UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage (Convention … 1972), which defines cultural heritage as monuments, groups of buildings and sites, which are works of man or the combined works of nature and man, and natural heritage as natural features, geological and physiographical formations and natural sites.

Cultural landscapes that have been internationally recognized and protected since 1992 (Cultural landscapes 2016) are characterized by unique land use adapted to natural conditions and an intangible relationship with nature. An important step towards the recognition of cultural landscapes was made through the 2000 adoption of the European Landscape Convention, which highlights the interaction between natural and human factors, but does not specifically mention terraced landscapes. In the Slovenian legal system, the landscape is mentioned in the Nature Conservation Act (2010), which in principle defines the landscape as a natural value (even though not even a single unit like this can be found in the Register of Natural Values), and in the Cultural Heritage Protection Act (2016), which also covers the Register of Immovable Cultural Heritage (Register … 2016), in which cultural landscapes are included.

Landscapes are also discussed in the 2010 Paris Declaration on the Satoyama Initiative, which covers socio-ecological production landscapes and seascapes. It conceives of landscapes as »*dynamic mosaics of habitats and land uses that have been shaped over the years by the interactions between people and nature in ways that maintain biodiversity and provide humans with goods and services needed for their well-being*« (Paris declaration on … 2010, article 1). *Satoyama* is a Japanese compound term referring to the area between the foothills of a mountain and arable flat land (< *sato* »arable, fertile« + *yama* »mountain, hill«). In the broader sense, satoyama landscapes are a mix of forests, paddy fields, plowed fields, pastures, creeks, ponds, and irrigation systems surrounding Japanese villages (Kobori and Primack 2003).

As an exceptional landscape system, terraced landscapes were globally recognized at the conference on terraced landscapes that took place in Mengzi, China, in November 2010 and where the Honghe Declaration on the Protection and Development of Terraces was adopted (Peters and Junchao 2012; Kladnik 2016a). That was also when the International Terraced Landscapes Alliance (ITLA) was established (Ažman Momirski and Kladnik 2015).

To date, no comprehensive systematic study on the protection and conservation of terraced landscapes as important cultural landscapes and hence cultural heritage deserving protection has been conducted either globally or in Slovenia. The best-known protected terraced landscapes are mentioned in the works of Tarolli, Preti, and Romano (2014), Varotto (2015), Peters (2015) and Andlar, Šrajer in Trojanović (2017) provided a systematic overview on typological diversity of the Croatian Adriatic terraced landscapes

This article provides an overview of the current state of protection of the terraced landscapes included on the UNESCO World Heritage List (World Heritage List 2016) and in the international database of Satoyama landscapes (Satoyama Initiative 2016) and the Slovenian Register of Immovable Cultural Heritage (Register … 2016) in one place, drawing attention to the structural deficiencies of the registers and seeking to further enhance efforts for more planned and systematic protection of terraced landscapes.

2 Methods

This study is based on a review of two international lists–the UNESCO World Heritage List (2016) and especially its list of cultural landscapes (Cultural Landscapes 2016), and the Satoyama Initiative list (2016)–and the Slovenian Register of Immovable Cultural Heritage (Register … 2016). Based on the justifications for inclusion on the list and the explanations of the reasons for protection, we identified heritage units (unambiguously or by making inferences based on knowing the actual conditions) that have been selected as worth protecting due to the important role of agricultural terraces. In this, the role of terraced landscapes can be a decisive factor or quite marginal.

Based on the extent of highlighting the significance of terraced landscapes or their role in the justifications for addition to the list, three types were defined at the global level (predominant, highlighted, and marginal) and four among the Slovenian cultural heritage sites (predominant, highlighted, marginal, indirectly identified).

Even though the criteria for classifying terraced landscapes under individual types are subjective, they are based on the comparison of published justifications. They are illustrated here with four sites from the Register of Immovable Cultural Heritage (2016), which we classified under various types. For a better comparison, all of the units are from the same Slovenian region: the mesoregion of the Koper Hills (Sln. *Koprska brda*).

The **predominant** type (Register … 2016):
Puče settlement: the cultivated terraces between Krkavče Creek (*Krkavški potok*) and Supot Creek (*Supotski potok*): »*The preserved traditional system of cultivated terraces was created where the plateau-like level ridges gradually change into the steep slopes above the Dragonja Valley. The villages of Krkavče and Koštabona dominate the wider area.*«

The **highlighted** type:
Seča: the Seča Peninsula cultural landscape: »*An area transformed by man for agricultural use, with cultivated terraces and walls built from local stone; dispersed construction, the Forma viva open air sculpture gallery on the promontory. Olive trees, grapevines, and orchards predominate among the cultivars.*«

The **marginal** type:
Strunjan: Strunjan Nature Park: »*The area south of Strunjan Cliff (*Strunjanski klif*) features a church with a monastery, dispersed tenant farmers' houses on a slope that has been converted into terraces, a settlement next to the former town harbor, saltpans, and a stone pine avenue.*«

The **indirectly identified** type:
Čentur: »*A special feature of this village is its characteristic architecture, the special structure of its parcels, and the unique way in which its farmland is cultivated. Arable land is divided into small parcels that extend outwards in concentric circles in order to adjust to the terrain.*«

3 Levels of protection around the globe and in Slovenia

This section presents the findings of the review of the UNESCO World Heritage List (2016), the Satoyama Initiative (2016) database, and the Slovenian Register of Immovable Cultural Heritage (Register … 2016).

3.1 UNESCO World Heritage List

The UNESCO classification uses the following three categories of cultural landscapes (Operational Guidelines … 2012):

- Cultural landscape designed and created intentionally by man;
- Organically evolved landscapes, developed as »*results from an initial social, economic, administrative, and/or religious imperative and has developed its present form by association with and in response to its natural environment*«; divided into two subtypes: a) a relict/fossil landscape and b) a continuing landscape »*which retains an active social role in contemporary society closely associated with the traditional way of life, and in which the evolutionary process is still in progress*«; and
- Associative cultural landscape.

Figure 1 presents the UNESCO typology of immovable cultural heritage (The World Heritage … 2004). However, because it is not universal, it is not generally established and applied in individual national legislations.

In June 2016, there were 8.5% of cultural landscapes among the 1,031 world heritage sites on the UNESCO World Heritage List (Cultural Landscapes 2016). Four of these are listed as transboundary properties, and a German one was removed in 2009 because it did not meet the protection criteria. Twenty are connected with terraced landscapes. Among the rest of the world heritage sites, five are relevant from the viewpoint of terraces. Four are classified under cultural sites and one, the Historic Sanctuary of Machu Picchu, is classified under mixed sites.

Thus we identified a total of 25 relevant terraced landscapes on the UNESCO list (Figure 2): in eight cases, they became part of world heritage almost exclusively due to their terraced character, whereby cultivated terraces are highlighted as their component part, and in nine cases they are mentioned marginally because they were ascribed a high level of protection primarily due to other landscape elements. The majority of the protected sites include a central area measuring several hundred square kilometers (with exceptions over 1,000 km^2) and a similarly large or smaller buffer zone.

The analysis of 1,641 world heritage sites included on the tentative list (Tentative Lists 2016) showed that only four partly referred also to terraced landscapes (one in France, one in Algeria, and two in Yemen).

The first site that mentions a terraced landscape in the justification, the Natural and Culturo-Historical Region of Kotor, Montenegro, was entered on the UNESCO list as early as 1979 and the second, the Historic Sanctuary of Machu Picchu, Peru, was added to the list in 1983. The first site that refers explicitly to a cultural landscape and a terraced landscape as part of it was the Rice Terraces of the Philippine Cordilleras, which was added to the list in 1995. The graph in Figure 3 shows that the number of these types of world heritage sites is gradually increasing and, what is even more evident, the significance of terraces in the justifications is increasingly more highlighted.

3.2 Satoyama Initiative

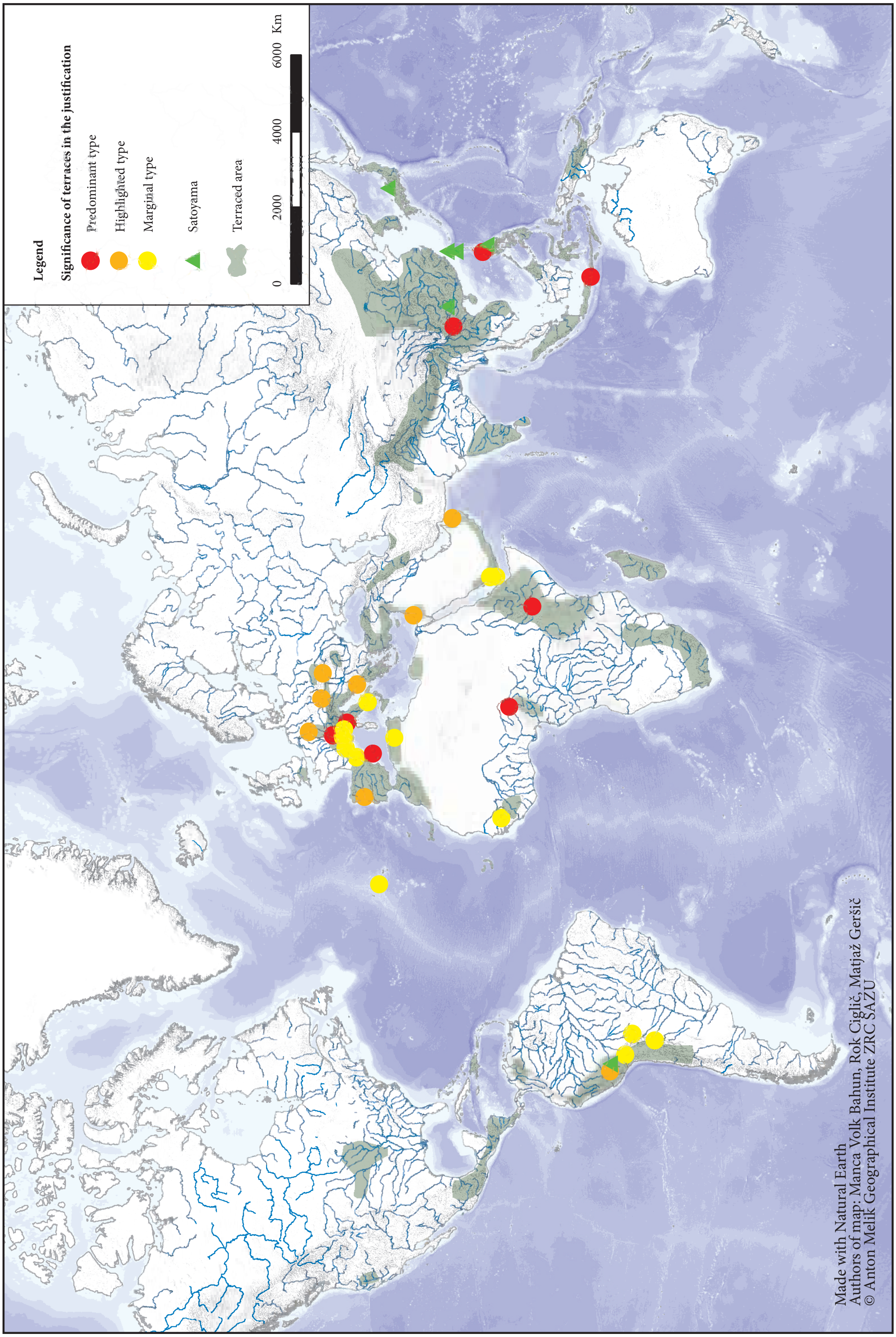
An important international register of cultural landscapes is being compiled as part of the International Partnership for the Satoyama Initiative (IPSI), which promotes societies in harmony with nature. As part of the Satoyama Initiative, an internet-based portal was established, which among other information provides well-presented case studies of socio-ecological production landscapes around the globe (Satoyama Initiative 2016).

Currently more than 80 case studies are presented in the database, including seven terraced landscapes. The significance of terraces is predominant in three, highlighted in two, and marginal in two. All of the entries on the Satoyama Initiative list are of a more recent date, from 2010 onwards. Two sites, both part of the Ifugao terraced landscape on the Philippine island of Luzon, are included on the UNESCO World

	Monuments	Groups of buildings	Places
Archaeological heritage:	Individual monuments, including earthworks, farms, villas, temples, and other public buildings, defensive works, etc., that are not in use or occupied	Settlements (towns, villages), defensive works, etc., that are not in use or occupied	Earthworks, burial mounds, cave dwellings, defensive works, cemeteries, routes, etc., that are not in use or occupied
Rock–art sites:	–	–	Caves, rock shelters, open surfaces, and comparable sites containing paintings, engravings, carvings, etc.
Fossil hominid sites:	–	–	Individual sites and landscapes containing skeletal material and/or evidence of occupation by early hominids
Historic buildings and ensembles:	Individual monuments, ensembles of monuments, works of art	–	–
Urban and rural settlements / historic towns and villages:	–	Towns, town centers, villages, and other communal groups of dwellings	–
Vernacular architecture:	Traditionally established building types using traditional construction systems and crafts	Groups of traditionally established building types	Cultural landscapes with vernacular settlements
Religious properties:	Buildings and structures associated with religious or spiritual values; e.g., churches, monasteries, shrines, sanctuaries, mosques, synagogues, temples, etc.	Historic settlements or towns with religious or spiritual associations: sacred cities, etc.	Sites with religious or spiritual associations: sanctuaries, sacred landscapes, or landscapes with sacred features, etc.
Agricultural, industrial and technological properties:	Factories; bridges, water–management systems (dams, irrigation, etc.)	Agricultural settlements; industrial settlements	Field systems, vineyards, agricultural landscapes; water management systems (dams, irrigation, etc.); mines, mining landscapes, canals, railways, etc.
Military properties:	Castles, forts, citadels, etc.	Citadels, town defenses;	Defensive systems

Figure 1: UNESCO typology of immovable cultural heritage (The World Heritage . . . 2004, 15). Green cells contain material related to cultural landscapes.

Figure 2: Terraced landscapes identified on the UNESCO World Heritage List (2016) and the Satoyama Initiative list (2016). ►


Legend
Significance of terraces in the justification
Predominant type
Highlighted type
Marginal type
Satoyama
Terraced area
0
2000
4000
6000 Km
Made with Natural Earth
Authors of map: Manca Volk Bahun, Rok Ciglič, Matjaž Geršič
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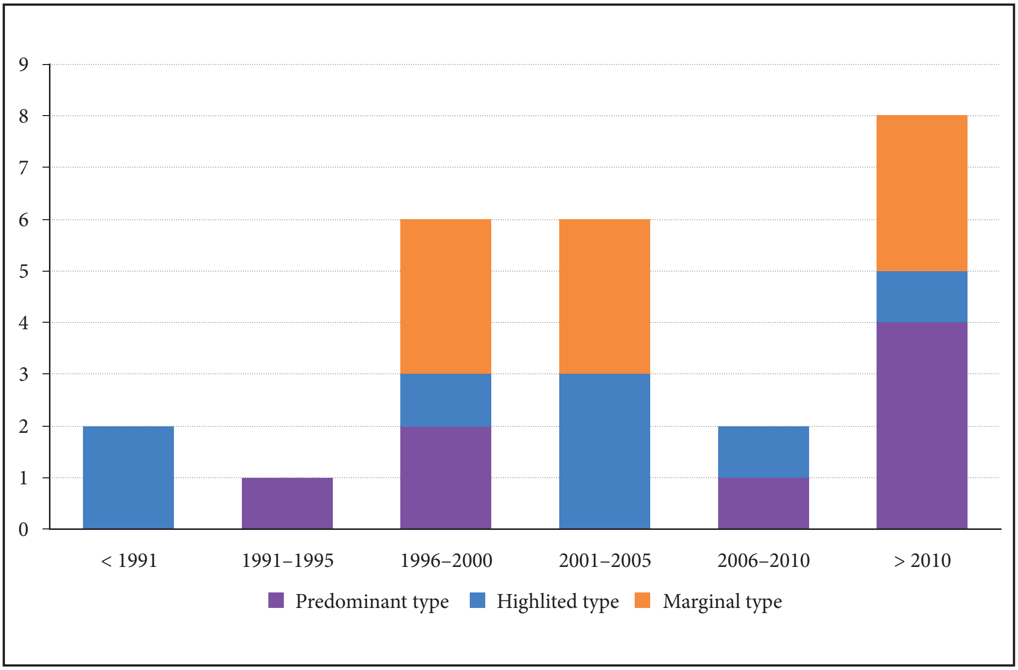

Figure 3: The period in which the terraced landscapes identified were entered on the UNESCO World Heritage List (2016) according to the significance of terraces in the justifications for entry on the list.

Figure 4: The cultural landscape of the Honghe Hani Rice Terraces in China.

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Figure 5: The terraced landscape of the Upper Douro (*Alto Douro*) Wine Region in Portugal.

Heritage List. All of the sites on the UNESCO World Heritage List and the Satoyama Initiative list are presented in Figure 6.

3.3 Slovenian Register of Immovable Cultural Heritage

In Slovenia, the protection of terraced landscapes is provided for as part of the Cultural Ministry's Register of Immovable Cultural Heritage (*Register nepremične kulturne dediščine*) (Register … 2016), which also includes cultural landscapes among the eight defined types of heritage and two non-defined types (unknown and other). In June 2016, the register included 317 sites, among which forty-three terraced landscapes can be identified (Figure 7, Table 1). In two cases, terraces were the decisive reason for addition to the register, in seventeen cases they were a very important reason, in twelve cases they were not mentioned at all because other reasons were more important for the entry, and in twelve cases agricultural terraces were not mentioned but they can be inferred from the descriptions.

Among the total of 50 mesoregions, only 18 include protected terraced landscapes. By far the greatest number of registered terraced cultural landscape sites can be found in the Koper Hills (10) and the Sava Hills (8). Among the nine landscape types, they can be found in six, but not on the Mediterranean plateaus and in the Alpine mountains, where terraced landscapes do not exist anyway.

Figure 6: Terraced landscapes as identified in 2016 on the UNESCO World Heritage List (2016), UNESCO Tentative Lists (2016), and Satoyama Initiative (2016). The names of sites fully recognized by UNESCO are given in plain text, sites on the UNESCO Tentative Lists in italics, and sites on the Satoyama Initiative list in underlined italics. ➤ p. 138

Figure 7: Terraced landscapes identified in the Slovenian Register of Immovable Cultural Heritage (Register … 2016). ➤ p. 139

Continent	Predominant	Highlighted	Marginal
Africa	• Konso Cultural Landscape • Sukur Cultural Landscape	–	• Bassari Country: Bassari, Fula, and Bedik Cultural Landscapes • *Parc des Aurès avec les établissements oasiens des gorges du Rhoufi et d'El Kantara*
Asia	• Cultural Landscape of Honghe Hani Rice Terraces • Cultural Landscape of Bali Province • Rice Terraces of the Philippine Cordilleras • *ARice Paddy Cultural Landscape Conservation in an Indigenous Community, Taiwan* • *»Muyong« in Ifugao Province, Northern Luzon Island in the Philippines* • *Town Revitalization Making the Most of Natural Landscape and Traditions of Kanakura Wajima City, Ishikawa Prefecture, Japan*	• Aflaj Irrigation Systems of Oman • Land of Olives and Vines – Cultural Landscape of Southern Jerusalem, Battir • *Gongliao–Hoho–Terraced–Paddy–Fields, Taiwan* • Role of Traditional Knowledge in Strengthening Socio–Ecological Production Landscapes	• Jibla and its Surroundings, Jabal Haraz • *Dong People's Rice–Fish–Duck Symbiotic System in China*
Europe	• Portovenere, Cinque Terre, and the Islands (Palmaria, Tino, and Tinetto) • Cultural Landscape of the Serra de Tramuntana • Lavaux, Vineyard Terraces	• Wachau Cultural Landscape • Upper Middle Rhine Valley • Tokaj Wine Region Historic Cultural Landscape • Natural and Culturo–Historical Region of Kotor • Alto Douro Wine Region	• Madriu–Perafita–Claror Valley • The Causses and the Cévennes, Mediterranean Agro–Pastoral Cultural Landscape • Costiera Amalfitana • Vineyard Landscape of Piedmont: Langhe–Roero and Monferrato • Landscape of the Pico Island Vineyard Culture • Parc national des Écrins
North America	–	–	–
Oceania with Australia	–	–	–
South America	–	• Historic Sanctuary of Machu Picchu	• Quebrada de Humahuaca • Fuerte de Samaipata • Spiritual and Political Centre of the Tiwanaku Culture • *The Ayllu System of the Potato Park, Cusco, Peru*

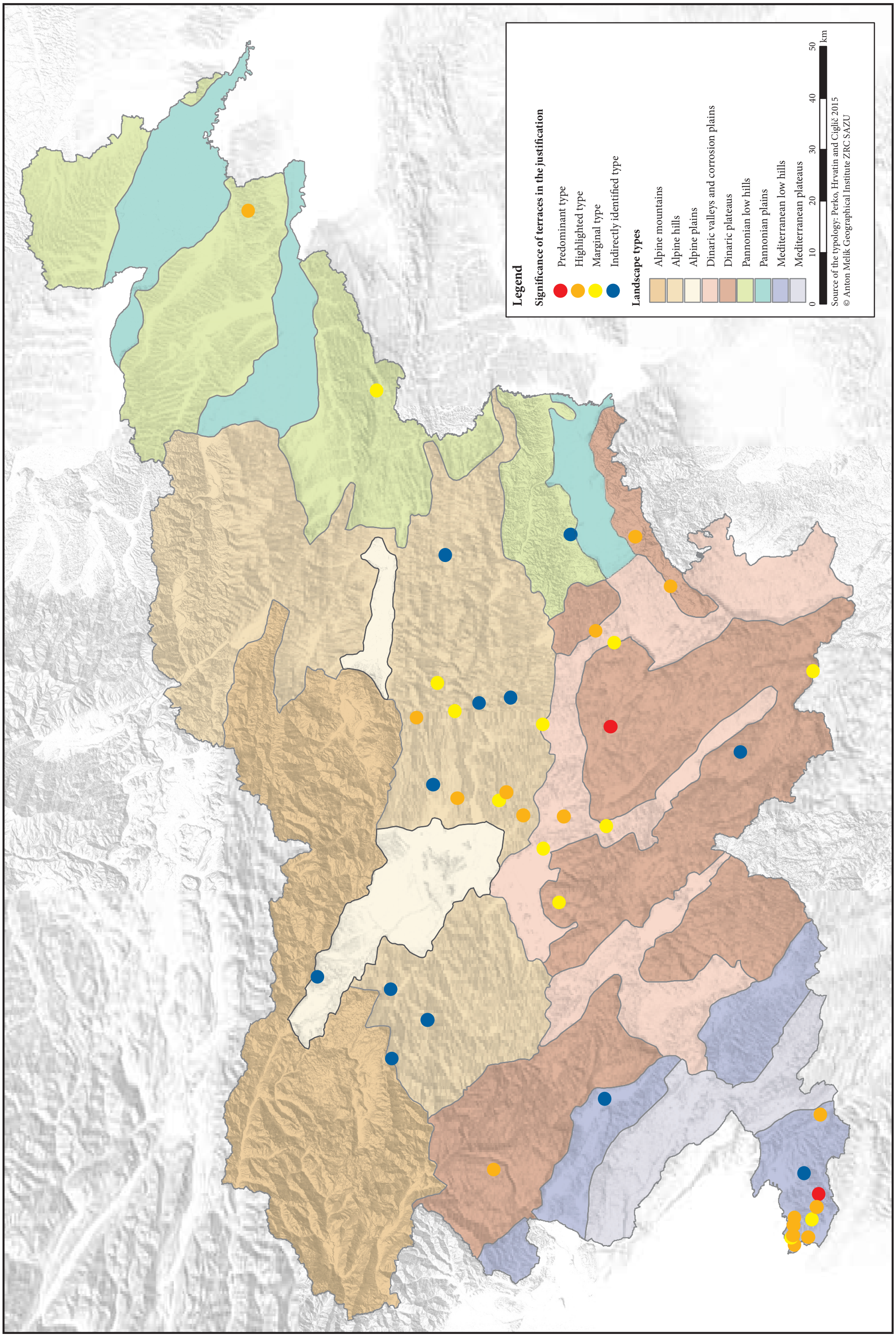
Legend
Significance of terraces in the justification
Predominant type
Highlighted type
Marginal type
Indirectly identified type
Landscape types
Alpine mountains
Alpine hills
Alpine plains
Dinaric valleys and corrosion plains
Dinaric plateaus
Pannonian low hills
Pannonian plains
Mediterranean low hills
Mediterranean plateaus
0 10 20 30 40 50 km
Source of the typology: Perko, Hrvatin and Ciglič 2015
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Table 1: Settlements in the Slovenian Register of Immovable Cultural Heritage (Register . . . 2016) for which the justification for their protection includes or implies various degrees of significance of terraces, by Slovenian mesoregions and landscape types.

Landscape type group	Landscape type	Mesoregion	Predominant	Highlighted	Marginal	Indirectly identified	Number of cases/ settlements with terraces
Mediterranean landscapes	Mediterranean low hills	Koper Hills (*Koprska brda*)	Puče	Izola, Jagodje, Movraž, Piran, Seča, Strunjan, Sveti Peter	Korte, Strunjan	Čentur	11
		Vipava Valley (*Vipavska dolina*)	–	–	–	Zemono	1
	Mediterranean plateaus	–	–	–	–	–	0
Dinaric landscapes	Dinaric plateaus	Gorjanci Hills (*Gorjanci*)	–	Javorovica, Veliki Cerovec	–	–	2
		Kambreško Hills and Banjšice Plateau	–	Lokovec	–	–	1
		Krim Hills (*Krimsko hribovje*) and Menišija Plateau (*Menišija*)	–	–	–	Gorenja Brezovica	1
		Kočevje Little Mount (*Kočevska mala gora*), Kočevje Rog (*Kočevski rog*), and Mount Poljane (*Poljanska gora*)	–	–	Laze pri Predgradu	–	1
		Radulja Hills (*Raduljsko hribovje*)	–	Hmeljčič	–	–	1
		Dry Carniola (*Suha krajina*) and Dobrepolje Karst polje (*Dobrepolje*)	Šmihel pri Žužemberku	–	–	–	1
		Big Mountain (*Velika gora*), Mount Stojna (*Stojna*), and Mount Gotenica (*Goteniška gora*)	–	–	–	Draga	1
	Dinaric valley systems and corrosion plains	Lower Carniola Lowland (*Dolenjsko podolje*)	–	Spodnja Slivnica, Temenica	Mali Vrh (near Mirna Peč)	–	3
		Velike Lašče Region (*Velikolaščanska pokrajina*)	–	–	Knej	–	1

Alpine landscapes	Alpine mountains	–	–	–	–	–	0
	Alpine hills	Cerkno Hills (*Cerkljansko hribovje*), Škofja Loka Hills (*Škofjeloško hribovje*), Polhov Gradec Hills (*Polhograjsko hribovje*), and Rovte Hills (*Rovtarsko hribovje*)	–	–	–	Gorenja Žetina, Spodnje Danje, Topolje, Velike Grahovše	4
		Sava Hills (*Posavsko hribovje*)	–	Selo pri Pancah, Šentgotard, Volavlje	Gabrje pri Jančah, Golčer, Javor	Javorje pri Gabrovki, Tepe, Vinje pri Moravčah, Zgornja Javoršica	10
	Alpine plains	Ljubljana Marsh (*Ljubljansko barje*)	–	–	Gumnišče	–	1
		Sava Plain (*Savska ravan*)	–	–	–	Leše	1
Pannonian landscapes	Pannonian low hills	Boč Hill and Macelj Hill (*Boč in Macelj*)	–	–	Donačka Gora	–	1
		Krško Hills (*Krško gričevje*)	–	–	–	Dolenja vas pri Raki	1
		Slovenian Hills (*Slovenske gorice*)	–	Jeruzalem	–	–	1
	Pannonian plains	–	–	–	–	–	0
			2	17	10	14	43

Figure 8: Land surrounding Šmihel pri Žužemberku in Dry Carniola was included in the register precisely because of its well-known terraced landscape.

Figure 9: Like all other terraced areas in the Brkini Hills, the land surrounding the village of Ostrožno Brdo has not yet been recognized by conservationists as deserving protection.

4 Discussion

Terraced landscapes account for 22.7% of cultural landscape sites and 2.4% of all sites on the UNESCO World Heritage List (2016), for which the listing is legally binding and is considered a great prestige considering that it has established itself as a successful brand (Erhartič 2014). We determined that the significance of terraces in the justifications for entering individual sites on the list is becoming increasingly more highlighted. This may have been contributed to by the 2010 adoption of the Honghe Declaration on the Protection and Development of Terraces (Peters and Junchao 2012), which among other things emphasizes the role and significance of intangible heritage, which comes especially to the fore in Third World countries, where collectiveness in work, free time, and rituals is still an important value.

In the international Satoyama Initiative (2016) database–which has just begun to be compiled and the main point of which is high-quality and systematic descriptions of the sites included, the protection of which is, however, not legally binding–there is a notable predominance of Asian and African landscapes. Terraced landscapes account for 8.8% of all cultural landscapes described in this database.

We determined that in the »cultural landscape« category of the Slovenian Register of Immovable Cultural Heritage (Register … 2016), terraces appear as a protection factor only in 13.7% of cases, and that among the total of 29,893 Slovenian immovable cultural heritage sites terraced landscapes account for only 0.14%. Knowing the actual conditions in the field, it can be arrgued that, despite seemingly suitable coverage of terraced landscapes in Slovenia, the existing range of protected sites included in the register is deficient. In this regard, deficient criteria for the inclusion and the occasionally terminologically deficient descriptions in the justifications for the sites' protection can be established (see, e.g., the description for Jeruzalem, reg. no. 7867; Register … 2016). This points to a considerable lack of awareness and poor identification of terraced landscapes' values among the responsible experts in the majority of regional units that prepare the protection strategy and plans and the expert bases justifying the inclusion of individual sites in the register.

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Figure 10: Terracing a slope in Rwanda as part of public works.

In Slovenia cultural landscapes and terraced landscapes as parts of them have not yet been officially recognized as part of intangible heritage, even though certain practices and skills of cultivating terraced land definitely form part of such heritage (Ažman Momirski et al. 2008). Due to farming organized by families in the areas of Slovenian terraced landscapes, we haven't identified any organization of labor, celebrations, and rituals connected with the cultivation and maintenance of terraces within the wider village community so far.

The Digital Encyclopedia of Slovenian Natural and Cultural Heritage (DEDI, 2016) among the 468 units also includes a description of the terraced landscape in the Upper Gorizia Hills (*Zgornja Goriška brda*) (Kladnik 2010). Just like any other area in most distinctly terraced Slovenian region of the Gorizia Hills (*Goriška brda*), the presented site has not yet been officially registered as a cultural heritage site. However, the author believes that considering its significance as a cultural value the site deserves to be protected against the possible deterioration that threatens the demographically endangered northern part of the region.

The review of the world and Slovenian heritage lists raises certain questions: which terraced landscapes are worth protecting and why, is their function or external appearance more important, when did they become heritage, in which cases do they deserve to be protected, and so on. Since only selected sites can be protected it is first necessary to inventory various terraced landscapes and create the criteria for their protection. Here (Table 2) we list a few possible criteria that were identified as part of the project Terraced Landscapes in Slovenia as Cultural Values.

Table 2: Criteria, identified for evaluating of terraced landscapes in Slovenia.

Criteria	Type of criteria
A large contiguous area of terraced land	Spatial
The method of terrace construction	Spatial and time related
The shape of terrace treads	Spatial
The height of terrace slopes	Spatial
Time of construction	Time-related
Planned construction (whether the terraces were planned or created spontaneously with slope processes caused by man)	Time-related
Rarity	Spatial and time related
State of conservation	Legislative
Any other accompanying features	–
Habitats of endangered plant and animal species	Natural/ecological

5 Conclusion

Based on the reviews performed, the following findings can be highlighted:

- Terraced landscapes and cultivated terraces began to be classified under heritage sites fairly late, or only after a special category of »cultural landscapes« was established in general;
- Terraced landscapes are a significantly more important element of protection than is evident from the descriptions because those that protected them did not realize the significance of cultivated terraces, and in Slovenia no uniform criteria were in place then, and still are not;
- Intangible aspects of terraced landscapes (e.g., group work, celebrations, rituals, etc.) are already being recognized around the globe, but this does not apply to Slovenia;
- In Slovenia, terraced landscapes could start being regarded as a special subtype of cultural landscape that deserves special treatment due to the complexity of treating it effectively.

The protection of terraced landscapes must definitely be connected with active survival strategies and the farmers for whom work in a terraced landscape represents an important source of food and an important level of subsistence or even market surplus production. To achieve all of this, it is necessary to maintain a vital cultural landscape with a sufficient number of people that are able to work and ready to contribute their share to further maintaining an attractive terraced landscape. If this landscape manages to be added to world protection lists, such as the UNESCO World Heritage List, this provides new tourism-based development prospects, which can generate many new jobs not only in the hospitality sector and accompanying activities, but also in secondary activities on farms.

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TRANSFORMATION OF THE JERUZALEM HILLS CULTURAL LANDSCAPE WITH MODERN VINEYARD TERRACES

Primož Pipan, Žiga Kokalj

The dimensions, form, and inclination of terrace platforms and slopes are completely adapted to the terrain, steepness, and lithological and pedological conditions. Terrace access also depends on these.

Transformation of the Jeruzalem Hills cultural landscape with modern vineyard terraces

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ABSTRACT: The terraced landscape in the Jeruzalem Hills is the result of specific socioeconomic conditions under communism, and now its appearance is drastically changing for the second time in the last fifty years. This article examines the creation of the new landscape layer of modern cultivated terraces and studies their disappearance and the return to a condition similar to the original state. The analysis is based on interviews and visual interpretation of aerial laser scanning (lidar) data. It focuses on the state of the landscape before terracing, the creation of terraces and formation of a terraced landscape, and its most recent transformation into slopes without terraces. It is determined that, despite the recognized aesthetic value of terraces, legal protection in the form of a nature park has not impacted their preservation because 56% of them have already been leveled. With the conversion of vineyards to vertical plantations, a new challenge is arising: increased erosion.

KEY WORDS: geography, terraces, terraced landscape, transformation of cultural landscape, visual interpretation of lidar, Jeruzalem Hills, Slovenia

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1 Introduction

The abandonment of farming on traditional agricultural terraces that were created for manual cultivation and are thus less suitable for mechanical cultivation is connected with migration to urban areas. At the global level, terraced landscapes with permanently abandoned terraces are especially common in the Andes in South America (Guillet et al. 1987; Denevan 1988; Goodman Elgar 2008) and in the European Mediterranean area (García-Ruiz and Lana-Renault 2011; Stanchi et al. 2012; Lasanta et al. 2013). In traditional terraced landscapes there is no need to build new terraces because enough abandoned ones are available (Kendall 2012).

There are also examples of construction of modern terraces. Near the Kenyan town of Machakos, many terraces have been created since the mid-1980s, so that now approximately 70% of the cultivatable land is terraced (Thornton 1999). In Europe, newly terraced areas include the countryside around Kaiserstuhl, Germany. Because of the exceptionally erosion-prone soil, after 1950 it was necessary to terrace the slopes for intensive vineyard and orchard cultivation. When this was done, they were also adapted to mechanical cultivation (Kladnik et al. 2016).

In Slovenia, the first detailed analyses of cultivated terraces are relatively new. Ažman Momirski et al. (2008) studied the Gorizia Hills in detail, and Ažman Momirski and Kladnik (2015) presented the terraced landscape in the Brkini Hills. Terracing across all of Slovenia was studied by Ažman Momirski and Kladnik (2009), Križaj Smrdel (2010), and Kladnik et al. (2016).

The creation of the modern cultivated terraces in the Jeruzalem Hills, which are part of the Slovenian Hills, is connected with the development of viticulture. In comparison with other agricultural terraces in Slovenia, these are among the newest because they started being created only fifty years ago, under the communist social arrangement, when agricultural production there was oriented toward collective farms. None of the detailed regional descriptions of the Slovenian Hills (Belec 1968; Luskovič and Sakelšek 1994; Kert 1998), studies focusing on viticulture (Bračič 1976; Ramšak 1996; Karba 2001; Simonič Roškar 2003),

Figure 1: Terraces with individual rows of vineyards on the south and east slope below Our Lady of Sorrows Church in Jeruzalem.

or articles about the history of the former collective farms (Oblak 2005) and land use (Žiberna 2015) have dealt in detail with the creation of the modern cultivated terraces there, nor with their transformation following denationalization, which started when Slovenia became independent in 1991. The area near the settlement of Vinski Vrh was mentioned with regard to the conversion of terraced vineyards back into vertical vineyards only by Urbanc (2002), and Erhartič (2009) evaluated the Jeruzalem terraces only from the aesthetic point of view (Figure 1).

This article provides an overview of the history of how the modern cultivated terraces were created in the Jeruzalem Hills, and it sheds light on their disappearance through the unplanned change of the terraced landscape into a state similar to its original configuration.

2 Methods

The study area was limited to Ljutomer Ponds–Jeruzalem Hills Nature Park (Odlok … 1976), which lies in the Municipality of Ljutomer and covers 1,346 hectares, and the neighboring Jeruzalem–Ormož Hills Nature Park (Odlok … 1992), which lies in the Municipality of Ormož and covers 1,911 hectares.

No research has previously dealt with this topic, and so we made use of fieldwork based on observations and four structured interviews that we carried out in the Jeruzalem Hills area with two local residents that own terraced land and with two non-owners. The questionnaire for owners contained twenty-two questions about the influence of terraces on the settlement, and their use, significance, and preservation. The non-owners were asked about the same issues, but questions about cultivating and maintaining the terraces were omitted. Two non-structured interviews were also carried out with the managers of a former

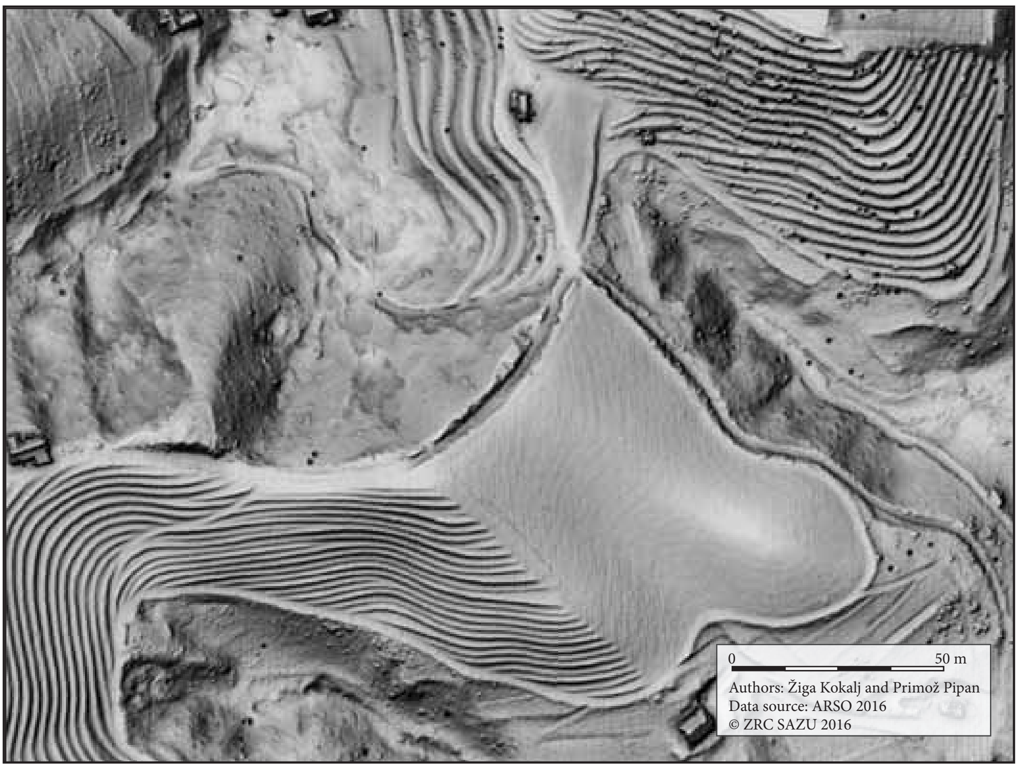

Figure 2: Lidar data make it possible to map existing terraces in detail (lower left, upper middle), including those being overgrown (upper right), and determination of the former presence of terraces where they can hardly be seen (center).

collective farm, and information was also obtained from two experts in cultural heritage and local history. The audio recordings and transcribed interviews are kept at the Archives of the ZRC SAZU Anton Melik Geographical Institute.

The areas of the current and potentially greatest extent of modern cultivated terraces were determined through visual interpretation of information from aerial laser scanning (lidar) data, which was acquired between March 31st and June 10th, 2014 as part of the project Laser Scanning of Slovenia. The original point cloud has a sufficient density of ground points (3.0 points/m² without repeated points) so that it was possible to rasterize it into an elevation model with a spatial resolution of 0.5 m and prepare an overview presentation with a combination of techniques of openness, sky-view factor, slope, and analytical hillshading (Figure 2). Such a presentation makes it possible to identify landforms, to separate between natural and anthropogenic landforms (Breg Valjavec 2014) and draw conclusions about their preservation regardless of the direction that they extend in (Kokalj, Zakšek and Oštir 2011). The pits in the terrain model (black dots in Figures 2 and 7) are a result of errors in the original data and they have not been removed.

Because of the great correspondence between the extent of existing and removed modern agricultural terraces and the areas of current vineyards, the graphic extent of vineyards from Actual Use of Agricultural Land (Dejanska … 2012) was used for the initial stage of digitization. Based on the lidar data and recent orthophotos, the areas were then corrected, some were removed and new ones were added, and they were categorized among areas with modern terraces that still exist or potential former terrace areas (Figure 6). Determining existing terraces using lidar data is not difficult because even overgrown or damaged terraces are clearly visible (Figures 2, 7B, 7D).

Delimiting leveled terrace areas is significantly more difficult and was based on the information on the general geomorphological configuration of the terrain, land use, proximity of terraces still preserved, and ratio between preserved terraces, potential areas of leveled terraces, and their current use. For example, slopes that are covered by woods and have no visible terraces today were not categorized among potentially leveled land because it was concluded that the financial outlay for leveling a terrace would have been too great to simply allow it to become overgrown soon thereafter. The areas marked on the Vineyard Location Map at the Ljutomer Parish Archive were examined in detail. Potentially leveled areas were also checked on aerial orthophotos from 1997, which are already available for this period in digital form. It was anticipated that they predate the beginning of the most intensive leveling of terraces.

3 Terracing the landscape

This section analyzes the construction of modern vineyard terraces as a new landscape layer in the Jeruzalem Hills cultural landscape. It focuses on the situation before terracing, the process of creating terraces, and the most recent transformation of the terraced landscape into slopes without terraces. The section is based on the authors' own work, especially on visual interpretation of aerial laser scanning (lidar) data and interviews.

3.1 The landscape before terracing

The traditional division of the land into vineyards varied and was primarily adapted to the terrain, which man had little influence on until the modern creation of terraced vineyards. Vineyards that were accessible only for manual labor had narrow boundaries between them adapted to the inclination and individual drainage ditches for precipitation. Each vineyard tended to make the greatest use of available land, which meant not only the optimum number of grapevines planted, but also the best use of water, sun, accessibility, traversability, and ease of manual cultivation. Only old illustrations make it possible to form an idea of the variety of what were in fact vertical plantations of vines, but which today one would hardly term as such based on their appearance (Pavličič 2016). Belec (1968, 168) refers to them as »*traditional staked vineyards*« (Figure 3) because each vine was tied to its own stake and not connected to others with a wire support and did not form rows, so that such a vineyard differed significantly from a modern vertical vineyard, in which the vines are planted in rows with wire supports (Figure 5).

Figure 3: Around 1960 traditional staked vineyards still stood near the church in Jeruzalem (photographer unknown; kept by the Ljutomer General Library as part of its Local History Collection).

3.2 Transforming the landscape by creating terraces

After 1945, the former vineyard workforce sought more long-term and better-paid employment in industrialized towns. In the spirit of communist policy, factories were also built in Ljutomer, which had had an agrarian character until then, and they employed several thousand people until Slovenian independence in 1991. After the Second World War, many reforms transformed viticulture into an activity of small private vineyard owners and large viticultural cooperatives (Pavličič 2016). In Jeruzalem there was a border between two collective farms because the vineyards north of the church belonged to what later became the Ljutomer Viticultural and Livestock Collective Farm (VŽK Ljutomer) and those south of it belonged to what became the Ormož-based Jeruzalem–Ormož Collective Farm. The amalgamation of viticultural activity with regard to estates, wineries, and wine sales made a new approach possible, the most prominent aspect of which was terracing the slopes.

Two decisive factors for terracing were the lack of a labor force for manual cultivation and the limitation of agricultural mechanization at the time, which was still unable to be used on steep slopes. Thus the relatively steep slopes had to be adapted to the capacities of the machinery at that time and reshaped into terraces.

Štrakl and Žličar (2016) describe in detail the beginnings of creating the terraces. VŽK Ljutomer started preparations for terracing vineyards in 1960, when Yugoslavia was promoting agricultural development with extremely favorable bank loans; the condition for receiving a loan for the Ljutomer area was at least sixty-five hectares of territory envisaged for terracing. The expert basis for large-scale terracing was experience from the settlement of Globoka, where a terraced vineyard had already been created before the Second World War, and with vineyards on Vardovščak Hill, where terracing had been used since 1953.

Targeted aerial photography was followed by planning at Agrobiro, a Ljubljana company. The engineers Sluga and Leonardi designed the plans for terracing the Jeruzalem Hills. They started being put into

Figure 4: A bulldozer with equipment for creating terraces; Železne Dveri Mansion in the background (photographer unknown, Ptuj Historical Archives, collection: SI_ZAP/0255 Agrotransport Ptuj 1957–1997, box: 18).

effect in 1965 in the settlements of Slamnjak, Ilovci, and Železne Dveri, from which the terraces expanded toward the south and west, towards Jeruzalem. Because of the loan conditions from the Belgrade bank Poljobanka, the work for this phase of terracing had to be completed by 1969. The processes for consolidating the land and the financial part of the terracing were headed by Franc Štrakl, and the terracing at the site by Franc Žličar, both from VŽK Ljutomer. For the initial work at the site, measurements were made by a local surveyor named Mursa. The construction was carried out by the companies Obnova Maribor and Agrotransport Ptuj because VŽK Ljutomer did not have its own machinery for creating terraces.

The terrain to be terraced was first leveled, excess vegetation was removed, and hollows and ridges were smoothed out (Figure 4). This was followed by staking out individual terraces; due to microlocation adaptation to soil quality, this did not completely follow the plan in places. Namely, problems with soil creep could occur during plowing, trenching, or leveling depending on the marl or loam content of the soil. The terrain was then worked with deep and heavy plowing, followed by the creation of variously sloped banks and leveling of platforms. An inclination of 2° outwards was ensured with a three-meter batten. Some of the paths between the terraces were also adapted to actual conditions at the site. The situation was similar for the terrace banks, which were originally intended to have a 45° slope but were increased to as much as 80° in order to avoid losing arable land.

Calculations show that the terraced land in VŽK Ljutomer's production area yielded one-third less per hectare, although individual grapevines produced much more as a result of the introduction of new cultivars. The yield was therefore quantitatively greater than before.

Similar terracing was carried out by the Jeruzalem–Ormož collective farm (Štrakl and Žličar 2016), only that the terracing was even more intense and continued until the end of the 1980s. All available land, including the former vinedressers' private gardens, were used to create terraces. In Jeruzalem the terraces therefore extend all the way to the houses at the top of the ridges (Brenholc 2014; Vočanec 2014).

3.3 The latest transformation of the terraced landscape

In the 1990s the appearance of the landscape in the Jeruzalem Hills started fundamentally changing again because of the conversion of terraced vineyards into vertical vineyards. Urbanc (2002, 173) determined that »*among the older terraced vineyards there are appearing new or renovated ones with leveled terraces and rows of grapevines running down the slope. This arrangement allows more vines per unit area and makes mechanical cultivation of the vineyard easier*.« Modern agricultural mechanization also makes possible the mechanical cultivation of steeper slopes. In comparison to terraces, vertical plantations have up to 60% more vines per unit area, which, in addition to easier and cheaper cultivation, also results in a greater profit due to both a more abundant yield and agricultural subsidies (Herga 2014; Prapotnik 2014).

Leveling terraces is most intense in Jeruzalem–Ormož Hills Nature Park, where only 190 hectares (or about 33%) of terraces remain from their greatest extent of 570 hectares. In Ljutomer Ponds–Jeruzalem Hills Nature Park, 220 hectares (61%) remain from their greatest extent of 363 hectares. In the southern part of the park, terraces comprise 10% of the land, and in the northern part somewhat more than 16%, whereas at the time of their greatest extent they comprised 30% and 27%, respectively. In the heart of the study area, terracing in the settlement of Jeruzalem is being preserved by the landowners whose vineyards were restored to them through denationalization and by the successors of both collective farms (Šmid Hribar et al. 2017).

4 Discussion

The terracing process, and especially the conversion of terraces back into level slopes, which was carried out over the last fifty years, shows that the landscape is dynamic and is constantly changing. Legal protection has no impact on the preservation of cultivated terraces because, based on our measurements, 56% of them have already been leveled in the study area. We feel that that the greatest extent of terraces may


PRIMOŽ PIPAN

Figure 5: Relevelling the slopes with vertical vineyards with wire supports, adapted to modern mechanized farming. Remnants of terraces are visible at the lower left, and terraces were recently removed from the slope in the background.

have been somewhat overestimated because of uncertainty in determining former terraces in certain parts, and so it would be necessary to confirm this through analysis of aerial photos from the period shortly after the terraces were created. It is interesting that the abandonment, but not destruction, of new vineyard terraces

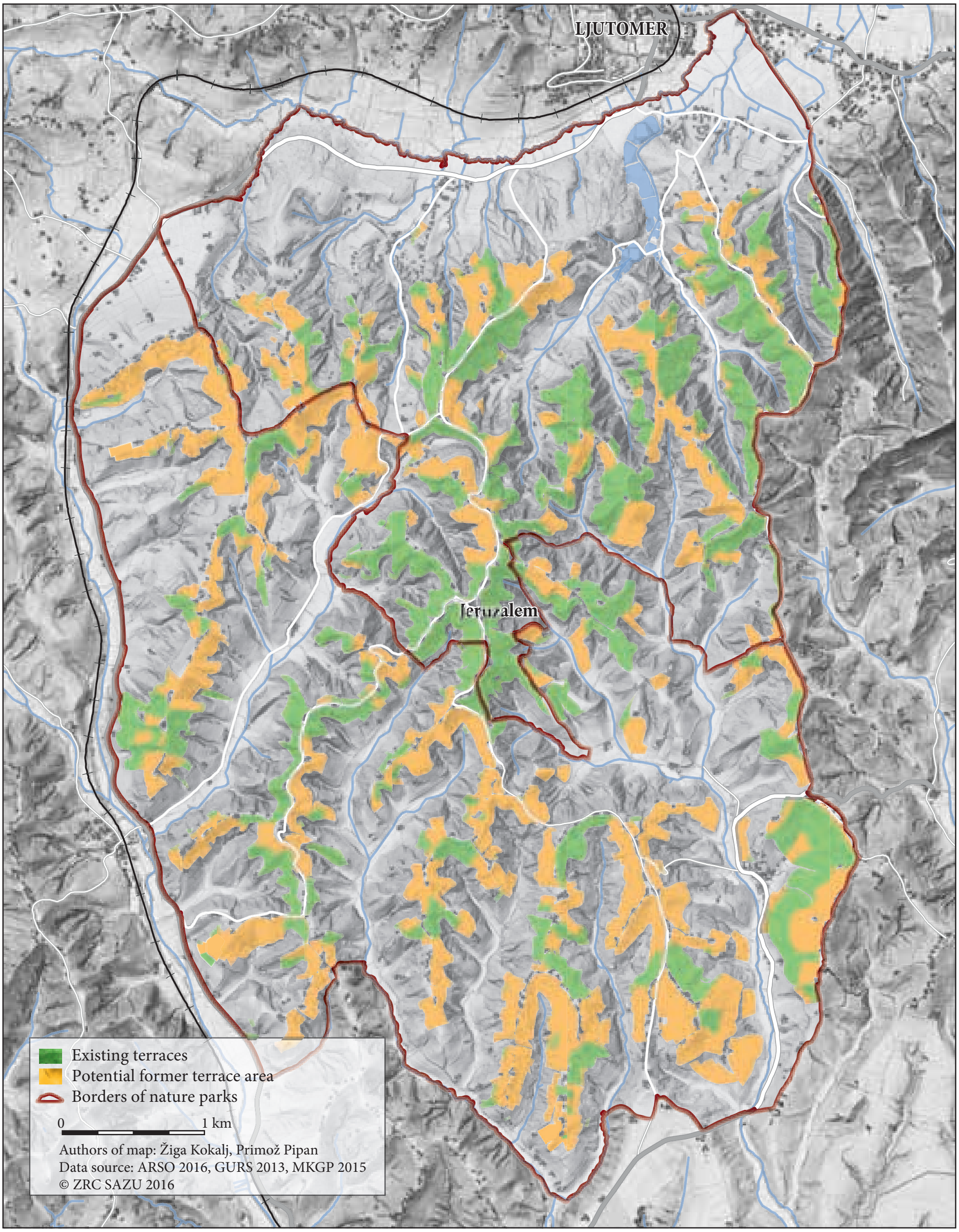

Figure 6: A large-scale map of areas where terraces still exist (green) and potential areas of former terraces (yellow). The borders of Ljutomer Ponds–Jeruzalem Hills Nature Park (northern part) and Jeruzalem–Ormož Hills Nature Park (southern part) are also shown.

has also been ascertained in Slovakia (Špulerová et al. 2017). After 1990, 28% of the terraces that had been created in the second half of the twentieth century in the Little Carpathians and in south-central Slovakia on slopes steeper than 6° were abandoned and overgrown.

Ten years after the terraces were created, the Municipality of Ljutomer established a nature park in its part of the Jeruzalem Hills, and sixteen years later the same was done by the Municipality of Ormož. Both of these protected areas were established without an expert basis, and today they still do not have a designated manager and exist on paper only. We agree with Erhartič (2009), who argues that both nature parks were established to protect the area from construction of detached homes and vacation houses in attractive locations. Nonetheless, the terraced vineyards have become such an important element of the cultural landscape that it was due to them that the Jeruzalem Hills area has been protected as an exceptional cultural landscape (Kladnik, Šmid Hribar and Geršič 2017). The area was registered as unit number 7867 in the national Register of Immovable Cultural Heritage (Register nepremične … 2015) with an establishment date of 1996 (Informacijsko … 2016). When the register was revised in 2003, there was a change in protection status for this heritage unit. The category »active protection« was changed to »other,« which in practice means only documentary or archival protection without any active protection measures (Informacijsko … 2016; Štajnbaher 2016).

The cultivated terraces in the Jeruzalem Hills are a recent manmade landscape element barely fifty years old. They initially helped people cultivate the steeper-than-average slopes, and now they are also (or primarily) valued because of their aesthetic merit. We agree with the opinion of Erhartič et al. that the general value of the landscape beauty (Smrekar, Polajnar Horvat and Erhartič 2016; Smrekar, Zorn and Komac 2016) of vineyard terraces is the main tourism asset for the Jeruzalem Hills (Erhartič 2009).

The vineyard terraces of the Jeruzalem Hills are among the main photo motifs used by the Slovenian tourism industry in many of its media campaigns to market Slovenia as a tourism destination. The profile of the Jeruzalem Hills has been enhanced precisely because of its terraces, which have become a synonym for terraced vineyards. Consequently, this area is difficult to imagine without them. Similarly to what Šmid Hribar and Ledinek Lozej (2013) determine for cultural values in Črni Vrh, we believe that in terms of cultural heritage the development potential of modern cultivated terraces can be turned into a successful product through a combination of knowledge, political will, and capable people. This is reflected, for example, in the designation of wine because in 2003 one of the wine producers used the name *Terase* (Terraces) for a blend of four varieties (Sauvignon, Riesling, Welschriesling, and Chardonnay). It is interesting that a wine was named after vineyard terraces in a time when these terraces have already started being leveled.

According to the interviewees, the main reasons for removing the terraces – in addition to modern agricultural mechanization, which also makes it possible to cultivate steep slopes – are denationalization and inheritance, together with the division of land connected with this. If there are several denationalization or inheritance beneficiaries, the division is simpler if the terraces are leveled because an individual parcel can be divided into several new ones. Vertical vineyards are generally planted on them because the new parcels are too narrow to set up functional terraces. In rare cases of division of terraced vineyards, the beneficiaries have divided individual terraces between themselves so that they could each cultivate their own. Terraces are also leveled in order to increase yields and the profit connected with this. According to the informants, the attractiveness of vineyard terraces is also recognized by those that leveled their former terraced vineyards and converted them into vertical plantations.

With the conversion of terraces into vertical vineyards, new challenges arose connected with increased erosion risk (Figures 7A, 7B, and 7C). There was even a case of a new owner creating completely new terraces on a slope where there had never been a vineyard in the past. Because of a lack of knowledge and experience, he unfortunately created them on unsuitable damp land, and so this soon triggered a landslip (Brenholc 2014; Vočanec 2014; Figure 7D).

Modern vertical vineyards are a new layer in the cultural landscape because this is not a return to the original configuration, before terraces were created, but a new layer on the palimpsest of the Jeruzalem Hills (Komac 2009). Namely, traditional staked vineyards (Figure 3) were characterized by a completely different arrangement of individual grapevines and drainage ditches on the slope, and by manual cultivation of the soil. Even though Antrop (2005) classifies the landscape of the Jeruzalem Hills among new European postmodern landscapes, its appearance is already fundamentally changing for a second time in half a century. The fact that, from the perspective of the traditional landscape these recent terraces are becoming an object of aesthetic valuation of landscape forms, despite their current disappearance, is confirmed by the findings of Urbanc et al. (2004) that preserved visible landscape elements in new circumstances can acquire new meaning for future generations.

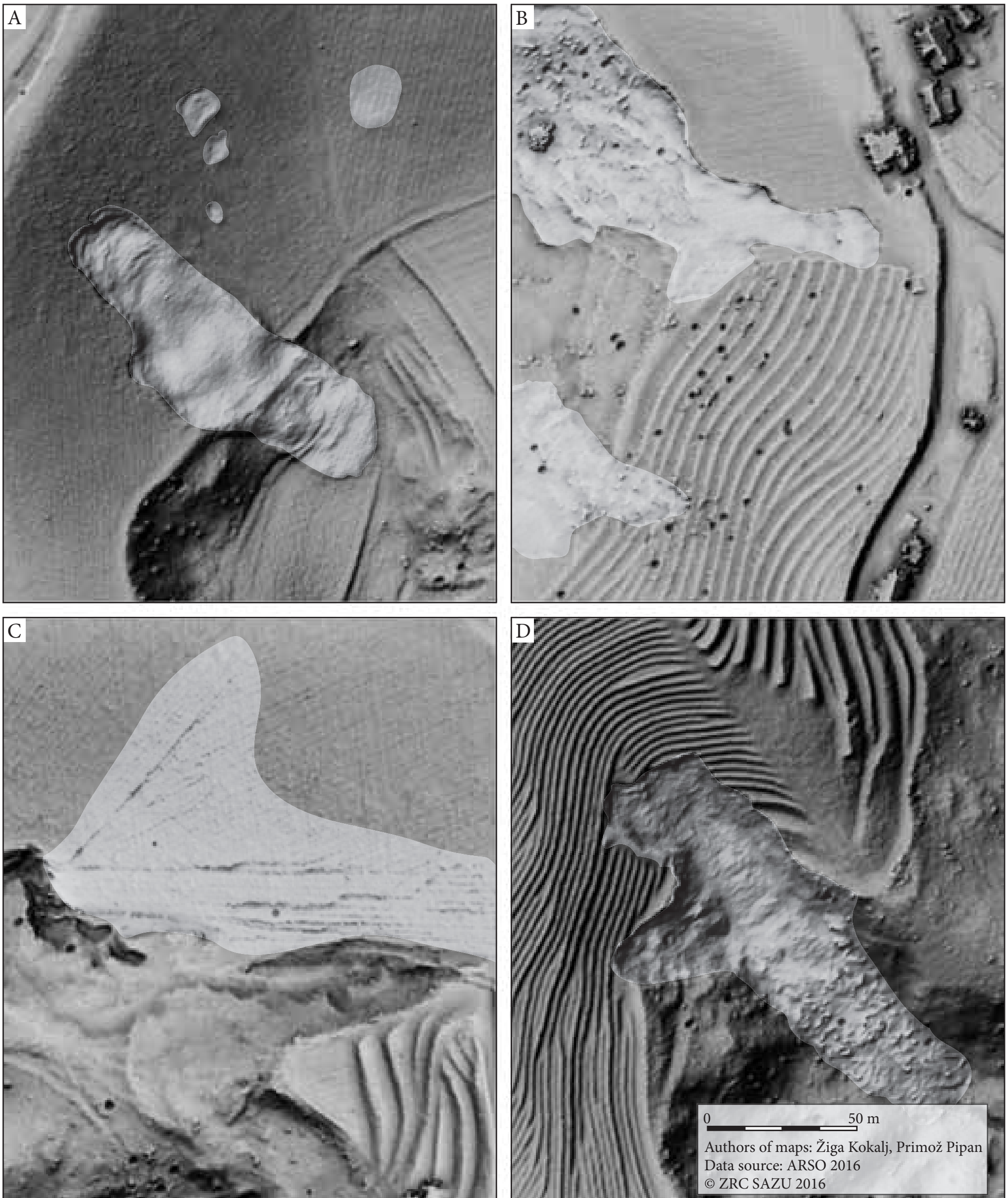

Figure 7: The removal and insufficient maintenance of terraces accelerates erosion processes such as landslides, landslips, and soil erosion, which also occur on terraced slopes.

5 Conclusion

The creation of modern cultivated terraces in the Jeruzalem Hills goes back to the communist social order, which made it possible to concentrate land in two collective farms through the nationalization of farmland. The creation of this layer of the cultural landscape lasted for a quarter century – from 1965 to 1991. The extent of modern cultivated terraces was at its greatest before the transition from communism to a market economy. This is a very brief layer that has nonetheless left a very striking aesthetic impression in the landscape.

This terraced landscape, which was created at a certain point in time due to a need for greater functionality, went beyond this during its quarter century of existence and also became important because of its aesthetic value. The aesthetic aspect became more important especially after the collapse of communism, when people had become used to its new appearance after a quarter century.

Because of their outstanding aesthetic value, the terraces in the Jeruzalem Hills were also recognized by the state as worthy of protection. After the collapse of communism and the subsequent denationalization of collective farms and the restitution of farmland to its former owners, the erasure of this landscape layer of modern cultivated terraces began. Nowadays, the appearance of the landscape is drastically changing for the second time in the past fifty years. Market forces and processes have already deconstructed over half of the terraced landscape, and this trend is still continuing.

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Guidelines for contributing authors in Acta geographica Slovenica

EDITORIAL POLICIES

1 Focus and scope

The Slovenian geographical journal *Acta geographica Slovenica* (print version: ISSN: 1581-6613, digital version: ISSN: 1581-8314) is published by the Anton Melik Geographical Institute of the Slovenian Academy of Sciences and Arts Research Center.

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We accept original research papers and review papers.

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- Perko, D. 1998: The regionalization of Slovenia. Geografski zbornik 38.
- Gams, I. 1994a: Types of contact karst. Geografia fisica e dinamica quaternaria 17.

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- de Kerk, G. V., Manuel, A. R. 2008: A comprehensive index for a sustainable society: The SSI – the Sustainable Society Index. Ecological Economics 66-2,3. DOI: https://doi.org/10.1016/j.ecolecon.2008.01.029
- van Hall, R. L., Cammeraat, L. H., Keesstra, S. D., Zorn, M. 2016: Impact of secondary vegetation succession on soil quality in a humid Mediterranean landscape. Catena, In press. DOI: https://doi.org/10.1016/j.catena.2016.05.021 (25. 11. 2016).

3.2 Citing books

- Cohen, J. 1988: Statistical power analysis for the behavioral sciences. New York.
- Nared, J., Razpotnik Visković, N. (eds.) 2014: Managing cultural heritage sites in Southeastern Europe. Ljubljana.
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- Luc, M., Somorowska, U., Szmańda, J. B. (eds.) 2015: Landscape analysis and planning. Heidelberg. DOI: https://doi.org/10.1007/978-3-319-13527-4

3.3 Citing parts of books or proceedings

- Zorn, M., Komac, B. 2013: Land degradation. Encyclopedia of Natural Hazards. Dordrecht. DOI: https://doi.org/10.1007/978-1-4020-4399-4_207
- Hrvatin, M., Perko, D., Komac, B., Zorn, M. 2006: Slovenia. Soil Erosion in Europe. Chichester. DOI: https://doi.org/10.1002/0470859202.ch25
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- Komac, B., Zorn, M. 2010: Statistično modeliranje plazovitosti v državnem merilu. Od razumevanja do upravljanja, Naravne nesreče 1. Ljubljana.

3.4 Citing expert reports, theses, and dissertations

- Breg Valjavec, M. 2012: Geoinformatic methods for the detection of former waste disposal sites in karstic and nonkarstic regions (case study of dolines and gravel pits). Ph.D. thesis, University of Nova Gorica. Nova Gorica.
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- Šifrer, M. 1997: Površje v Sloveniji. Elaborat, Geografski inštitut Antona Melika ZRC SAZU. Ljubljana.

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- Bender, O., Borsdorf, A., Heinrich, K. 2010: The interactive alpine information system GALPIS. Challenges for mountain regions, Tackling complexity. Internet: http://www.mountainresearch.at/images/Publikationen/Sonderband/bender-borsdorf-heinrich.pdf (4. 8. 2014).

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- Internet 1: http://giam.zrc-sazu.si/ (22. 7. 2012).
- Internet 2: http://ags.zrc-sazu.si (23. 7. 2012).

3.7 Citing sources without authors

- WCED – World commission on environmental and development: Our common future – Brundtland report. Oxford, 1987.
- Popis prebivalstva, gospodinjstev, stanovanj in kmečkih gospodarstev v Republiki Sloveniji, 1991 – končni podatki. Zavod Republike Slovenije za statistiko. Ljubljana, 1993.

3.8 Citing cartographic sources

- Državna topografska karta Republike Slovenije 1 : 25.000, list Brežice. Geodetska uprava Republike Slovenije. Ljubljana, 1998.
- Franciscejski kataster za Kranjsko, k. o. Sv. Agata, list A02. Arhiv Republike Slovenije. Ljubljana, 1823–1869.
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- The vegetation map of forest communities of Slovenia 1 : 400,000. Biološki inštitut Jovana Hadžija ZRC SAZU. Ljubljana, 2002.
- Digitalni model višin 12,5. Geodetska uprava Republike Slovenije. Ljubljana, 2005.

3.9 Citing official gazettes

- Zakon o kmetijskih zemljiščih. Uradni list Republike Slovenije 59/1996. Ljubljana.
- Zakon o varstvu pred naravnimi in drugimi nesrečami. Uradni list Republike Slovenije 64/1994, 33/2000, 87/2001, 41/2004, 28/2006 in 51/2006. Ljubljana.
- 1999/847/EC: Council Decision of 9 December 1999 establishing a Community action programme in the field of civil protection. Official Journal 327, 21. 12. 1999.

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No

3 Editorial notes regarding the paper's content.

4 Length of the paper is acceptable for further processing (20.000 characters including space). If longer, the paper has to be shortened by the author and resubmitted.
- The paper has less than 20.000 characters.
- The paper has more than 20.000 characters, but less than 25.000.
- The paper has more than 25.000 characters.

5 The style and formatting of the paper is according to the AGS guidelines – the paper is prepared in plain text, no other text formatting is used than bold and italic. See the Guidelines of AGS journal for details.)
Yes
No

6 Notes regarding style and formatting.

7 Citing in the paper is according to the AGS guidelines and style, including DOI identificators.
Yes
No

8 The reference list is suitable (the author cites previously published papers with similar topic from other relevant scientific journal).
Yes, the author cited previously published papers on similar topic.
No, the author did not cite previously published papers on similar topic.

9 Scientific language of the paper is appropriate and understandable.
Yes
No

10 Supplementary files (ai, cdr, pdf, tif, jpg, xlsx etc.) that were added to the paper are in proper format and resolution (including the introductory photo), maps are prepared according to the AGS Guidelines. (In this step contact the technical editor [rok.ciglic@zrc-sazu.si] for assistance if needed).
- Supplementary files are correct.
- Supplementary files are not appropriate and need a major correction.
- Some supplementary files need corrections.

11 Describe the possible deficiencies of the supplementary files:

12 DECISION OF THE RESPONSIBLE EDITOR
The paper is accepted for further processing and may be sent to the reviewer.
The paper is accepted for further processing but needs technical improvements (see notes).
The paper is accepted for further processing but its content needs additional improvements (see notes).
The paper is not accepted for publication because:
- It is more suitable for a specialized journal.
- Does not fit the aims and scopes of the AGS journal.
- Is not an original scientific paper.
- The presentation of the results is poor.
- The paper is of very low quality.
- The paper has already been published elsewhere.
- Other (see comments below).
- Other reasons for rejection of the paper.

ACTA GEOGRAPHICA SLOVENICA REVIEW FORM

1 RELEVANCE

1a) Are the findings original and the paper is therefore a significant one?
yes
no
partly

1b) Is the paper suitable for the subject focus of the AGS journal?
yes
no

2 SIGNIFICANCE

2a Does the paper discuss an important problem in geography or related fields?
yes
no
partly

2b Does it bring relevant results for contemporary geography?
yes
no
partly

2c What is the level of the novelty of research presented in the paper?
high
middle
low

3 ORIGINALITY

3a Has the paper been already published or is too similar to work already published?
yes
no

3b Does the paper discuss a new issue?
yes
no

3c Are the methods presented sound and adequate?
yes
no
partly

3d Do the presented data support the conclusions?
yes
no
partly

4 CLARITY

4a Is the paper clear, logical and understandable?
yes
no

4b If necessary, add comments and recommendations to improve the clarity of the title, abstract, keywords, introduction, methods or conclusion:

5 QUALITY

5a Is the paper technically sound? (If no, the author should discuss technical editor [rok.ciglic@zrc-sazu.si] for assistance.)
yes
no

5b Does the paper take into account relevant current and past research on the topic?
yes
no
Propose amendments, if no is selected:

5d Is the references list the end of the paper adequate?
yes
no
Propose amendments, if no is selected:

5e Is the quoting in the text appropriate?
yes
no
partly
Propose amendments, if no is selected:

5f Which tables are not necessary?

5g Which figures are not necessary?

6 COMMENTS OF THE REVIEWER

Comments of the reviewer on the contents of the paper:
Comments of the reviewer on the methods used in the paper:

7 RECOMMENDATION OF THE REVIEWER TO THE EDITOR-IN-CHIEF

My recommendation is:
Please rate the paper from 1 [low] to 100 [high]:
Personal notes of the reviewer to editor-in-chief.

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Since 2003 (from volume 43 onward) the name of the joint journal has been *Acta geographica Slovenica*. The journal continues the numbering system of the journal *Geografski zbornik / Acta geographica*.

Those interested in the history of the journal are invited to read the paper "The History of *Acta geographica Slovenica*."

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