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DIVERSITY OF TERRACED LANDSCAPES IN SLOVENIA

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ABSTRACT

This article presents the diversity of Slovenian terraced landscapes which is illustrated mainly at the level of Slovenian landscape types, focusing on a comparison of terraced landscapes in selected pilot settlements. In addition to basic GIS analyses based on LIDAR data, the diversity of metric parameters of characteristic terraced areas are also presented, highlighting the dimensions and configuration of terraces, their platforms and slopes, as well as their current land use. Attention is also drawn to the most recent processes transforming characteristic terraced landscapes.

Keywords: terraced landscape, terrace, land use, landscape metrics, Slovenia

DIVERSITÀ DEI PAESAGGI TERRAZZATI SLOVENI

SINTESI

L'articolo presenta la diversità dei paesaggi terrazzati sloveni che viene illustrata principalmente a livello degli tipi di paesaggio sloveni. La ricerca è incentrata sul confronto tra aree terrazzate presso villaggi pilota. Oltre alle basiche analisi GIS basate sui dati LIDAR viene presentata anche la diversità dei caratteristici parametri metrici delle aree terrazzate, evidenziando le dimensioni e la configurazione delle terrazze, le loro piattaforme e pendii, così come pure l'uso del suolo attuale. L'attenzione è inoltre rivolta ai più recenti processi di trasformazione dei paesaggi terrazzati caratteristici.

Parole chiave: paesaggio terrazzato, terrazzo, uso del suolo, le metriche del paesaggio, Slovenia

INTRODUCTION

Terraced landscapes are constructed cultural landscapes. Their aesthetic value is defined by a repeating pattern of terrace platforms and slopes, or hill slope geometrization. Terraced landscapes are spatial features with an exceptional physiognomy, in which terraces are the most important element of the cultural landscape (Ažman Momirski, Kladnik, 2015b).

Due to their typical landform, there are frequent attempts to typify agricultural terraces, which influence the terraced landscape aesthetics. The land-use typology of terraces (Ažman Momirski, Kladnik, 2009, 19) is widely accepted and used.

Relative to landscape diversity, only a few countries, even much larger ones, can be compared to Slovenia (Ciglič, Perko, 2013). In this tiny piece of central Europe, the Alps, the Dinaric Alps, the Pannonian Basin, and the Mediterranean meet and intertwine, as do Slavic, Germanic, Romance, and Hungarian cultural influences (Perko, 1997; Perko, 1998; Perko, 2007; Kladnik, Perko & Urbanc, 2009; Ciglič, Perko, 2012; Ciglič, Perko, 2013; Perko, Ciglič, 2015; Perko, Hrvatin and Ciglič, 2015). For this reason, Slovenia is renowned for its great geographical variety, which is also reflected in cultural terraces that build various terraced landscapes. Four major landscape types and nine subtypes can be distinguished (Figure 1; Kladnik, Perko & Urbanc, 2009).

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, Perko, 2013).

The international study of terraced landscapes reached its peak with the first two international conferences on terraced landscapes. At the first one, which took place in Mengzi, southwest China in November 2010, the International Terraced Landscapes Alliance (ITLA) was established and the Honghe Declaration on the protection and development of terraces (Junchao, 2012) was adopted. Together with over one hundred conference papers on various aspects of terraced landscapes from around the globe, this declaration was also published in extensive volumes in Chinese and English

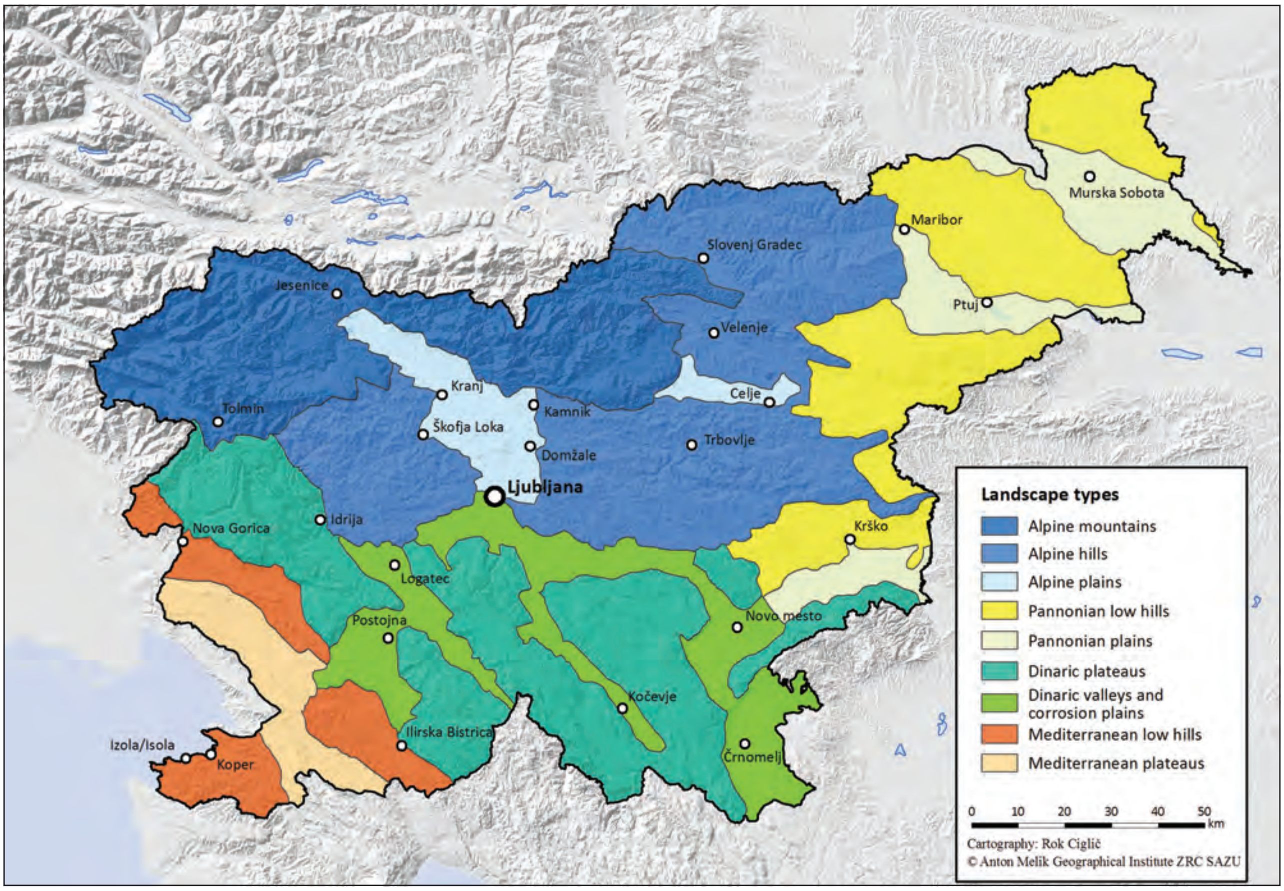

Figure 1: Slovenian landscape types.

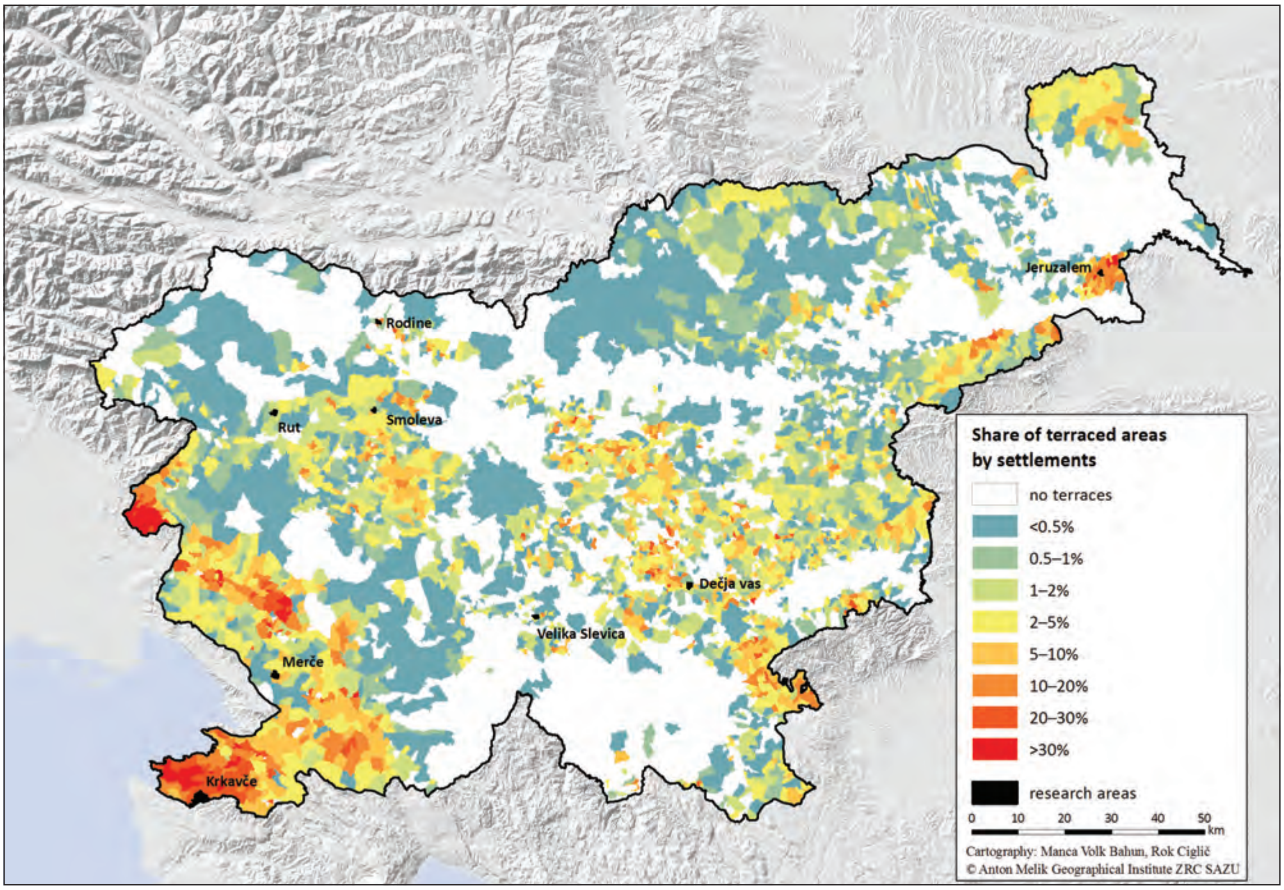

Figure 2: Share of terraced areas in Slovenia in 2015 and pilot settlements.

(Peters, Junchao, 2012, 8–9). The second ITLA conference was held in Cusco, Peru in May 2014. There were only a few presentations of European terraced landscapes. An extensive volume of conference proceedings (Tillmann, de Mesquita, 2015) also contains two Slovenian articles about factors in the conservation and decline of cultivated terraces in Slovenia (Ažman Momirski, Kladnik, 2015a) and Slovenia's best-known terraced landscape in the Gorizia Hills (Ažman Momirski, 2015).

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, Kladnik, 2009). Also noteworthy is 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, Gabrovec, 2014), a study created based on fieldwork in selected Slovenian terraced landscapes (Križaj Smrdel, 2010), and the volume *Terasirana pokrajina Goriških brd* (Terraced Landscapes of the Gorizia Hills; Ažman Momirski et al., 2008), which still remains the most in-depth study of a Slovenian terraced landscape. The extensive volume *Terasirane pokrajine* (Terraced Landscapes; Kladnik et al., 2016) was published in April 2016, upon the seventieth anniversary of the ZRC SAZU Anton Melik Geographical Institute. In addition to terraced landscapes in Slovenia, it presents other terraced landscapes around the world, as well as natural and manmade non-agricultural terraces.

The aim of the article is to present geographical distribution and characteristics of selected typical terraced landscapes in Slovenia. The metric characteristics and the qualities of individual terraces or their components (terrace platforms and terrace slopes) were analysed that together create characteristic terraced landscapes. Detailed investigations were done in the pilot settlements areas[1], whereby for each landscape type we selected one characteristic settlement with terraced terrain (Figure 2): for Mediterranean low hills the pilot settlement was Krkavče, for Mediterranean plateaus Merče, for Dinaric plateaus Dečja vas, for Dinaric valleys and cor-

1 Eight pilot areas were selected and examined in the applied research project "Terraced Landscapes in Slovenia as Cultural Values" (no. L6-4038).

rosion plains Velika Slevica, for Alpine mountains Rut, for Alpine hills Smoleva, for Alpine plains Rodine, and for Pannonian low hills Jeruzalem. The exception was the landscape type Pannonian plains, where terracing accounted for only 0.05% of the land and therefore no pilot settlement was selected.

DATA

In order to assess the geographic distribution and characteristics of agricultural terraces in Slovenia we employed color digital ortophoto images (DOPs; Digitalni orto …, 2011–2015), with a resolution of 0.50 m, records of the actual utilization of agrarian and forest lands kept by the Ministry of Agriculture, Forestry and Food (Podatki o dejanski rabi tal, 2015), data obtained from aerial laser scanning (Light Detection and Ranging, 2015), and a digital elevation model (DEM; Digitalni model višin, 2009–2011).

We also used a 1:5,000 base topographic map layer, or 1:10,000 for mountainous areas (Temeljni topografski načrt 1:5000 and 1:10.000, 1993–1995), in which agricultural terraces are marked with a special easy-to-recognize topographic symbol. We analyzed the terraced areas identified in this way using geoinformation tools to determine their elevation, aspect, inclination, bedrock composition (Litostratigrafska karta Slovenije, 2011; Zemljevid tipov kamnin, 2012), and land use.

The cartographic representation of land use in the cadastral survey carried out under Emperor Francis I (the Franciscean cadaster) in the 1820s was also used. The 1:2,880 maps of the Franciscean cadaster for the cadastral municipalities with seven of the eight pilot settlements are accessible at the Archives of the Republic of Slovenia in Ljubljana, and the maps for Krkavče are kept at the State Archives in Trieste. A more detailed overview of the Franciscean cadaster maps used is given in Table 1.

The interpretation key for the Records on Actual Land Utilization (Interpretacijski ključ, 2013) was used although it treats the slopes of terraced areas differently. Applied to the category "field" is a provision specifying that utilization also includes the terrace slopes between the fields with a ground floor no wider than 2 m. Applied to vineyards and orchards is a rule stipulating that this type of utilization includes all "*overgrown and grassed slopes of vineyard terraces that show an example of good agricultural and environmental practice of preventing erosion*" (Ažman Momirski, Gabrovec, 2014, 35).

BASIC CHARACTERISTICS OF CULTURAL TERRACES IN SLOVENIA

In order to better understand the details of the pilot areas presented below, we first present some basic characteristics of cultural terraces in Slovenia (Table 2) and then focus on the main attributes of the pilot areas. Slovenia is crisscrossed by cultivated terraces in a way that few other European countries are. With exception of Pannonian plains terraces appear in all Slovenian landscape types (Ažman Momirski, Kladnik, 2009; Ažman Momirski, Kladnik, 2012) and 1.71% of land has been reworked into agricultural terraces. By far the greatest share is in Mediterranean landscapes (8.96%), whereas everywhere else the share is below average. The "hotspots" of terraced landscapes are clearly visible in Figure 2, where they stand out as contiguous red and orange areas.

Terraces in Slovenia appear at elevations from 0 to nearly 1,200 m (the Bukovnik farm, the highest in Slovenia, lies at an elevation of 1,327 m), and in terms of area

Table 1: Franciscean cadaster maps used.

Landscape types	Pilot settlement	Archive call number	Time created
Mediterranean landscapes			
Mediterranean low hills	Krkavče	AST-179, I/FJ/I43	1817–1825
Mediterranean plateaus	Merče	AS-179, G/FJ/G131	1817–1825
Dinaric landscapes			
Dinaric plateaus	Dečja vas	AS-176, N/N214	1818–1828
Dinaric valleys and corrosion plains	Velika Slevica	AS-176, N/N93	1818–1828
Alpine landscapes			
Alpine mountains	Rut	AS-179, G/FJ/G64	1817–1825
Alpine hills	Smoleva	AS-176, L/L175	1818–1828
Alpine plains	Rodine	AS-176, L/L45	1818–1828
Pannonian landscapes			
Pannonian low hills	Jeruzalem	AS-177, M/F/M476	1819–1825
Pannonian plains	–	–	–

Table 2: Terraced areas within Slovenian landscape types by lithology, aspect, and land use.

Landscape type	Share of terraced areas (%)	The predominant rock type of terraced area and its share (%)	The predominant aspect of terraced area and its share (%)	The predominant land-use category of terraced area in 2015 and its share (%)
Mediterranean low hills	12.39	Flysch 89.4	SW 14.9	Meadows and pastures 22.3
Mediterranean plateaus	3.56	Carbonate rock 79.7	SW 23.5	Meadows and pastures 53.9
Dinaric plateaus	0.69	Carbonate rock 64.3	S 19.4	Meadows and pastures 61.3
Dinaric valleys and corrosion plains	1.60	Carbonate rock 62.5	S 19.9	Meadows and pastures 59.8
Alpine mountains	0.21	Carbonate sedimentary rock 45.8	S 30.7	Meadows and pastures 83.3
Alpine hills	1.46	Carbonate rock 42.4	S 22.6	Meadows and pastures 78.4
Alpine plains	0.38	Carbonate sedimentary rock 56.6	S 36.2	Meadows and pastures 76.9
Pannonian low hills	1.86	Non-carbonate sedimentary rock 44.9	SE 16.8	Vineyards 29.8
Pannonian plains	0.05	Non-carbonate sedimentary rock 62.9	E 18.6	Meadows and pastures 40.5

the majority can be found in an elevation band between 200 and 300 m (21.2%).

With regard to rock composition, three types strongly stand out. Of these, 39.8% are on underlying flysch, which is characteristic of Mediterranean Slovenia. A further 27.3% of terraces are on dolomite and limestone, which are common in Dinaric and Alpine regions, and 13.9% are on non-carbonate sedimentary rock, common in Pannonian landscapes.

Nearly half of all terraces (45.0%) are on moderately sloping terrain with an inclination from 15 to 30% (from 8.6 to 16.7°). The steepest terraced slopes are found in Alpine hills (42.5% of them are on slopes with an inclination of 30 to 50%, from 16.8 to 26.6°), and the gentlest ones are on Mediterranean plateaus, where a full 65.0% of them are on slopes with an inclination of no more than 15% (8.5°).

Currently, most terraced land is used for meadows and pastures (44.6%), followed by vineyards with a significantly smaller share (15.7%). Fields account for 8.2% of terraced areas, orchards 5.6%, and olive groves 3.6%. 9.0% of terraced areas are being overgrown by bushes and trees, and 8.9% have been overgrown by forest. The actual area of terraced land that has undergone afforestation is considerably greater because we are certain that DOP digitization was unable to inventory all such terraces. Olive groves are exclusively connected with Mediterranean low hills, where they are planted on 9.3% of the terraced areas there. Vineyards are most common on terraced areas of Pannonian low hills and Mediterranean low hills (29.8 and 25.2%), where there are also the most orchards (8.0 and 7.1). Fields are by far most common in Pannonian low hills (17.8%), Pannonian plains (16.6%), and Dinaric valleys and on corrosion plains (14.8%).

Most Slovenian terraces have a southern or southwest aspect (20.2 and 16.3%, respectively). Despite the dominance of meadows and pastures on terraces in cold and steep Alpine landscapes, exposure to solar radiation there is considerably more important than in the warmer more intensively cultivated Mediterranean landscapes.

Therefore, strong predomination of southern exposures is characteristic for Alpine plains (36.2%) and Alpine mountains (30.7%). For the Pannonian landscapes, alongside southern exposures there is a higher than average share of eastern and western exposures, whereas aspect is relatively the least important factor in terracing in Dinaric landscapes, with a strong predominance of terraces covered in meadows and pastures.

Terraces in western Slovenia were probably built as early as Roman times, whereas in Pannonian Slovenia terracing is a relatively new phenomenon. Data indicate that the first terraced plantation in the Drava Valley (NE Slovenia) wine-growing area was built in the settlement of Gruškovec in the Haloze region between 1892 and 1899 (Bračič, 1967). After the Second World War, the terracing of slopes was promoted by large state-owned holdings due to easier and more profitable farming on steep slopes (Belec, 1968) while the terraces were abandoned in other areas. The abandonment of agricultural terraces is not a new phenomenon because early studies by Vrišer (1954), Melik (1960), and Titl (1965) reported the extensive abandonment of cultivated terraces in western Slovenia. This suggests that abandonment is a long-term process with numerous causes (Ažman Momirski, Kladnik, 2015a). The greatest share of abandoned terraces that have already undergone afforestation was found in Mediterranean low hills (13.9%) and Dinaric plateaus (12.0%).

METHODS

Using the above mentioned data we determined the location, purpose, and characteristics of terraces in pilot areas which represent typical Slovenian landscapes, namely Alpine, Dinaric, Mediterranean, and Pannonian. Characteristics of individual representative terraces were analyzed through fieldwork and by measuring the length of terraces and height of terrace slopes using geoinformation tools based on a DEM with a resolution of 1 m. Based on elevation in the DEM and a shaded relief map, we measured the longest terraces and created characteristic cross-sections of terraced slopes within individual pilot areas. In this manner, we also obtained information about the greatest lengths of terraces and the heights of the terrace slopes, which we double-checked through field measurements.

For every pilot settlement area, we used digitization of terraced areas to determine the number of terraced patches (NTP), after which we also calculated mean terraced patch area (MTPA), total length of terraced patch edges (TLTPE), mean length of terraced patch edge (MLTPE), and density of terraced patch edges (DTPE), which reflect the diversity and fragmentation of a terraced landscape in a particular area.

For spatial pattern analyses to determine land-use diversity within terraced areas in individual pilot settlements areas and to compare them with one another, we used some indicators from FRAGSTATS software, version 4 (McGarigal, Cushman & Ene, 2012; McGarigal, 2015). This is an improved version of a basic study (McGarigal, Marks, 1994; McGarigal, Marks, 1995) that provides thorough insight into the interior landscape structure. The selected indicators show whether a particular landscape is diverse in terms of the number of land-use categories in it and with regard to the presence or distribution of each individual category.

For this analysis, we used the program V.LATE (Lang, Tiede, 2003) to calculate the landscape metrics.

We used four indicators. Patch richness (PR; Patch Richnes, 2015; McGarigal, Marks, 1994; McGarigal, 2015) equals the number of different patch types present within the landscape boundary. In our case, this is the number of different land-use types. Relative patch richness (RPR; Relative Patch Richness, 2015; McGarigal, Marks, 1994; McGarigal, 2015) equals the number of different patch types present within the landscape boundary divided by the maximum potential number of patch types specified by the user, based on the particular patch type classification scheme, multiplied by 100 (to convert to percent). In our case, the maximum number (eleven land-use categories) is the total number of land-use categories in all eight pilot settlements. The Shannon's diversity index (SHDI; Shannon's Diversity Index, 2015; McGarigal, Marks, 1994; McGarigal, 2015) equals the negative sum across all patch types (*m*) of the proportional abundance (P_i) of each patch type multiplied by that proportion:

$$SHDI = -\sum_{i=1}^{m}(P_i \ln P_i)$$

The SHDI value is 0 when the landscape contains only 1 patch (i.e., no diversity), and increases as the number of different patch types (i.e., patch richness, PR) increases and/or the proportional distribution of the area among patch types becomes more equal. The higher the SHDI value, the more diverse the landscape is regarded.

Shannon's evenness index (SHEI; Shannon's evenness index, 2015; McGarigal, Marks, 1994; McGarigal, 2015) is calculated in the following form (the observed value of Shannon's diversity index is divided by the maximum value of Shannon's diversity index):

$$SHEI = \frac{SHDI}{SHDI_{max}}$$

The SHEI value is constrained between 0 and 1 and tells how close a certain landscape's diversity is to the maximum diversity (according to a given number of land categories). Maximum diversity is achieved when all of the categories have the same area ratio; for example, when the area share of each of four categories is

Table 3: Share (%) of terraced areas and main characteristics of terraces in the pilot settlement areas.

Landscape type	Share of total terraced areas (%) within landscape type	Pilot settlement	Total area (m^2)	Terraced areas (m^2)	Share of terraced areas (%)	Lower elevation limit of terraced areas (m)	Upper elevation limit of terraced areas (m)	Length of longest terrace (m)	General form of terrace platform	Average height of terrace (terrace platform and slope together) (m)	General characteristics of terrace slope	Height of highest terrace slope (m)
Mediterranean low hills	12.39	Krkavče	6,446,560	2,310,853	35.8	10	275	200	Level, gently sloping	2.65	Earthen, steep to diagonal, grassy, dry walls rare	3
Mediterranean plateaus	3.56	Merče	3,923,510	520,408	13.3	350	445	210	Gently sloping	1.55	Dry walls, earthen, step, covered in bushes	2
Dinaric plateaus	0.69	Dečja vas	3,056,900	610,009	20.0	318	365	250	Gently sloping	2.25	Earthen, steep, grassy	2.5
Dinaric valleys and corrosion plains	1.60	Velika Slevica	1,136,520	271,418	23.9	549	635	800	Moderately sloping	1.90	Earthen, steep, grassy	2
Alpine mountains	0.21	Rut	10,174,200	438,177	4.3	590	820	330	Moderately sloping	3.20	Earthen, steep to diagonal, grassy, dry walls rare	5
Alpine hills	1.46	Smoleva	1,831,300	201,589	11.0	495	860	220	Gently to moderately sloping	8.00	Earthen, steep to diagonal, grassy, partially planted with fruit trees and bushes	8
Alpine plains	0.38	Rodine	1,806,220	223,084	12.4	508	585	220	Gently sloping	3.15	Earthen, very diagonal, grassy	3
Pannonian low hills	1.86	Jeruzalem	598,348	244,567	40.9	280	342	725	Level	1.75	Earthen, diagonal, grassy	2.5
Pannonian plains	0.05	–	–	–	–	–	–	–	–	–	–	–

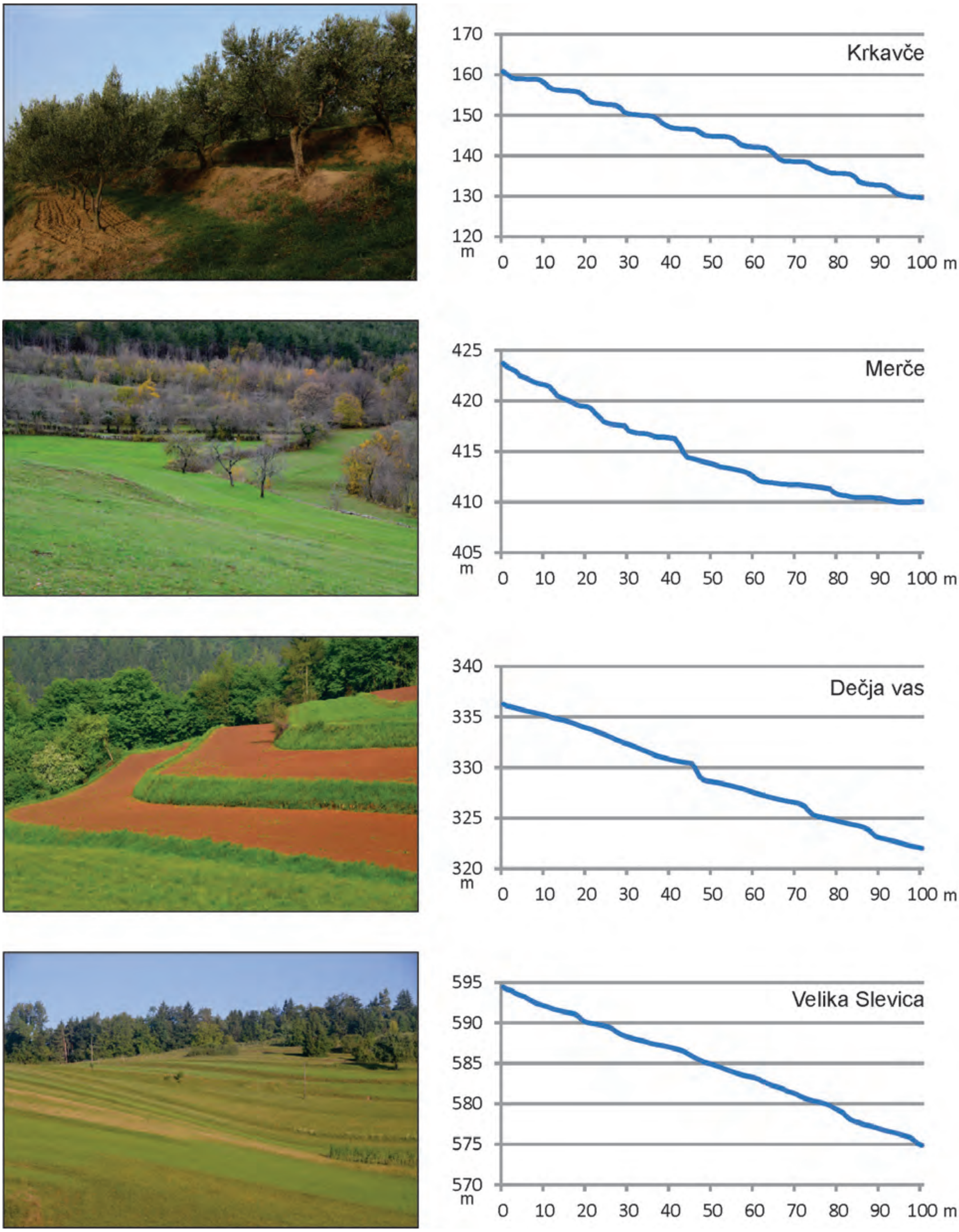

Figure 3: Photos of terraces in pilot settlement areas and cross-sections of terraced slopes in pilot settlement areas.

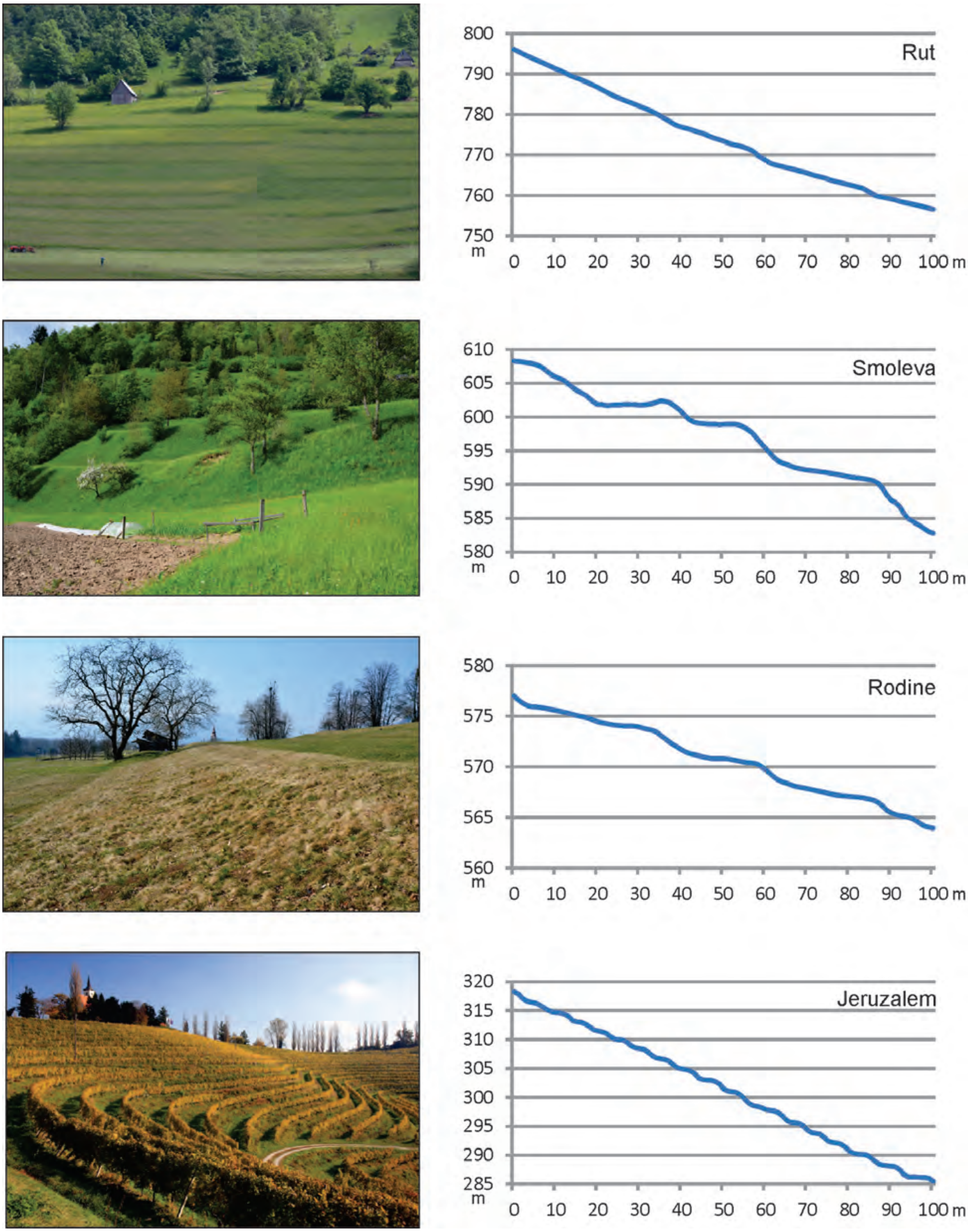

Figure 3: Photos of terraces in pilot settlement areas and cross-sections of terraced slopes in pilot settlement areas.

25%, or when each of five categories has a 20% share. It is directly comparable only for areas with the same number of categories (in our case, land-use categories).

Assessments of aesthetic value and exposure to landslide hazard, overgrowth, and planned transformation were carried out based on a field investigation and comparison of terraced areas in the selected pilot settlements.

RESULTS

The results at the level of settlements as representative units for individual Slovenian landscape types are presented in tabular form (Tables 3–6) and further detailed in Figure 3. The text gives only a condensed overview of the most significant findings important for understanding the topic at hand.

The analyses with geoinformation tools revealed that slope aspect and inclination in the pilot settlements agrees considerably with that at the level of the corresponding landscape types.

The shares of terraced areas on the village land of the pilot areas vary greatly, from 4.3% in Alpine settlement Rut to 40.9% in the winegrowing village of Jeruzalem as a representative of Pannonian low hills. In all cases, the terraced areas lie near the settlement cores because this was the easiest way for farmers to manage them while intensively cultivating them. The following principle applies: the greater the share of terraced land, the more this is scattered around the village settlement cores. In the settlements studied, terraces are distributed at elevations between 10 and 860 m, whereby the greatest elevation differences are in the pilot settlement of Smoleva as a representative of Alpine hills.

The physical characteristics of the terraces that make up terraced landscapes differ considerably from one another. The longest terraces are in the villages of Velika Slevica and Jeruzalem (up to 800 m).

Terrace platforms vary in their width.

They are level only in the narrow belts of vineyard terraces in Jeruzalem and in places in Krkavče, otherwise they gently slope outwards, and in the hilliest settlement of Rut and in Velika Slevica, where the low earthen terrace slopes make them relatively indistinct, their inclination is considerable. In Rodine the terrace slopes are so gently sloping that it is quite difficult to distinguish them from the even more gently sloping terrace platforms. Rather diagonal terrace slopes are seen in the vineyard terraces in Pannonian low hills, whereas steep terrace slopes predominate elsewhere.

The highest terrace slopes by far are found in Smoleva, where they have a height of up to eight meters in the lower part of the terraced land. Otherwise in most of the

Table 4: Some indicators of the presence of terraced areas in the pilot settlements areas.

Landscape type	Pilot settlement	Total area (m^2)	Terraced areas (m^2)	Share of terraced areas (%)	Total number of terraced patches (NTP)	Mean terraced patch area (MTPA) (m^2)	Total length of terraces patch edges (TLTPE) (m)	Mean length of terraced patch edge (MLTPE) (m)	Density of terraced patch edges (DTPE) (m/ha)
Mediterranean low hills	Krkavče	6,446,560	2,310,853	35.8	1216	1,900	259,918.3	213.75	1,124.77
Mediterranean plateaus	Merče	3,923,510	520,408	13.3	332	1,567	73,766.83	222.19	1,417.48
Dinaric plateaus	Dečja vas	3,056,900	610,009	20.0	216	2,824	47,163.98	218.35	773.17
Dinaric valleys and corrosion plains	Velika Slevica	1,136,520	271,418	23.9	138	1,967	21,711.05	157.33	799.91
Alpine mountains	Rut	10,174,200	438,177	4.3	161	2,722	30,038.41	186.57	685.53
Alpine hills	Smoleva	1,831,300	201,589	11.0	70	2,880	19,250.07	275.00	954.91
Alpine plains	Rodine	1,806,220	223,084	12.4	59	3,781	14,595.00	247.37	654.24
Pannonian low hills	Jeruzalem	598,348	244,567	40.9	65	3,763	11,607.11	178.57	474.60
Pannonian plains	–	–	–	–	–	–	–	–	–

Table 5: Some indicators of the diversity of terraced areas in the pilot settlements areas.

Landscape type	Pilot settlement	Total area (m²)	Terraced areas (m²)	Share of terraced areas (%)	Number of possible land-use categories	Patch richness (PR)	Relative patch richness (RPR) (%)	Shannon's diversity index (SHDI)	Shannon's evenness index (SHEI)
Mediterranean low hills	Krkavče	6,446,560	2,310,853	35.8	11	9	81.82	1.835	0.835
Mediterranean plateaus	Merče	3,923,510	520,408	13.3	11	8	72.73	1.013	0.487
Dinaric plateaus	Dečja vas	3,056,900	610,009	20.0	11	7	63.64	1.017	0.522
Dinaric valleys and corrosion plains	Velika Slevica	1,136,520	271,418	23.9	11	7	63.64	0.562	0.289
Alpine mountains	Rut	10,174,200	438,177	4.3	11	6	54.55	0.671	0.374
Alpine hills	Smoleva	1,831,300	201,589	11.0	11	6	54.55	0.999	0.558
Alpine plains	Rodine	1,806,220	223,084	12.4	11	6	54.55	0.663	0.370
Pannonian low hills	Jeruzalem	598,348	244,567	40.9	11	8	72.73	0.393	0.189
Pannonian plains	–	–	–	–	–	–	–	–	–

settlements studied they do not exceed three meters in height, which is also their extreme value, because in Velika Slevica, Rut, and Merče, for example, most of them are less than one meter in height.

Considering more or less oblique terrace platforms as part of the terrace slopes, together with which they form the terraces, on average the highest terraces by far are in Smoleva (8 m), followed by terraces in Rut (3.2 m) and Rodine (3.15 m), whereas the lowest and thus least distinct are in Merče (1.55 m) and Velika Slevica (1.9 m), and also in Jeruzalem (1.75 m).

Everywhere except in Merče, where a large portion of the terrace slopes are formed with dry walls, earthen terrace slopes predominate. Individual terrace slopes are also formed with dry walls in Krkavče and Rut, where, just as in the entire Soča Valley, the influences of the Mediterranean cultural environment can be felt.

In the majority of settlements they are overgrown with grass, only in Merče are they overgrown with thick bushes, and in Smoleva in addition to bushes they are also reinforced by occasional fruit trees.

The greatest number of terrace patches by far with various land use is found in Krkavče (1,216), whereas in Rodine (59), Jeruzalem (70), and Smoleva (70) their number is less than one hundred. The number of terrace patches depends on the size of the village territory, and so the information about the mean patch area is significantly more informative. This also shows the diversity of land use. The largest mean patches are in Rodine (3,781 m²) and Jeruzalem (3,763 m²), and the smallest are in Velika Slevica (1,967 m²), Krkavče (1,900 m²), and especially in Merče (1,567 m²). Regarding individual land-use categories, the greatest among all of these is the vineyard patch in Jeruzalem (31,365 m²). This points to the relative monotony of the terraced landscape there, which in no way reduces its aesthetic attractiveness. On average, the meadow and pasture patches in Rodine (26,641 m²) and Rut (25,996 m²) are not much smaller.

The size of the patches is also related to the lengths of their edges, which however do not have exactly the same ratio because individual patches vary in the complexity of their shape. Thus the patches with the longest edges are in Smoleva (275 m), and the shortest in Velika Slevica (157 m). The greatest density of edges is in Merče (1,417 m/ha) and the smallest in Rut (685 m/ha).

Out of all eleven possible land-use categories that appear in all of the pilot settlements areas, the most can be found in Krkavče (nine), followed by Merče and Jeruzalem (eight each). Therefore Krkavče also has the greatest relative richness (81.8%), and the lowest (54.6%) is found in the Alpine pilot settlements of Rut, Smoleva, and Rodine, which each have six different land-use categories. This is also confirmed by the calculated values of Shannon's evenness index (SHEI), which express the

Table 6: Some valuations of a terraced landscape based on observations of terraced areas in pilot settlements areas.

Landscape type	Pilot settlement	Aesthetic, experiential value	Exposed to landslides	Exposed to overgrowth	Exposed to planned transformation
Mediterranean low hills	Krkavče	Great	Moderate	Great	Moderate
Mediterranean plateaus	Merče	Low	None	Great	Low
Dinaric plateaus	Dečja vas	Medium	Low	Moderate	Low
Dinaric valleys and corrosion plains	Velika Slevica	Medium	Low	Low	Low
Alpine mountains	Rut	Great	Low	Moderate	Low
Alpine hills	Smoleva	Medium	Moderate	Great	Low
Alpine plains	Rodine	Low	Low	Low	Low
Pannonian low hills	Jeruzalem	Exceptional	Great	Low	Great
Pannonian plains	–	–	–	–	–

ratio between the calculated and highest possible SHDI for a particular number of categories. In Jeruzalem a high number of land-use categories are represented (eight out of eleven possible), but only one of them, vineyards, occupies a considerable amount of the terraced land because the SHEI value is only 0.189 or 18.9% of total possible diversity (for eight categories this is 2.079). The situation is different in Krkavče, where great diversity is evident because the SHEI value is 0.835 or 83.5% of total possible diversity, which is 2.197 for nine categories. Thus Shannon's diversity index (SHDI), which is higher if there are more categories and if these are equally distributed, is the highest by far in Merče (1.835), and the lowest by far in Jeruzalem (0.393), which is more evidence of the diversity of the landscape of Mediterranean low hills and the "monotony" of the intensive vineyard cultivation of Pannonian low hills.

In the pilot settlements, terraced areas differ in their exposure to overgrowth, which is most intense in both of the Mediterranean pilot settlements (Krkavče and Merče) and in Alpine hills (the pilot settlement of Smoleva). They also differ in their exposure to landslide risk; this is greatest in Pannonian low hills (the pilot settlement of Jeruzalem), whereas this danger is practically non-existent in the pilot settlement of Merče as a representative of Mediterranean plateaus.

The aesthetically most attractive landscape is the geometrically regular planned terraced landscape in the Jeruzalem Hills, which however is threatened by the planned rearrangement of terraced vineyards into vertical plantations, which are more profitable. There are also aesthetically very attractive terraced landscapes in the Koper Hills (in Krkavče) and on the southern slopes of the Lower Bohinj Mountains (in Rut). In the first case, the proximity of the coast, which is well developed for tourism, exerts a certain pressure on their degradation, which is reflected in unplanned construction, unsupervised overgrowth, and the transfer of land ownership to people moving to the area from Slovenia's interior, who mostly engage in unsustainable farming because of a lack of agricultural skills.

DISCUSSION

Terraces occur in all Slovenian landscape types, but they vary in terms of density, purpose, and current functions (Ažman Momirski, Kladnik, 2015a). Large variety is related to underlying geographical processes that operate at different time and spatial scales and trigger changes in the landscape. The ones presented below specifically affect terraces as an important landscape element. The most important factor that affects terraced landscapes is probably constant land-use changes. Fundamental changes in land use in terraced areas between the eras of subsistence-oriented farming and modern global farming are clearly shown in a comparison of the diagrams in Figures 5 and 6. The Franciscean cadaster was created in the period before the maximum number of rural inhabitants around 1900 (Kladnik, 2003), but it clearly indicates subsistence farming. Despite this, in Jeruzalem, Krkavče and Merče there was already a perceptible exceptional role of market-oriented viticulture, which at that time in Jeruzalem was based exclusively on vertical plantations of grapevines. Today, the share of vineyards has decreased everywhere, most noticeably in Krkavče. A comparison of the two diagrams clearly shows a decrease in the presence of fields in terraced areas in all areas except Krkavče. An exception is Dečja vas in Dry Carniola (*Suha krajina*), which is an example of a traditional settlement where development has

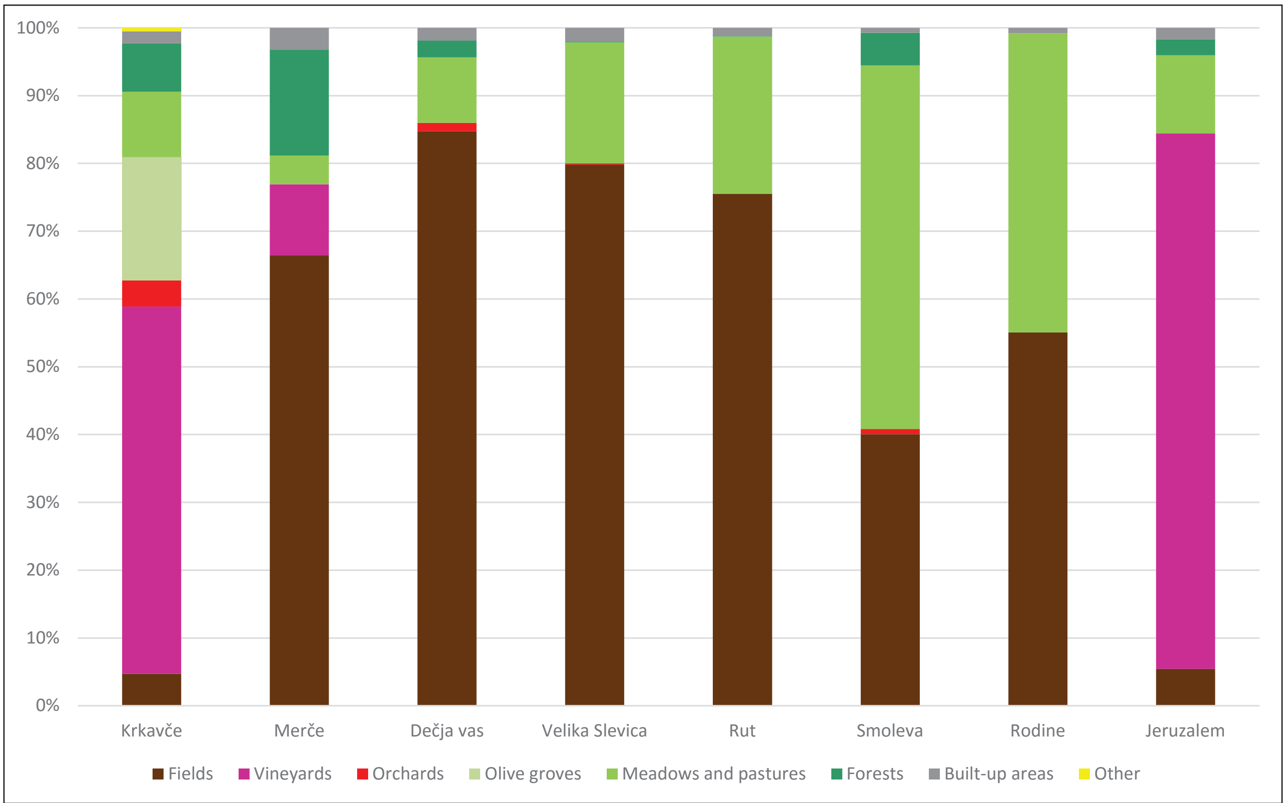

Figure 4: Land use in the terraced areas in the pilot settlements areas according to the Franciscean cadaster (between 1817 and 1828).

lagged and subsistence farming still plays an important role; half of the terraces there are still occupied by fields. Noteworthy is also the strong growth in afforested terraced areas in Krkavče, Smoleva, and Merče, where there was already considerable forest cover at the time of the Franciscean cadaster, and in Rut.

In many areas land use changes depended on social changes and contributed to the abandonment of terraced landscapes or their extensification. This often led to degradation processes, among which the most significant are soil erosion and slope instability in the form of landslides. Such degradation is the result of intense precipitation and poor maintenance of support walls. This is mostly an irreversible process because recultivation rarely takes place (Crosta, Imposimato & Roddeman, 2003; Komac, Zorn, 2005; Zorn, Komac, 2007; Gabrovec, Komac, Zorn, 2012; Zorn, Komac, 2013).

When looking at the development of terraced landscapes, one cannot ignore the influence that terrace construction techniques have on their formation. These are changing from manual to mechanical techniques, which became established together with mechanization in the construction business. The construction and deterioration of terraces were the two prevalent stages of transformation during the manual construction era (Ažman Momirski, Kladnik, 2009).

With changes in land use, construction and management techniques, the diversity of terraced landscapes has generally decreased, especially if one considers the diversity of raising field crops, where cultivars are constantly changed through crop rotation. It is different in Krkavče and to some extent in Merče, where, due to the multiple interests of the locals and many newly arrived landowners, it is even possible to see an increase in landscape diversity – which is represented in terraced land overgrown and in the presence of the majority of land-use categories, within which various use can be identified.

CONCLUSION

The study of terraced landscapes intensified at the end of the twentieth century. The EU included cultivated terraced landscapes in its 2007–2013 rural development plan and its agricultural biodiversity action plan (to improve or maintain biodiversity and prevent its decrease due to agricultural activities). The preservation and maintenance of terraced landscapes is also among the priorities of the thematic strategy for soil protection. The EU also supports areas with limited development opportunities and agricultural areas with highly ranked natural values, which in many cases include terraced land (Lasanta et al., 2013).

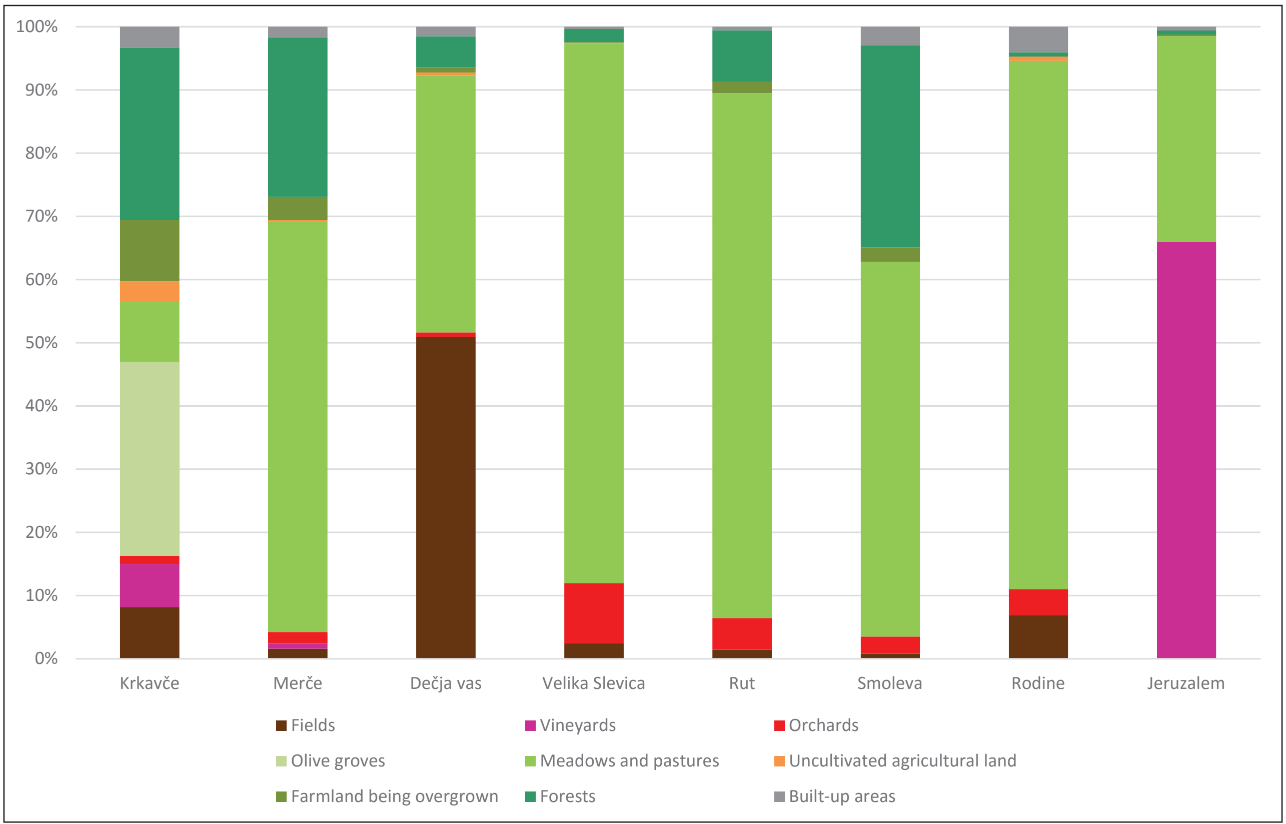

Figure 5: Land use in the terraced areas in the pilot settlements areas in 2015.

The diversity of terraced landscapes in Slovenia is a result of varied natural, social, and economic conditions. This diversity has been influenced by natural conditions and historical development, not only in more distant time periods, but also during the sociopolitical changes that took place in the last decades.

The intensity with which terraces are used is significantly affected by modern developmental trends (industrialization, urbanization, and globalization), which are accompanied by pronounced demographic changes. In Slovenia, these are primarily a decreasing number of people engaged in farming, rural depopulation, and population aging, as well as changes in the rural lifestyle and, not least of all, in farming itself. In some areas, terraced landscapes are therefore subject to modernization, whereas on other land abandonment is contributing to significant changes to them. Our analysis presents some geographical and spatial aspects of these phenomena.

We analyzed the relations between terraced landscapes and some characteristics of geographical space, such as land use, slope inclination, and aspect. This analysis was made using a GIS analysis of Slovenian territory at 25 × 25 m resolution. Because the data were collected by digitalization of DOP images and topographic maps, their accuracy is rather low and the data can only be used at the regional level. On the other hand, the basic characteristics of terraces, such as the length of their edges and number of terrace patches, were presented based on the example of pilot areas. Pilot settlements were analyzed using lidar data with a high resolution of 1 m and broad possibilities for future use, including analysis of short-term and long-term changes in land use and vegetation. The pilot settlements were selected to represent typical Slovenian landscapes.

Based on our analysis of pilot areas we argue that different processes have shaped the terraced areas in different Slovenian landscapes. In Mediterranean landscapes, cultivated terraces have been a significant feature that has shaped the appearance of the landscape for centuries. In the past, the dominant pattern was terraces with non-uniform heights and widths, with slopes reinforced with walls made of large flysch stones. Now, due to mechanical cultivation, the shape of terraces is becoming increasingly uniform. Most of the terraces are used for vineyards and orchards, and for olive cultivation. Modern viticultural terraces were constructed after mechanized farming was introduced. They are regularly renovated and rebuilt, and are in good shape compared to terraces in remote areas. In some places, especially in the Brkini Hills, grass has replaced the tilled fields and orchards that were predominant several decades ago.

Terraces in the Dinaric landscapes are less intrusive in the landscape because they are usually not entirely flat and the slopes between them are not very high. Because terraces are adapted to the terrain, their design is not uniform. Here, traditional agricultural terraces prevail and are a persistent landscape element although the prevailing land use is grassland. Except for a few exceptions, new terraced land was not detected, although in places small terraces have been joined into larger, broader ones with higher slopes.

In Alpine landscapes, construction of terraces was very difficult. Even though terraces adapt to the terrain, in many places they have quite a uniform shape, with similar dimensions, which is especially true regarding their inclination, the width of the terrace platforms, and the height of the slopes. The most common type is traditional agricultural terraces, which were used for tilled fields in the past, but now have been converted into meadows, which also dominate on hillslopes with a southern exposure. There are no new terraces, and old ones are being abandoned and overgrown, and are deteriorating in many places.

The Pannonian hilly landscapes have exclusively been used for vineyards and fruit orchards since the very beginning. Viticultural terraces are limited to low hills, where they were created in the 1960s and 1970s in order to make mechanical cultivation possible. Because of mechanical cultivation, their configuration is quite uniform, which especially contributes to the attractive appearance of the landscape. They are still mostly well maintained; however, in recent years terraces in many places have been disappearing through planned changes of terraced vineyards into vertical plantations, which are more profitable.

Terraced landscapes have a clear added value and are an important cultural heritage. This has already been acknowledged by some European countries, which have succeeded in including them on the UNESCO World Heritage List, such as Portugal (the Douro Valley), Spain (the Tramuntana Range), Italy (Cinque Terre), Switzerland (Lavaux), Austria (Wachau), Germany (the Upper Middle Rhine Valley), and Hungary (the Tokaj Wine Region). But this can only come to the force if the terraces are appropriately maintained. Only in this way they can express their attractive image, which should not only be a source of pride for the locals, but can also prove to be an important development potential.

This article offers us some clues on where and how to focus future research. One of the rather new aspects presented here is that of diversity. Diversity itself does not guarantee attractiveness, because this can only be recognized by visiting several such areas, which allows those interested to compare them with one another. The landscape perspective presented in the article may be an added value.

In order to activate this potential, it is necessary to protect the cultural landscape as an important part of Slovenian cultural heritage and ensure sufficiently effective economic and regional development, which may attract more people to terraced areas. Terraced landscapes have important economic potential since they can promote the development of tourism, which ought to market the diversity of Slovenia and its landscapes as its primary destination. In this task, the diversity of Slovenia's terraced landscapes can also be a key element.

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POVZETEK

V članku predstavljamo raznolikost slovenskih terasiranih pokrajin, ki je posledica pestrih naravnih in družbenih razmer, še posebej pa jo je zaznamoval zgodovinski razvoj, ne le v časovno bolj oddaljenih razdobjih, ampak tudi v času korenitih družbenopolitičnih sprememb po drugi svetovni vojni. Na intenzivnost rabe teras v terasiranih pokrajinah pomembno vplivajo sodobne razvojne težnje (industrializacija, urbanizacija, globalizacija), ki jih spremljajo izrazite demografske spremembe, na slovenskem podeželju predvsem deagrarizacija in staranje prebivalstva, pa tudi spremembe v načinu življenja na podeželju in nenazadnje v kmetovanju samem. Raznovrstnost terasiranih pokrajin ponazarjamo na ravni slovenskih pokrajinskih tipov, ki jih predstavljamo z analizo terasiranih območij v izbranih pilotnih naseljih. Poleg temeljih analiz z geoinformacijskimi orodji, izvedenimi tudi na podlagi lidarskih podatkov, predstavljamo raznovrstnost metričnih lastnosti značilnih terasiranih območij, pri čemer izpostavljamo dimenzije teras, njihovih ploskev in brežin, oblikovanost brežin ter preteklo in sodobno rabo tal. Kulturne terase s svojo raznolikostjo oblikujejo značilno kulturno pokrajino kot pomembno kulturno dediščino. Zaradi povezanosti kmetijstva in turizma imajo lahko terasirane pokrajine v globalizirani ekonomiji čedalje večjo dodano vrednost.

Ključne besede: terasirana pokrajina, kulturne terase, raba tal, pokrajinska metrika, Slovenija

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