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Fotografija na naslovnici: Raziskave udornice, kot je ta pri Malem Naravnem mostu v Rakovem Škocjanu, so v zadnjih letih omogočile globlje razumevanje kraških procesov (fotografija: Matej Lipar).

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LAND-USE CHANGES IN SLOVENIAN TERRACED LANDSCAPES

Drago Kladnik, Matjaž Geršič, Primož Pipan, Manca Volk Bahun

MATEVŽ LENARČIČ

Overgrowth of former winegrowing terraces in the Haloze Hills.

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Land-use changes in Slovenian terraced landscapes

ABSTRACT: This article presents the findings of a study on long-term land-use changes in eight areas of various Slovenian landscapes. The emphasis is on comparing changes on terraced and non-terraced land from the early nineteenth century to the present and on a typological classification of land-use change, whereby a fifth type (i.e., extensification) is added to the established four types in Slovenia: afforestation, grass overgrowth, intensification, and urbanization. The article explains which factors have a decisive impact on land-use changes, especially in terms of abandoning terrace cultivation. The methodology used proves that there are important differences in the rate of land-use change between terraced and non-terraced land.

KEY WORDS: geography, terraces, terraced landscape, land use, land-use changes, land-use change typology, Slovenia

Spremembe rabe zemljišč v slovenskih terasiranih pokrajinah

POVZETEK: V članku predstavljamo rezultate raziskave dolgoročnega spreminjanja rabe zemljišč na osmih območjih v različnih slovenskih pokrajinah. Poudarek je na primerjavi sprememb na terasiranih in neterasiranih zemljiščih od začetka 19. stoletja do sodobnosti ter tipološki klasifikaciji spreminjanja zemljiške rabe, kjer smo v Sloveniji ustaljenim štirim tipom (ogozdovanje, ozelenjevanje, intenzifikacija, urbanizacija) dodali petega, ekstenzifikacijo. Ob tem pojasnjujemo, kateri dejavniki odločilno vplivajo na spreminjanje rabe zemljišč, še posebej z vidika opuščanja obdelave teras. Z uporabljeno metodologijo smo dokazali, da obstajajo pomembne razlike med stopnjo spreminjanja zemljiške rabe na terasiranih in neterasiranih zemljiščih.

KLJUČNE BESEDE: geografija, terase, terasirana pokrajina, raba zemljišč, spreminjanje rabe zemljišč, tipologija spreminjanja rabe zemljišč, Slovenija

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1 Introduction

Cultivated terraces, which constitute terraced landscapes, are among the most evident human signatures on the landscape (Honghe Declaration 2010; Scaramellini and Varotto 2008; Kladnik 2017). They are a result of transformation of the natural environment by societies to overcome their physical limitations (topography, climate, and soil) and obtain necessary resources for their survival (Romero Martín, Gonzáles Morales and Ramón Ojeda 2016). Traditional agricultural terraces were created with manual cultivation in mind. Because many are not adapted to modern mechanized agriculture, they are being abandoned (Ažman Momirski and Kladnik 2009). Abandoning the cultivation of terraces is also the result of rural flight and social restratification connected with the decreasing importance of agriculture and the strengthening of other economic activities (Arnáez et al. 2011; García-Ruiz and Lana-Renault 2011; Stanchi et al. 2012; Lasanta et al. 2013). Terraces are also disappearing due to ownership changes and consequent differences in vineyard planting patterns (Pipan and Kokalj 2017). In addition, land use on terraces is changing, with pronounced overgrowth (Žiberna 2015).

The best-known protected terraced landscapes worldwide are mentioned in studies by Tarolli, Preti and Romano (2014), Peters (2015), Varotto (2015), and Kladnik, Šmid Hribar and Geršič (2017). In Slovenia, the first detailed study of agricultural terraces and terraced landscapes was conducted by Titl (1965) and Moritsch (1969) followed by Ažman Momirski et al. (2008) significantly later. Terraced landscapes have also been explored by Ažman Momirski and Kladnik (2009; 2015), Križaj Smrdel (2010), Ažman Momirski and Gabrovec (2014), Ažman Momirski and Berčič (2016), Geršič (2016), and Kladnik et al. (2016). In 2017, a special issue of the journal *Acta geographica Slovenica* (57-2) was published, titled Terraced Landscapes (Kladnik, Kruse and Komac 2017), and a volume on terraced landscapes was published in Slovenian (Kladnik 2016) and English (Kladnik 2017) to commemorate the seventieth anniversary of the ZRC SAZU Anton Melik Geographical Institute.

The authors of this article are not familiar with any Slovenian or international study that compares changes on terraced and non-terraced land or that provides a typological classification of land-use change. Petek (2007) did provide an exhaustive study of land-use change in the northern Gorica Hills (Sln. *Goriška brda*), but he did not pay any special attention to agricultural terraces. Similarly, the study of the terraced landscape of the Gorica Hills (Ažman Momirski et al. 2008) extends no further than a comparison of land use at the time of the survey conducted under Emperor Francis I of Austria and during the early twenty-first century.

The Mediterranean and the Alps are most extensively covered in studies of land use in European terraced landscapes. These types of studies are limited to individual regions or smaller pilot areas. For example, in the Mediterranean, Grimalt Gelabert, Blazquez Salom and Rodriguez Gomila (1992) explored land use on the terraces of the northwestern part of Mallorca, Dunjó, Pardini and Gispert (2003) examined land-use change effects on abandoned terraced soils in the Mediterranean catchment of Serra de Rodes in northeast Spain, and Kosmas, Gerontidis and Marathianou (2000) explored the same on the Greek island of Lesbos. Agnoletti et al. (2011) studied rural development in traditional terraced landscapes of northern, central, and southern Italy, Agnoletti et al. (2015) conducted a territorial analysis in Tuscany (Italy), Modica, Praticò and Di Fazio (2017) explored the abandonment of traditional terraced landscape in Calabria (Italy), and Andlar, Šrajer, and Trojanović (2017) provided a typology of terraced landscapes along the Adriatic coast in Croatia. With regard to the Alps, two extensive publications covering this area were published a decade ago (Fontanari and Patassini 2008; Scaramellini and Varorro 2008), also featuring articles on land use. Outside the Mediterranean and the Alps, these types of studies have also been conducted in Hungary (Kiss et al. 2005) and Slovakia (Špulerová et al. 2017).

Relative to landscape diversity, only a few countries, even much larger ones, can be compared to Slovenia (Ciglič and Perko 2013; Perko and Ciglič 2015), where the Alps, the Dinaric Mountains, the Pannonian Basin, and the Mediterranean meet and intertwine, as do Slavic, Germanic, Romance, and Hungarian cultural influences (Kladnik, Perko and Urbanc 2009; Ciglič and Perko 2012). For this reason, Slovenia is renowned for its great geographical variety, which is reflected in its natural and cultural diversity, and many transitional areas. It is also reflected in different types of terraces and terraced landscapes (Kladnik 2016; 2017).

Land use and its changes in Slovenian terraced landscapes have been dealt with in detail by Ažman Momirski and Gabrovec (2014), using the cases of Krkavče and Ostrožno Brdo in southwest Slovenia, and as part of studying other aspects this topic has also been highlighted by Kladnik et al. (2016) and Šmid

Hribar et al. (2017). Using selected areas of southwest Slovenia, Geršič (2016) established that by studying microtoponyms on terraces it is also possible to determine past land use, and Ažman Momirski (2017) explored the reliability of land-use data on terraced landscapes in Slovenia. The possibility of identifying abandoned terraces using aerial photos was already reported decades ago by Denevan (1988), and identifying terraces with Lidar was discussed by Berčič (2016).

The main research hypothesis of this article is that land-use changes are influenced by whether the land in question is terraced or non-terraced. In addition, the article also explores the changes in land use since the early nineteenth century and the factors that have had a decisive impact on that. The analyses conducted in the pilot areas make it possible to interpret processes at the level of the entire country.

2 Study areas and methods

Eight pilot sites were selected (Figure 1) within eight of the nine landscape types according to Perko's natural classification of Slovenia (Perko 1998a; 1998b; 2007; Perko, Hrvatin and Ciglič 2015). The pilot sites have an above-average share of terraced land in comparison to the proportion of terraces in individual landscape types. These types of areas made it easier to identify the processes and dynamics of land-use change. The selection was also based on the morphometric characteristics of the terraces (inclination, aspect, and elevation). No pilot site was selected in the Pannonian plains landscape type (Kladnik et al. 2016).

The cartographic representation of land use in the nineteenth century was determined using the Franciscean cadaster, which was carried out under Austrian Emperor Francis I in the 1820s (Golec 2010, 366). The 1:2,880 maps of the Franciscean cadaster for the cadastral municipalities with seven of the eight pilot sites 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, Italy.

Even though the Franciscean cadaster uses a series of land categories that are no longer included in the modern cadaster, they were combined into the following seven basic land categories based on an established key (Petek 2005, 24–26; Ažman Momirski et al. 2008, 73): fields, vineyards, orchards, olive groves, meadows and pastures, forests, and built-up areas. A similar categorization was also provided by Kumer and Gabrovec (2019). Land-use digitization was performed manually.

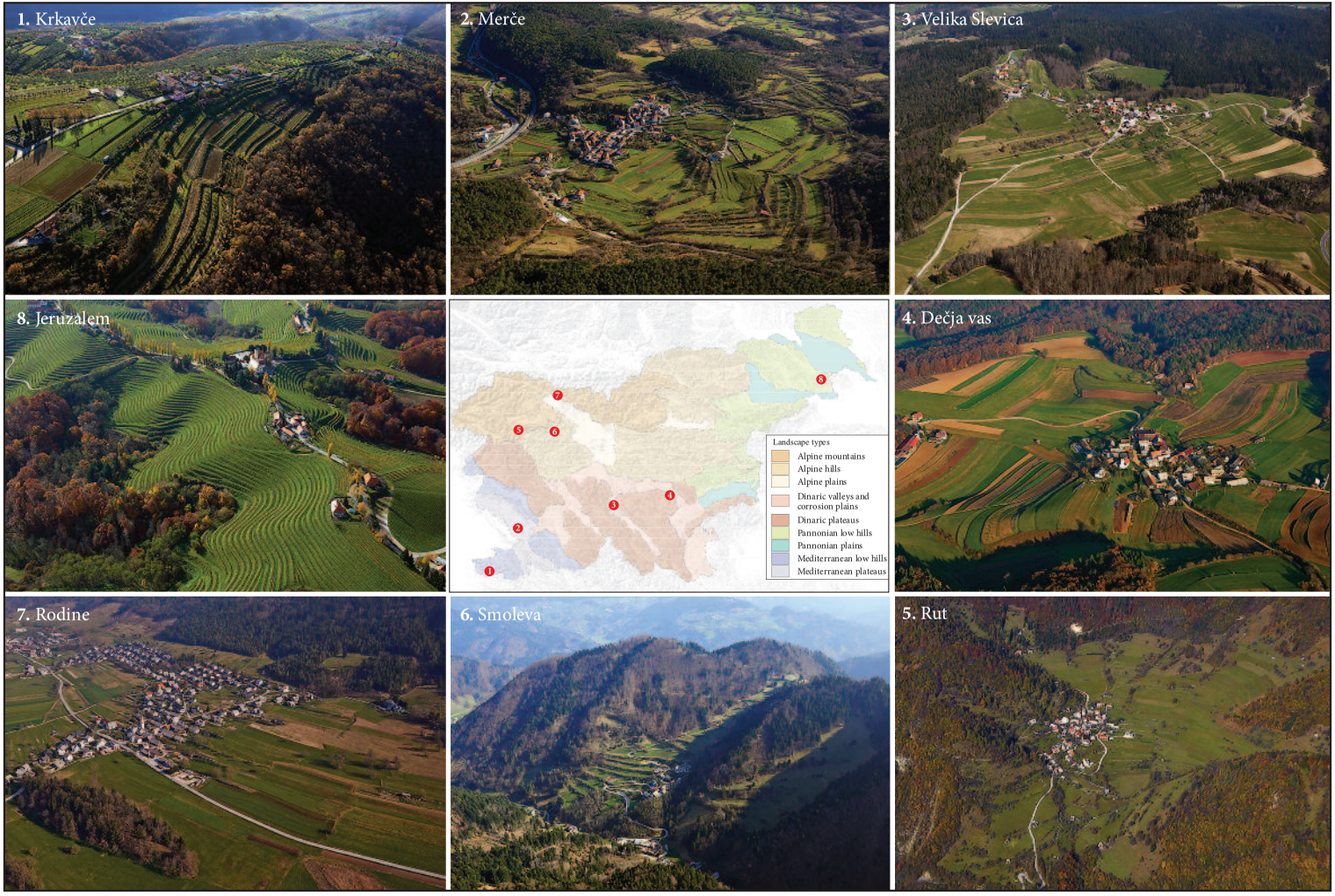
For contemporary cartographic representation of land use, we used Land Use data base for 2018 (Evidenca dejanske rabe … 2018). The following ten land categories were identified in the pilot areas: fields, vineyards, orchards, olive groves, grassland (meadows and pastures), uncultivated agricultural land, farmland being overgrown, forests, built-up areas, and other.

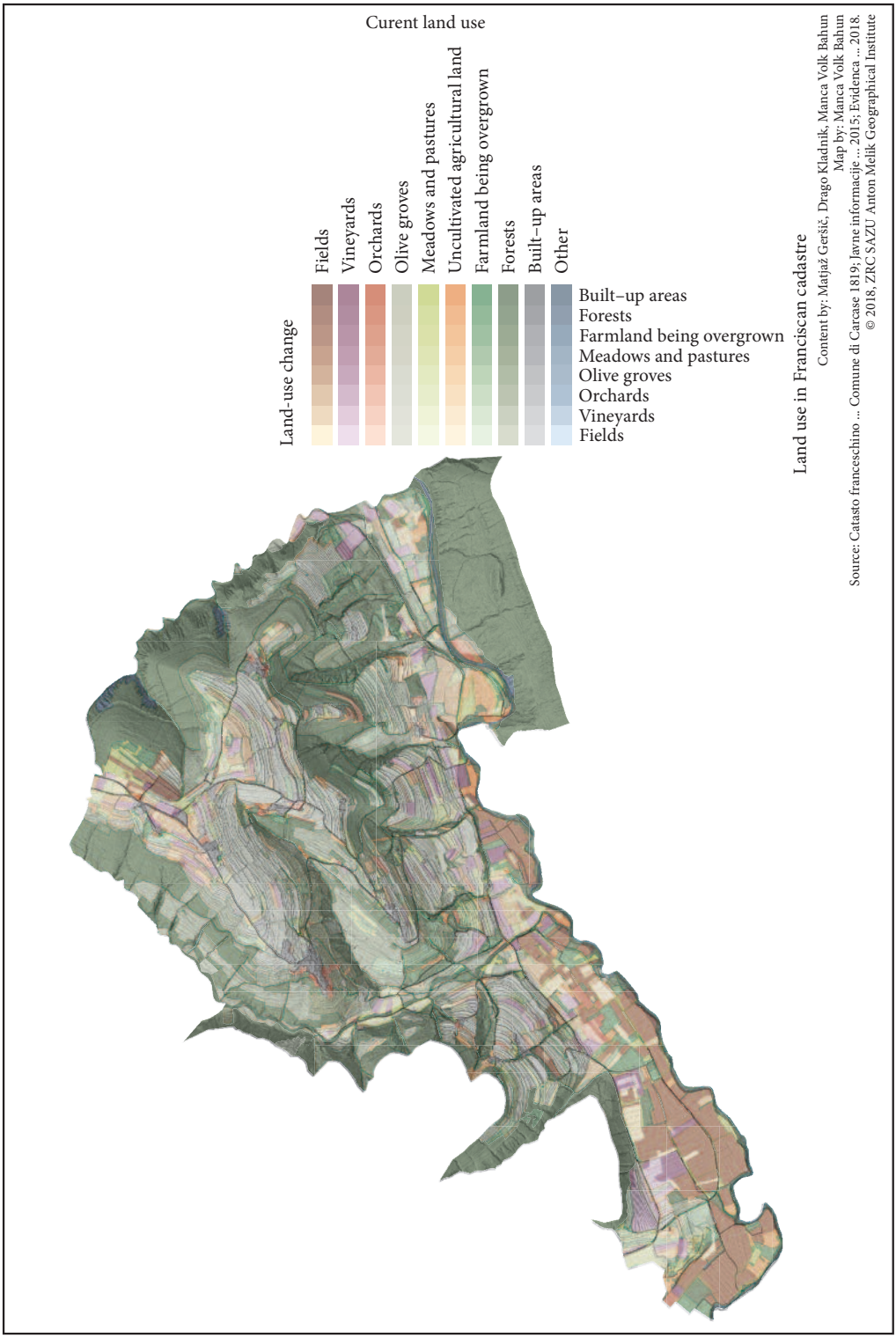
First, we ascribed numerical values to the vector data based on the past and present land use. Then we converted both layers to a 1×1 m raster grid. We added up the two raster layers produced this way, obtaining information for each square meter on whether land use has changed there since the early nineteenth century (and, if it has, how). A total of eighty-one different values were identified across all the pilot areas. We then vectorized the two summed-up raster layers.

In the end, the present-day terraced and non-terraced areas were delimited, which made it possible to compare them. To determine the exact contemporary location of terraces, we employed color digital ortophoto maps, with an image resolution of 0.50 m, fieldwork, and data obtained from aerial laser scanning (Light Detection and Ranging, or lidar), which makes it possible to identify overgrown terraces. The visualization, which was the basis for interpretation, was a combination of techniques suggested by Kokalj, Zakšek and Oštir (2011).

We used the present-day state as the starting point for comparing land use in terraced and non-terraced areas, even though we are aware of the disadvantages of this approach. Unfortunately, there are no accurate cartographic sources available to provide detailed information on the extent of terraces in the past. The cartographic material in the cadaster does not show terraces, but they are mentioned in certain protocols or the text section of the cadaster, such as with the Piran cadastral municipality (Catasto franceschino, Elaborati 1819–1819). From the maps of the Franciscean cadaster we could only indirectly speculate about their extent

Figure 1: Eight pilot sites selected. ► p. 123
Figure 2: Land-use changes from the time of the Franciscean cadaster to 2018 in the Krkavče pilot area. ► p. 124
Figure 3: Typology of land-use change from the time of the Franciscean cadaster to 2018 in the Krkavče pilot area. ► p. 125


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


Curent land use
Land-use change
Fields
Vineyards
Orchards
Olive groves
Meadows and pastures
Uncultivated agricultural land
Farmland being overgrown
Forests
Built–up areas
Other
Built–up areas
Forests
Farmland being overgrown
Meadows and pastures
Olive groves
Orchards
Vineyards
Fields
Land use in Franciscan cadastre
Content by: Matjaž Geršič, Drago Kladnik, Manca Volk Bahun
Map by: Manca Volk Bahun
Source: Catasto franceschino ... Comune di Carcase 1819; Javne informacije ... 2015; Evidenca ... 2018.
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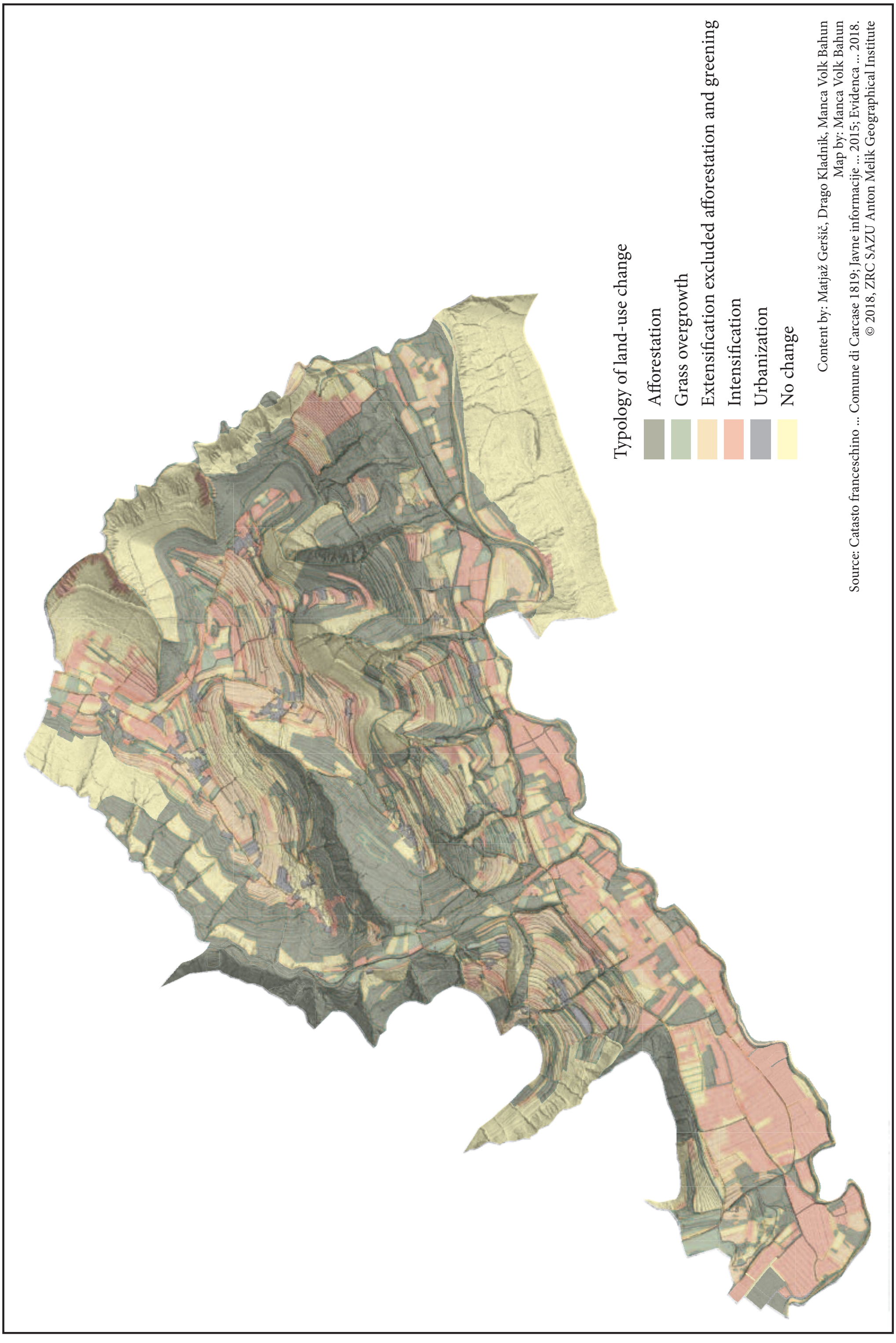
Typology of land-use change
Afforestation
Grass overgrowth
Extensification excluded afforestation and greening
Intensification
Urbanization
No change
Content by: Matjaž Geršič, Drago Kladnik, Manca Volk Bahun
Map by: Manca Volk Bahun
Source: Catasto franceschino ... Comune di Carcase 1819; Javne informacije ... 2015; Evidenca ... 2018.
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when the cadaster was created. Based on interviews (Kladnik 2017) and selected studies (e.g., Ažman and Gabrovec 2014; Geršič 2016), we concluded that, at the time the Franciscean cadaster was compiled, agricultural terraces existed to approximately the same extent as today in seven of the eight pilot areas, only in the Jeruzalem area in the Pannonian low hills were they created later – that is, during the 1960s and 1970s (Kladnik 2017; Pipan and Kokalj 2017) – and that the original land use has not changed significantly. Therefore, an accurate reconstruction of land-use change in terraced and non-terraced areas is impossible, but available data make it possible to determine the main principles of change and suitably typify them.

A land-use change typology that consists of seven types of change and is adapted to the satellite detection of changes has become widely established at the European level (Feranec et al. 2010). In Slovenia, the first land-use change typology was worked out by Medved (1970). Afterward, his typology was slightly modified by various authors (Gabrovec and Kladnik 1997; Gabrovec, Kladnik and Petek 2001; Petek 2005). All Slovenian typologies were adapted to changes at the level of cadastral municipalities. Because the changes identified in this article are identified at the level of land parcels, we further modified the already established Slovenian typology. We defined the following types:

- Afforestation: various land categories changing into forest or land being overgrown;
- Grass overgrowth: various land categories changing into meadows, pastures, or grassland;
- Extensification: more intensive categories of cultivated land changing into less intensive categories. International literature as well as Slovenian authors (e.g., Žiberna 2014) normally also count grass overgrowth and afforestation under extensification, but due to their frequency and significantly different characters they are dealt with separately in this article;
- Intensification: less intensive farmland categories changing into more intensive ones;
- Urbanization: various land categories changing into built-up land, including roads and paths.

With regard to extensification and the intensity of farm activities in individual land categories, we relied on the arable equivalent (Urbanistični … 1975, 171; Kladnik 1999, 29), which we modified due to the specific terrain features of terraced landscapes and the modernization of agriculture. For permanent crops, we lowered it below the fields coefficient, keeping it higher for vineyards than orchards, and higher for orchards than olive groves.

The procedure was graphically illustrated only for the Krkavče pilot area, which is characterized by highly diverse land use, especially for terraced areas (Kladnik et al. 2016). All nine basic land categories can be found in Krkavče. Figure 2 shows all the land-use changes detected from the time of the Franciscean cadaster to 2018 in color shades, regardless of whether they appear on terraces or non-terraced land. The typology of land-use change is shown in Figure 3, again using the Krkavče pilot area.

3 Results

Terraced land comprises 16.7% of land across all the eight pilot areas (compared to 1.7% in all of Slovenia; Kladnik et al. 2016, 472), but there are significant differences between individual areas. The smallest share (4.3%) can be found in the Alpine Rut and the largest (40.9%) in the winegrowing Jeruzalem in the Pannonian low hills.

Land use on terraced land in individual pilot areas has changed significantly from the time of the Franciscean cadaster to 2018 (Figures 4 and 5). In the early nineteenth century, fields predominated in the Merče, Velika Slevica, Dečja vas, Rut, and Smoleva pilot areas. In Smoleva, the percentage of meadows was slightly higher than that of fields even back then, whereas costal Krkavče and Pannonian Jeruzalem were strongly dominated by vineyards; a fair share of vineyards was also found in Merče on the Karst Plateau. Olive groves were found only in Krkavče, where they occupied just under a fifth (18.2%) of the terraced land. There were only few »pure« orchards, although fruit trees were common in various mixed-use categories, such as meadows or pastures with fruit trees (Petek 2005, 25). In the Mediterranean region, attention should be drawn to traditionally mixed cultivation (*cultura mista*): areas where several crops are grown together. This mainly includes various crops mixed with grapevines or olive groves (Titl 1965; Kladnik 1999, 105). Already back then, a significant part of terraced land in Krkavče and Merče was overgrown by forest (the share in Merče was as much as 15.7%).

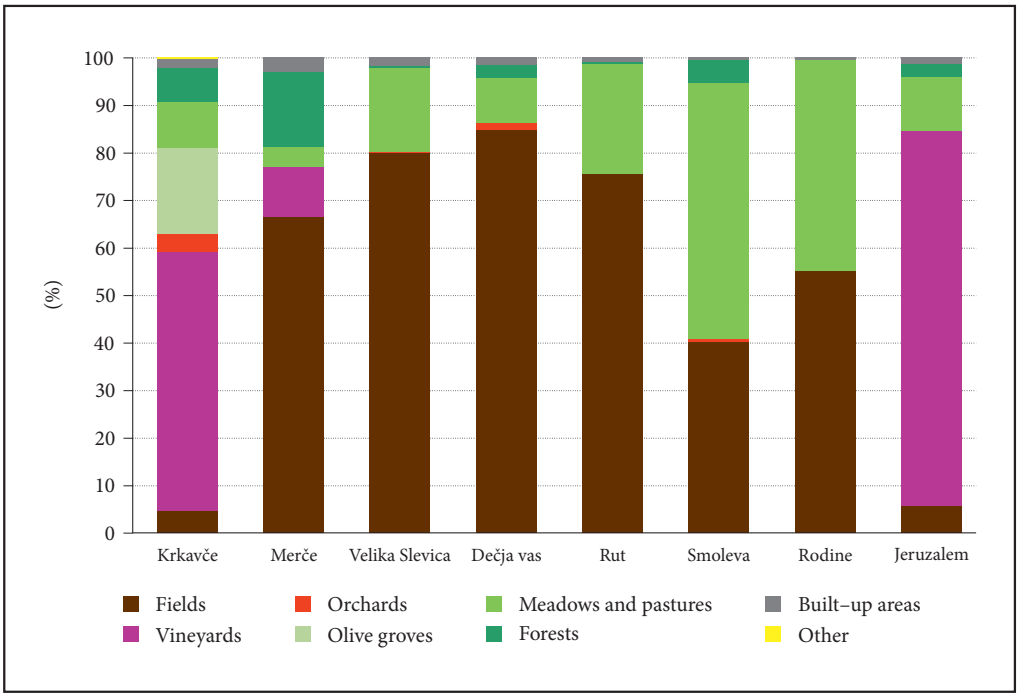

Figure 4: Land use on terraced land in pilot areas in the Franciscean cadaster (1820s).

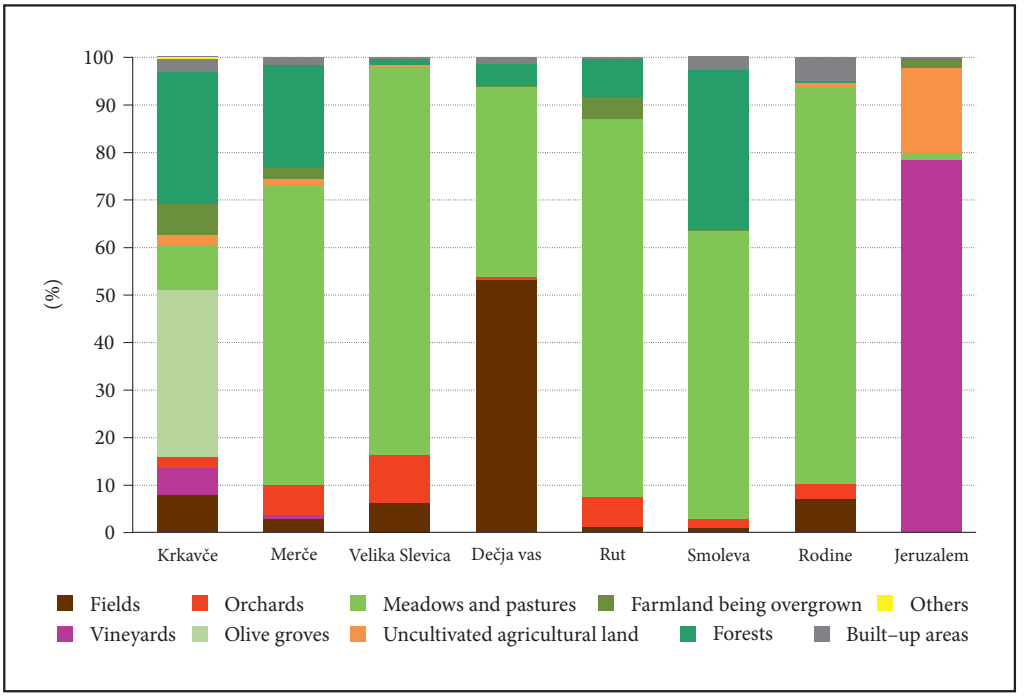

Figure 5: Land use on terraced land in pilot areas in 2018.

Except in Jeruzalem in the Pannonian low hills, the present-day land use is significantly different. With the exception of Krkavče, the share of fields is significantly smaller everywhere and has been replaced by meadows and pastures. Only in Dečja vas in the share of fields is still above 50%. The share of orchards has increased everywhere (up to 10.1% in Velika Slevica), making them a separate and hence basic land category. Except in Krkavče, these are traditional rural orchards and not intensive fruit tree plantations. In Krkavče, the share of olive groves has increased significantly (to 35%), mainly at the expense of vineyards. In addition to fields changing into meadows and pastures, a general extensification of production is also indicated by uncultivated land and especially the afforestation of terraced land. Forest already covers more than a fifth of terraced land in Merče, more than a fourth in Krkavče, and more than a third in Smoleva.

Land use at the time of the Franciscean cadaster and at present is shown in detail using the cases of Krkavče as a Mediterranean landscape (Figure 6), Dečja vas as a Dinaric landscape (Figure 7), Smoleva as an Alpine landscape (Figure 8), and Jeruzalem as a Pannonian landscape (Figure 9). Certain areas make it possible to observe the current land use and its changes on both terraced and non-terraced land.

The typology of land-use change on terraced and non-terraced land in individual pilot areas is presented in Figure 10a-h. The graphs show that in six of the eight pilot areas the »no change« category is significantly more common on non-terraced land than terraced land; the only exceptions are the Rodine and Jeruzalem areas, where slightly more changes were recorded on terraced land than non-terraced land. Consequently, the fewest changes were observed on the non-terraced land of the pilot areas of Velika Slevica (land use has remained the same on 61.5% of non-terraced land), Dečja vas (76.8%), Rut (65.3%), and Smoleva (58.8%). The dynamics have been significantly greater on terraced land because the share of the »no change« category was below 50% everywhere except in Dečja vas (51.8%), where a large share of fields has been preserved on the terraces. A share just below 50% is typical of Jeruzalem (49.9%), where traditional staked vineyards already predominated before terracing, followed by Rodine (39.0%), where a significant share of meadows was already found on the terraces two centuries ago.

Grass overgrowth and afforestation predominate among the types of land-use change identified. As a rule, grass overgrowth is more common on terraced land (in the Merče, Velika Slevica, and Rut pilot areas the share of this type of change on terraces is over 50%). With the exception of Dečja vas, Velika Slevica, and Jeruzalem, afforestation predominates on non-terraced land, where forest has overgrown more than a fifth of the land or, in the case of Merče and Rodine, even more than two-fifths. Grass overgrowth is distinctly poorly represented on both terraced and non-terraced land in Krkavče and Jeruzalem, and the same applies to afforestation in Dečja vas and Jeruzalem. The terraced land in Krkavče, Smoleva, and Merče has been the most subject to afforestation.

Except in Krkavče, the remaining three types of land-use change are significantly less common. Significant extensification can be observed in Krkavče, especially due to orchards being converted into olive groves on the terraces. However, on the other hand, intensification can also be observed due to converting forests and, to a smaller extent, pastures into olive groves and the simultaneous construction of terraces. Intensification is even more pronounced on non-terraced land, especially at the bottom of the Dragonja Valley, where meadows were converted into fields and, to a smaller extent, vineyards after the regulation of the river. Strong extensification on terraces can also be identified in Jeruzalem, where the cultivation of terraced vineyards is gradually being abandoned, but some fields were already converted into vineyards earlier, during the construction of terraces. Urbanization is more common on non-terraced land and is slightly more pronounced only in Rodine and Jeruzalem.

Figure 6: Land use from 1819 (top) and in 2018 (bottom) in the Krkavče pilot area. ► p. 129
Figure 7: Land use from 1825 (top) and in 2018 (bottom) in the Dečja vas pilot area. ► p. 130
Figure 8: Land use from 1825 (top) and in 2018 (bottom) in the Smoleva pilot area. ► p. 131
Figure 9: Land use from 1824 (top) and in 2018 (bottom) in the Jeruzalem pilot area. ► p. 132
Figure 10a-h: Types of land-use change from the time of the Franciscean cadaster to 2018 on terraced and non-terraced land in individual pilot areas. ► p. 133–136

Content by: Matjaž, Geršič, Drago Kladnik, Manca Volk Bahun
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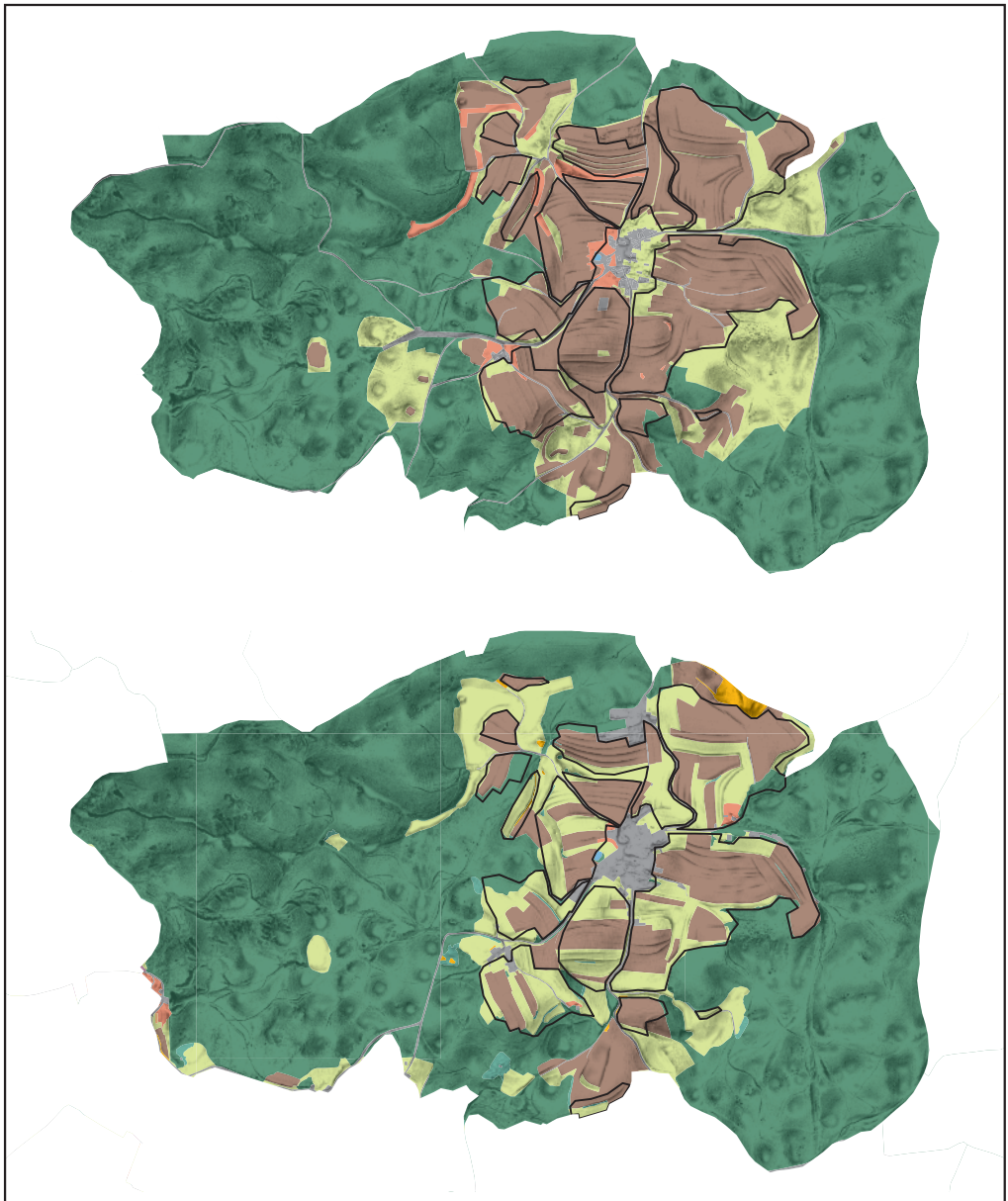

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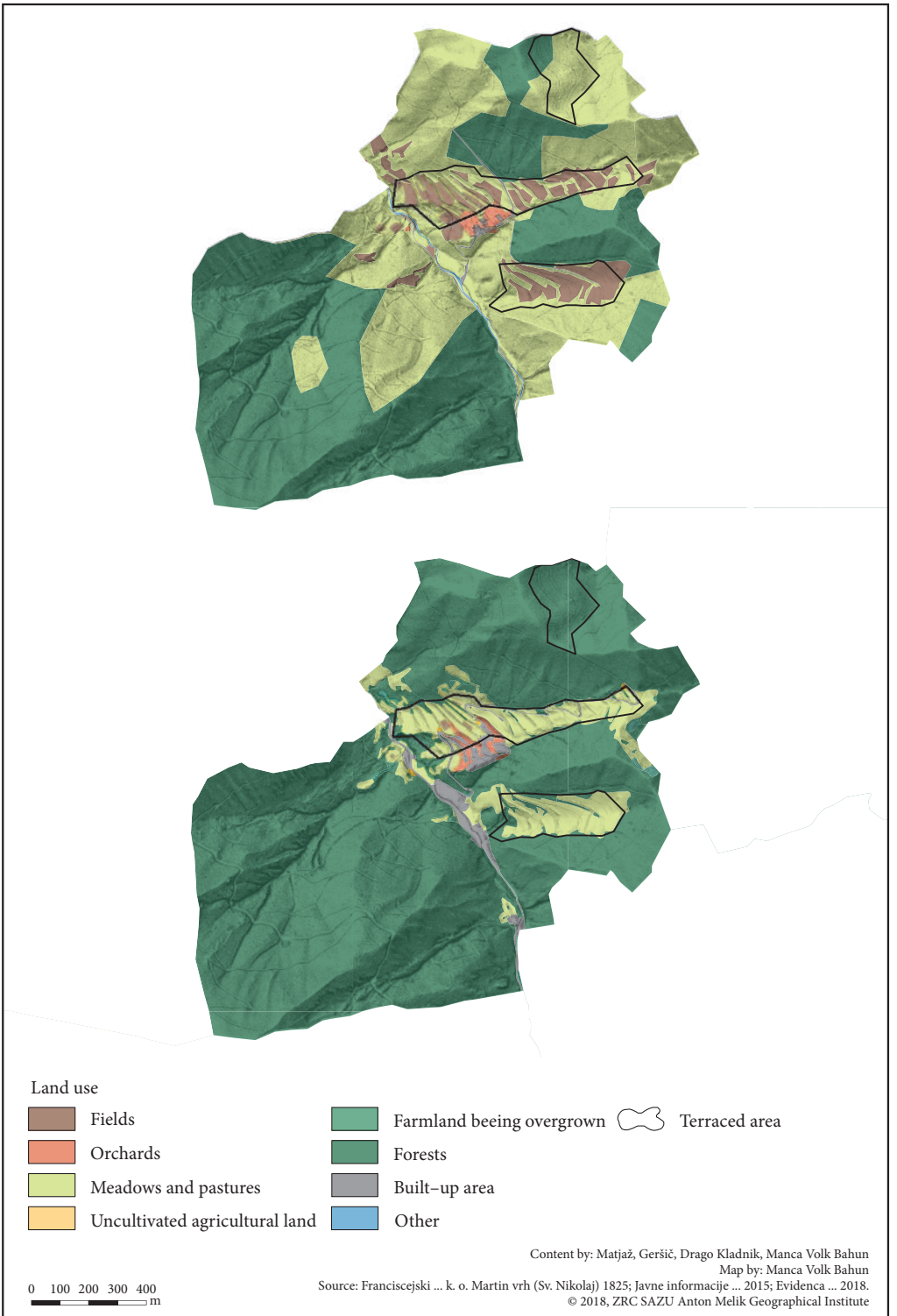
Land use
Fields
Orchards
Meadows and pastures
Uncultivated agricultural land
Farmland beeing overgrown
Forests
Built–up area
Other
Terraced area
0 100 200 300 400
m
Content by: Matjaž, Geršič, Drago Kladnik, Manca Volk Bahun
Map by: Manca Volk Bahun
Source: Franciscejski ... k. o. Martin vrh (Sv. Nikolaj) 1825; Javne informacije ... 2015; Evidenca ... 2018.
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Land use
Fields
Vineyards
Orchards
Meadows and pastures
Uncultivated agricultural land
Farmland beeing overgrown
Forests
Built–up area
Other
Terraced area
0 100 200 300 400
m
Content by: Matjaž, Geršič, Drago Kladnik, Manca Volk Bahun
Map by: Manca Volk Bahun
Source: Franciscejski ... k. o. Plešivica 1824; Javne informacije ... 2015; Evidenca ... 2018.
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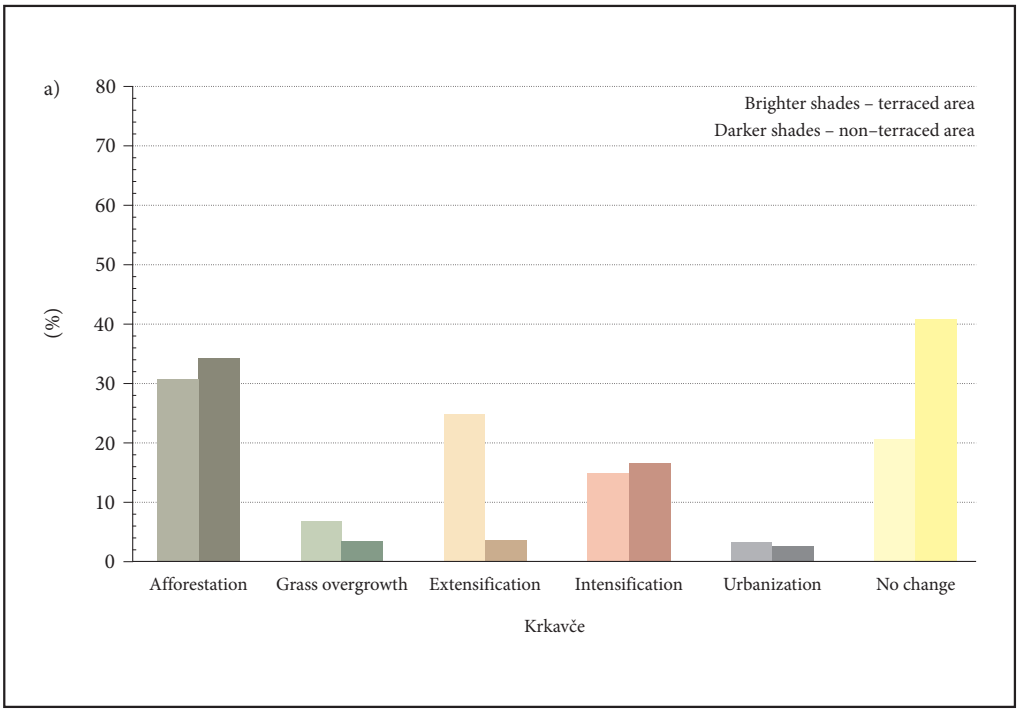
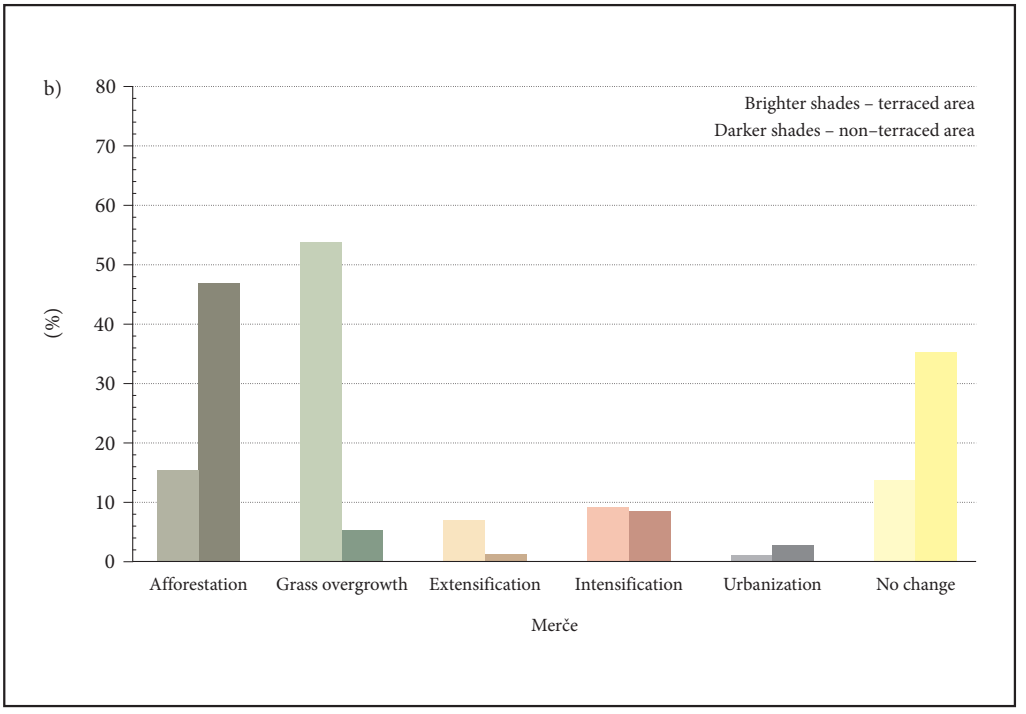
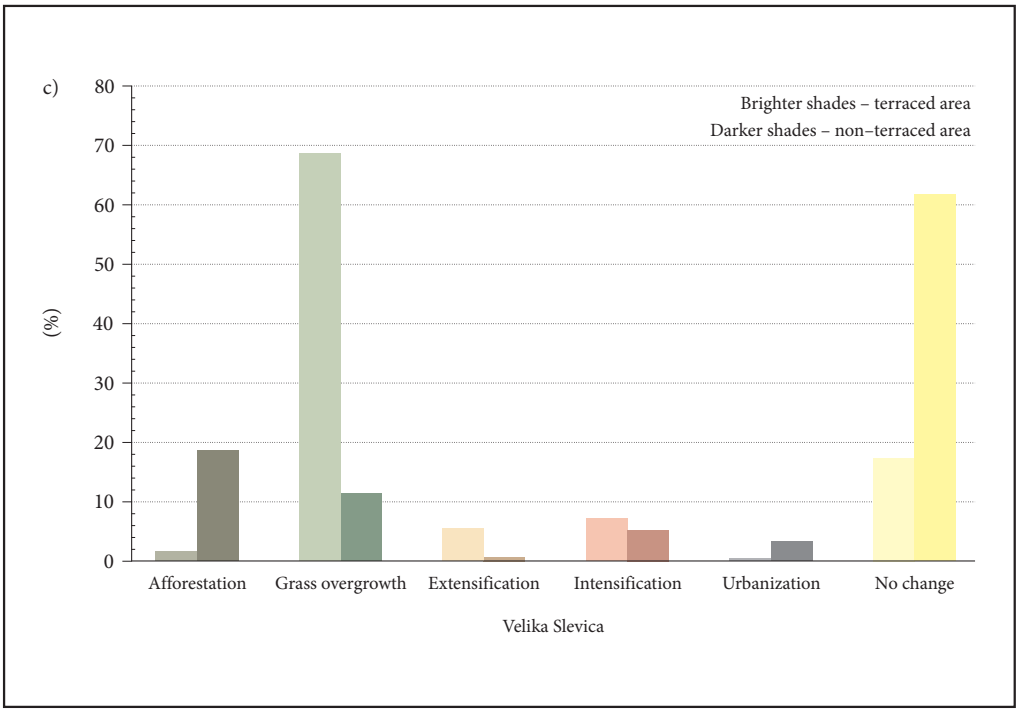
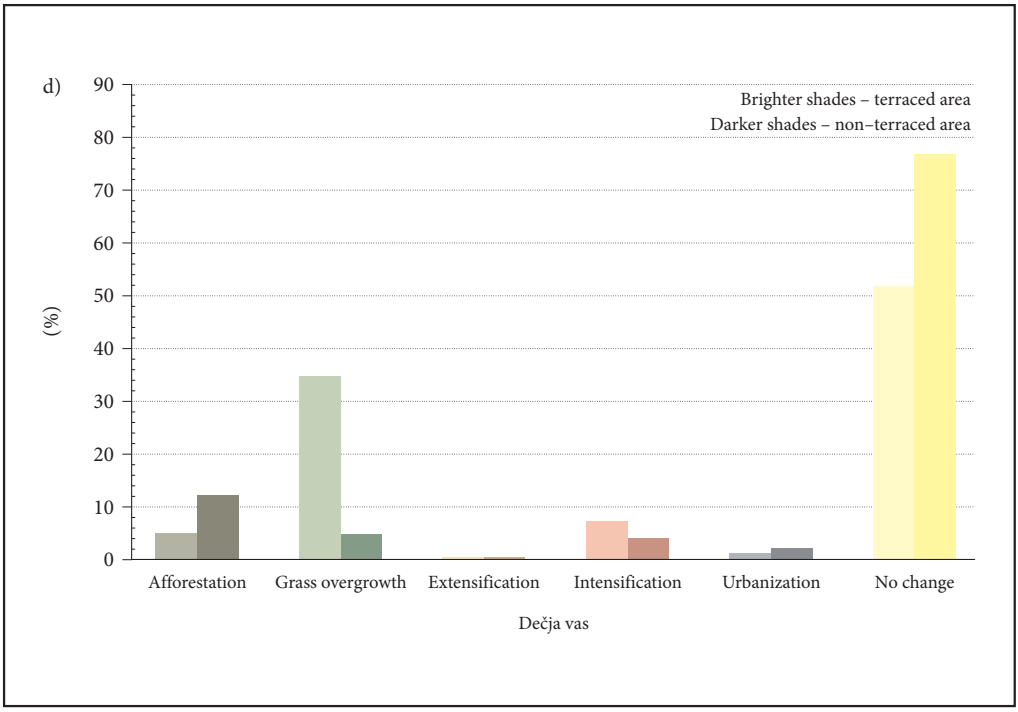
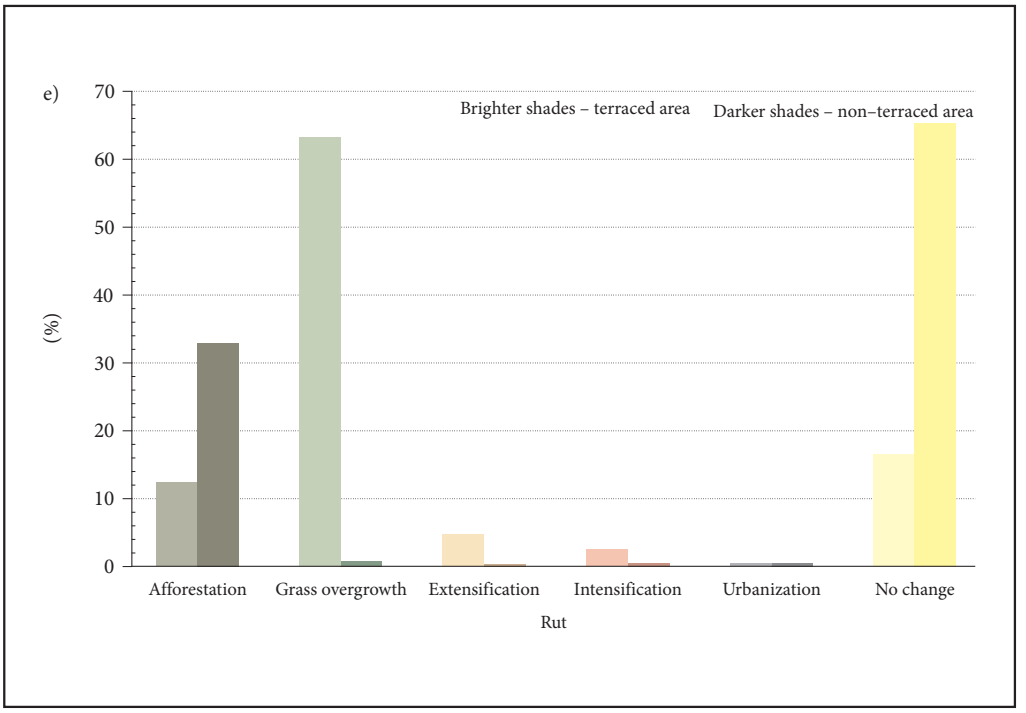
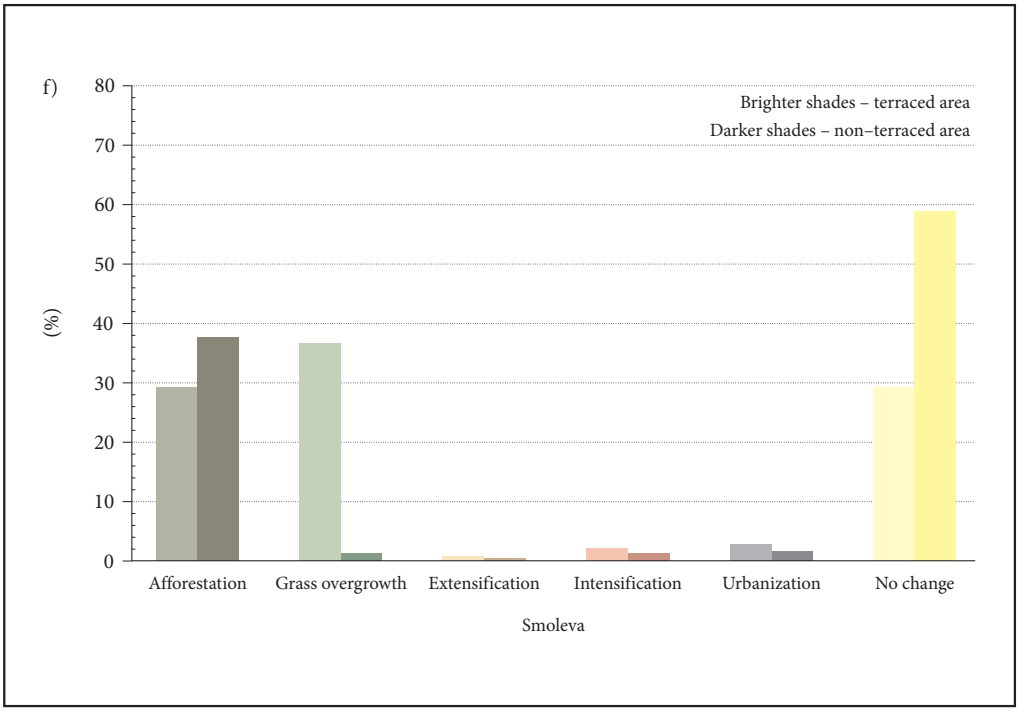

a)
Brighter shades – terraced area
Darker shades – non–terraced area
(%)
0
10
20
30
40
50
60
70
80
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Krkavče

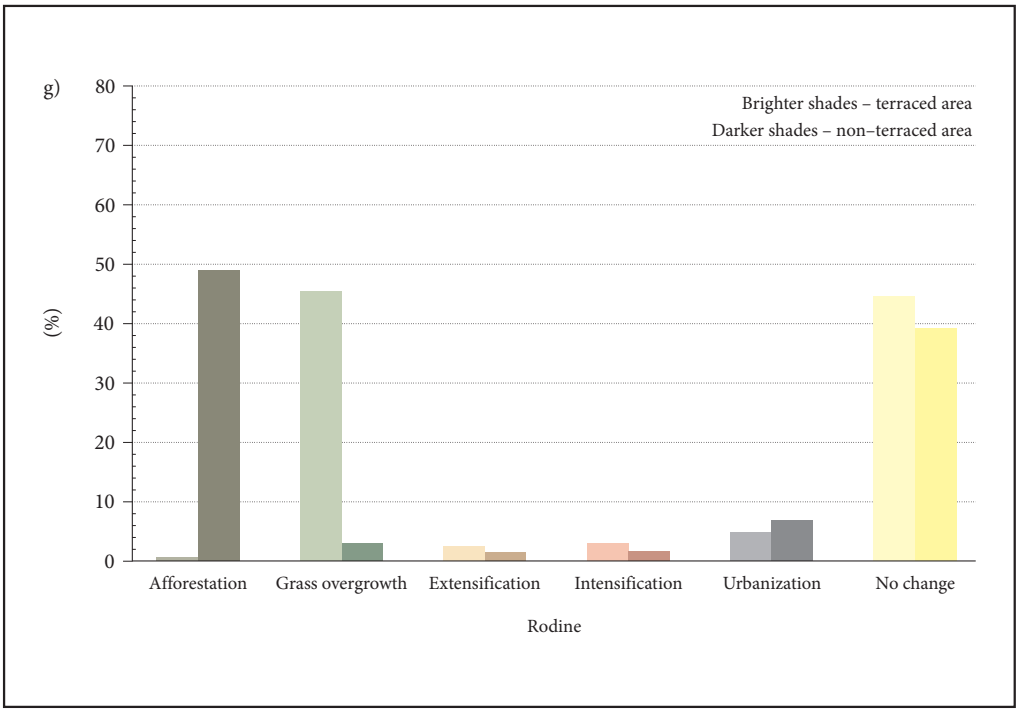

b)
Brighter shades – terraced area
Darker shades – non–terraced area
(%)
0
10
20
30
40
50
60
70
80
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Merče

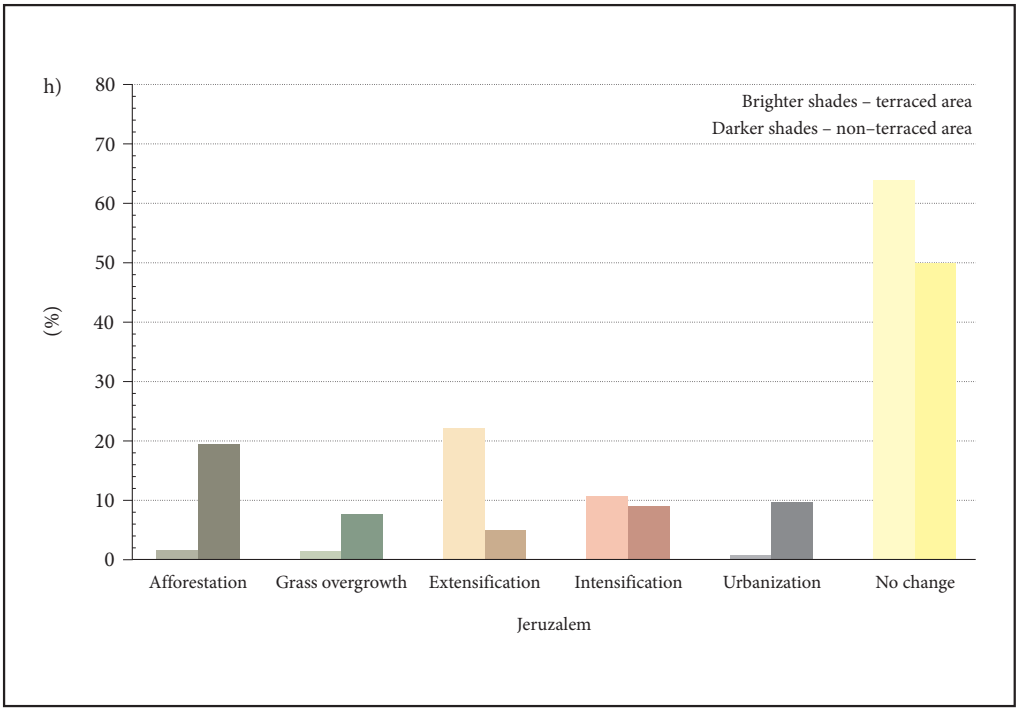

c)
(%)
80
70
60
50
40
30
20
10
0
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Velika Slevica


d)
(%)
90
80
70
60
50
40
30
20
10
0
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Dečja vas


e)
Brighter shades – terraced area
Darker shades – non–terraced area
(%)
70
60
50
40
30
20
10
0
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Rut


f)
Brighter shades – terraced area
Darker shades – non–terraced area
(%)
80
70
60
50
40
30
20
10
0
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Smoleva


g)
80
70
60
50
40
30
20
10
0
(%)
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Rodine


h)
80
70
60
50
40
30
20
10
0
(%)
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Jeruzalem

4 Discussion

A comparison of the overall findings regarding the representation of individual types across all eight pilot areas (Figure 11) reveals that terraced areas are significantly more exposed to land-use change than non-terraced areas. Specifically, the »no change« category only appears on just over a fourth (26.8%) of terraced land, whereas on non-terraced land the share amounts to 55.5%. Striking differences between terraced and non-terraced land can be observed with regard to the percentage of grass overgrowth and afforestation. Grass overgrowth can be identified on more than a fourth (26.7%) of terraced land, whereas it is only present on 2.8% of non-terraced land. On the other hand, afforestation is common on a third (33.6%) of non-terraced land and just under one-fifth (19.5%) of terraced land. This is also influenced by the fact that terraces were constructed on higher-quality land. Due to the spread of olive groves in Krkavče and the abandonment of vineyards in Jeruzalem, the »extensification« category is only typical on 14.6% of terraced land and only 1.1% of non-terraced land, whereas the predominance of intensification is less pronounced on terraced land (10.3% compared to 5.0%). In both areas compared, building-up is approximately the same (2.1% on terraced land and 2.0% on non-terraced land); it barely seems significant at first glance, but it causes permanent loss of fertile land.

The oldest terraces are in Krkavče, where they are believed to date back to Antiquity (Gaspari 1998). The dry stone walls that formerly predominated there have largely been replaced by earthen embankments (Šmid Hribar et al. 2017). In Jeruzalem and Krkavče, in the nineteenth century 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 (Geršič et al. 2016, 222–223; Pipan and Repolusk 2017, 118–119). Today, the share of vineyards has decreased everywhere, most noticeably in Krkavče, where, despite occasional frost damage to olives (which was especially bad in 1929; Ogrin 2010), olive cultivation has increased considerably (Geršič et al. 2016, 181; Pipan, Šmid Hribar and Topole 2017, 85). The construction of terraces in Jeruzalem after the Second World War increased the area covered by vineyards, but the shift from

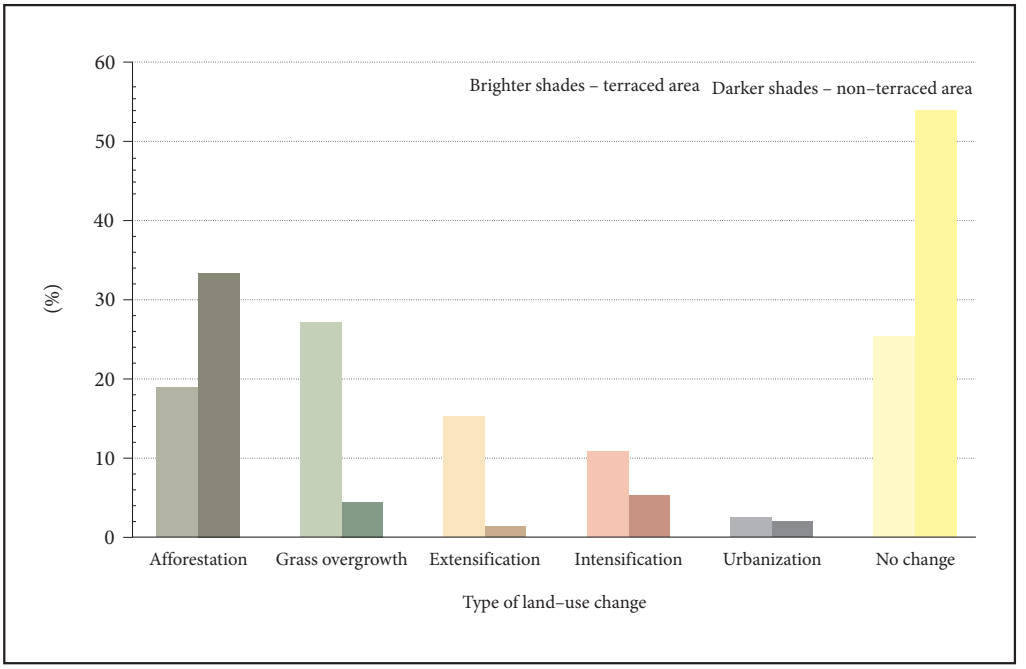


Figure 11: Types of land-use change from the time of the Franciscean cadaster to 2018 on terraced and non-terraced land for all pilot areas together.

communism to capitalism after Slovenia's independence in 1991 resulted in extensive conversion of terraced vineyards into vertical plantations, which provide a larger, albeit lower-quality, grape yield (Pipan and Kokalj 2017). During the transitional period of converting these plantations, the land is recorded as uncultivated in the Land Use database (Evidenca dejanske rabe … 2018). An interesting fact that should be mentioned in this regard is the recent emergence of vineyards on sunny slopes in Rut at an elevation of nearly 700 m, which were not yet recorded in the Franciscean cadaster.

A comparison between the two periods most clearly shows a pronounced decrease in the presence of fields in terraced areas in all pilot settlements except Krkavče, where a significant amount of tilled land was created at the bottom of the Dragonja Valley. Its decline is so great that fields became an insignificant land-use category (Geršič et al. 2016, 188–189, 189–200, 205, 212–213; Pipan, Šmid Hribar and Topole 2017, 90–91; Gabrovec and Tiran 2017, 99–100; Geršič et al. 2017, 106, 111). Changing fields into meadows can also be ascribed to the shift from subsistence agriculture and mixed farming to market-oriented animal husbandry, which in hilly areas is primarily based on fodder production in meadows and grazing livestock. An exception is Dečja vas in Suha krajina Region, which is an example of a remote settlement on fertile soil, far from nonagricultural employment opportunities, where subsistence farming continues to play an important role (Geršič et al. 2016, 192–195; Gabrovec and Tiran 2017, 94–97).

An important role in land-use changes in terraced areas is played by their capacity to adapt to mechanized agriculture (Titl 1965; Šmid Hribar et al. 2017). Without suitable access roads and turning areas for farm equipment, it is not possible to mechanically cultivate small and narrow parcels of land, and consequently they are being abandoned. This is further accelerated by the unfavorable demographic structure with an elderly rural population; local development factors can also play an inportant role. The predominant extensification of land use also results from unresolved ownership, land fragmentation, and the parcels being far away from the farms. Aspect is a decisive natural factor causing land-use change because, in order to adapt to optimal use, land with a poorly insolated northern or eastern exposure becomes abandoned and overgrown faster and to a larger extent (Kladnik et al. 2016).

The methodology used proved that changes in land use are influenced by whether the land in question is terraced or non-terraced. Despite the deficiencies indicated in the section on methodology and the significant differences between the pilot areas resulting from Slovenia's landscape and developmental diversity, our findings mostly agree with the hypothesis formulated at the beginning of the article. The typology of land-use change that we have developed sheds additional light on the land-use characteristics of Slovenian terraced landscapes that were already established earlier and presented in many studies (Petek 2007; Ažman Momirski et al. 2008; Ažman Momirski and Kladnik 2009; Erhartič 2009; Križaj Smrdel 2010; Ažman Momirski and Gabrovec 2014; Ažman Momirski and Kladnik 2015; Žiberna 2015; Ažman Momirski and Berčič 2016; Berčič 2016; Geršič et al. 2016; Kladnik et al. 2016; Gabrovec and Tiran 2017; Geršič et al. 2017; Kladnik, Šmid Hribar and Geršič 2017; Pipan and Kokalj 2017; Pipan and Repolusk 2017; Pipan, Šmid Hribar and Topole 2017; Šmid Hribar et al. 2017). Specifically, it presents the differences between terraced and non-terraced land in these landscapes, which has never been done before.

5 Conclusion

Even though the methodology used relied on current land use as the basic period of comparison, we proved that there are important differences in the rate of land-use change between terraced and non-terraced land, and also that significant differences exist within one and the other in terms of the direction or type of land-use change.

A comparison of the types of land-use change identified in individual pilot areas (Figure 10a-h) reveals great similarity in the development dynamics of Merče (a Mediterranean landscape), and Rut and Smoleva (both Alpine landscapes). Closer to this pattern is also the situation in Velika Slevica (a Dinaric landscape), with more pronounced grass overgrowth and less pronounced afforestation, Dečja vas (a Dinaric landscape) with less pronounced grass overgrowth and even less pronounced afforestation, and Rodine (an Alpine landscape) with pronounced afforestation of non-terraced land. The situation is completely unique in Krkavče (a Mediterranean landscape) and Jeruzalem (a Pannonian landscape). Even though the terraces in Krkavče are the oldest and the ones in Jeruzalem the youngest, both pilot areas are characterized by the traditional market orientation of agriculture, which is why the land-use changes strongly reflect both economic growth and the general economic and political-administrative situation.

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