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Front cover photography: Exploration of the collapse dolines, such as the one at the Small Natural Bridge in Rakov Škocjan, has enabled a deeper understanding of karst processes in recent years (photograph: Matej Lipar).
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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Contents

Special issue – Franciscean cadaster as a source of studying landscape changes

Acta geographica Slovenica, 59-2, 2019, 7–26

THE USEFULNESS OF UNSUPERVISED CLASSIFICATION METHODS FOR LANDSCAPE TYPIFICATION: THE CASE OF SLOVENIA

Drago Perko, Rok Ciglič, Mauro Hrvatin

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The landscape classification of countries with a high landscape diversity, such as Slovenia, using a computer and various classification methods is a difficult task. The picture shows three landscape types: fertile flysch Mediterranean hills with the Bay of Koper (foreground), Mediterranean karst plateaus (middle), and high Dinaric karst plateaus (background).

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The usefulness of unsupervised classification methods for landscape typification: The case of Slovenia

ABSTRACT: Supervised and unsupervised classification methods can be a useful tool in determining various geographical spatial divisions, especially regionalizations and typifications. Because Slovenia is geographically very diverse, its divisions are a particularly significant and interesting research challenge. The main objective of this article is to determine the effectiveness of unsupervised classification methods, and therefore we compare the well-established landscape typology of Slovenia from 1996 with landscape typologies that were modeled using various unsupervised classification methods. Our results show that landscape typologies modeled using unsupervised classification methods deviate more from the original landscape typology of Slovenia than landscape typologies modeled using random and expert-supervised classification methods.

KEY WORDS: geography, geographic information system, modeling, classification, landscape typology, Slovenia

Uporabnost metod nenadzorovane klasifikacije za pokrajinsko tipizacijo na primeru Slovenije

POVZETEK: Metode nadzorovane in nenadzorovane klasifikacije so lahko koristno orodje pri določanju različnih geografskih prostorskih delitev, še posebej pri regionalizacijah in tipizacijah. Ker je Slovenija geografsko zelo raznolika, so njene delitve še posebej velik in zanimiv raziskovalni izziv. Glavni namen članka je ugotoviti učinkovitost metod nenadzorovane klasifikacije, zato primerjamo uveljavljeno pokrajinsko tipizacijo Slovenije iz leta 1996 s pokrajinskimi tipizacijami, ki smo jih modelirali z različnimi metodami nenadzorovane klasifikacije. Naši rezultati kažejo, da se pokrajinske tipizacije, modelirane z metodami nenadzorovane klasifikacije, izvirni pokrajinski tipizaciji Slovenije ne približajo tako dobro, kot pokrajinske tipizacije, modelirane z metodami naključne in ekspertne nadzorovane klasifikacije.

KLJUČNE BESEDE: geografija, geografski informacijski sistem, modeliranje, klasifikacija, pokrajinska tipizacija, Slovenija

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1 Introduction

Regionalizations and typifications are among the most complicated fields of research in geography (Hammond 1964; Dikau, Brabb and Mark 1991; Kladnik 1996; Brabyn 1998; McMahon, Wiken and Gauthier 2004; Gallant, Douglas and Hoffer 2005; Iwahashi and Pike 2006; Ellison 2010; Ciglič 2014). This is especially the case with the spatial divisions of Slovenia, which despite being a small country has some of the most diverse landscapes in the world (Melik 1935; Ilešič 1956; 1958; Gams 1983; Natek 1993; Gams, Kladnik and Orožen Adamič 1995; Gabrovec and Hrvatin 1998; Gams 1998; Perko 1998; Plut 1999; Špes et al. 2002; Kladnik, Perko and Urbanc 2009; Perko and Hrvatin 2009; Hrvatin and Perko 2012; Ciglič and Perko 2012; 2013). This is most likely why Slovenian geographers have only produced four true landscape typologies to date. The first one, which included eighteen landscape types, was produced by Anton Melik in 1946 (Melik 1946), the second was produced by Drago Perko in 1996 and included nine landscape types (Kladnik 1996; Perko 1998; Perko 2001; Perko 2007), the third one, produced in 2002 by Metka Špes et al., contained thirteen types (Špes et al. 2002), and the fourth was produced in 2014 by Drago Perko et al. and included twenty-four landscape types (Perko, Hrvatin and Ciglič 2015).

Through increasingly more precise and accessible digital spatial data, technological development has also introduced changes to geographical classifications, including regionalization and typification, with various models and geographic information systems becoming widely used and influential research methods (Demeritt and Wainwright 2005).

The term **classification** has several definitions (McGarigal, Cushman and Stafford 2000). Thus, for example, it can refer to any formal arrangement of data into a hierarchy of categories or distribution into classes (Whittow 2000), or systematic assignment to classes or groups based on shared characteristics (Clark 1998). Classifications can be roughly divided into supervised and unsupervised classifications. To date, Slovenian geographers have primarily modeled supervised classifications and compared them against the 1996 landscape typology of Slovenia, which comprises nine types combined into four groups and is most widely used and also included in Slovenian legislation. Landscape typology models were produced using various supervised classification methods based on the training samples of already classified or defined cells of individual landscape types. It was determined that the method selection had a strong impact on the results because modeled typologies matched the original ones by 51 to 75% (Ciglič 2014; Ciglič and Perko 2015). During the last testing of the original 1996 typology, its accuracy was estimated at 94% (Ciglič et al. 2017). The capacity and impact of methods were also determined using distorted classifications (Ciglič 2018), which allowed for additional evaluations of the original classification.

However, for the first time in Slovenian research history, this article deals with models of Slovenia's landscape typologies based on unsupervised classification methods and contain the same number of types (groups) as the original 1996 landscape typology. Unsupervised models are compared against the original typology and supervised models, which contributes to evaluating supervised and unsupervised classification methods as well as assessing the suitability of the original typology's concept and design. With regard to unsupervised classification, it is important to know that the characteristics of individual types (i.e., groups) are not known in advance, but that unsupervised classification methods define or identify them by themselves.

2 The importance of landscape classification

There is still no agreement on whether landscape classification entails searching for actual or merely abstract units (Gams 1984; Udo de Haes and Klijn 1994; Bailey 1996), but, in any case, a classification is a minor or major abstraction of differences between features (Natek and Žiberna 2004). It is natural for people to seek order and organization among phenomena (Haggett 2001), which also applies to spatial or landscape phenomena. Because landscapes constantly change, constant verification of landscape types is essential (Mücher et al. 2003), facilitating more economical use of natural resources and their replenishment. Landscape changes must be accompanied by ongoing adaptation of society's organization and operation to the environment (Plut 2005), which makes it possible to implement principles of sustainability in the economy, society, and environment. Landscape types are important because they relatively homogenously respond to human impact (Špes et al. 2002) and demand similar landscape planning.

Spatial classification following the natural characteristics of a landscape forms the basis for optimal spatial organization. Environmental issues also relate more to natural borders than administrative ones (Bailey 1996; Olson et al. 2001), which is why spatial classifications based on natural factors are becoming increasingly common and are replacing political classifications (Bernert et al. 1997). For instance, NUTS3 regions, which in the Mediterranean often include rural and urban coastal areas (Hazeu et al. 2011), may vary greatly in terms of their natural and social characteristics.

Various disciplines use classifications adapted to the content of their research and their needs (e.g., climate, vegetation, and soil classifications), but often their work would be made easier through uniform landscape classifications (Brabyn 2018), especially at different spatial levels (McMahon, Wiken and Gauthier 2004). A landscape classification at the highest spatial level can be used to outline borders for general purposes and various disciplines, whereas spatial units or landscape types at a lower level can serve as a starting point for more specific purposes (Bailey 1996) or classification within individual disciplines. This requires understanding of the relations between a landscape as a whole and its components (e.g., land use and biodiversity), which is vital for managing the environment (landscape) and its resources (Jongman et al. 2006).

Landscape classification is also important for preserving the natural and cultural landscape; inventorying, evaluating, and monitoring the current situation; managing, planning, and conducting measurements; exploring scenarios; sampling; transferring models into the physical environment; presenting landscape diversity; analyzing environmental pressures; and so on (Runhaar and Udo de Haes 1994; Bailey 1996; Bunce et al. 1996; Bernert et al.1997; Bastian 2000; Mücher et al. 2003; Loveland and Merchant 2004; Romportl and Chuman 2012).

Based on all the above, it is not surprising that in some places classifications even have a formal character, being part of official documents or even legislation in specific countries. In 1996, the EU introduced the Pan-European Biological and Landscape Diversity Strategy (Pan-European … 1996), and in 2000 it adopted the European Landscape Convention (The European … 2018). For example, in Slovenia the landscape typology of the country (Perko 1998) is used in defining land quality assessment criteria (Pravilnik o določanju … 2008).

3 Classification methods

Classification entails combining similar units based on logical criteria (Dodge 2008). As part of geographic information systems, units are defined with p data layers or, in other words, they have p dimensions. Classifications can be made based on a single criterion or factor (a monothetic approach) or several factors (a polythetic approach). The former involves a one-dimensional and the latter a multidimensional data space (Loveland and Merchant 2004).

Many classification methods are used (McGarigal, Cushman and Stafford 2000; Rogerson 2006; Abonyi and Feil 2007; Dodge 2008; Warner and Campagna 2009) and, in terms of results, each of them more or less imposes a specific structure and leads to a specific solution. Therefore, it is best to compare the results of various methods (Ferligoj 1989; McGarigal, Cushman and Stafford 2000; Theodoridis and Koutroumbas 2006; Ciglič 2018).

Classification methods are divided into soft and hard or relative and absolute, but most often a distinction is made between supervised and unsupervised classifications (Warner and Campagna 2009). With supervised methods, known values of training cells are available for classification, whereas that is not the case with unsupervised ones (Theodoridis and Koutroumbas 2006); both are, however, at least partially shaped by an individual's subjective judgment and knowledge (Warner and Campagna 2009).

As part of supervised classification, specific examples of units are selected from individual groups, which should have the most typical values possible, and based on these examples rules are designed for assigning all the remaining units to the types defined in advance. In contrast, as part of unsupervised classification, units can be categorized based on their characteristics or values even without any prior information about the units (Ferligoj 1989; Oštir 2006), which is a certain advantage compared to supervised classifications. The aim of unsupervised classification in groups is to achieve the maximum internal homogeneity and the minimum external isolation of groups (Ferligoj 1989) or to minimize variance within the group and maximize variance between groups (Rogerson 2006).

Unsupervised classification methods have several weaknesses (McGarigal, Cushman and Stafford 2000), such as sensitivity to outliers, which these methods often assign to a separate class, and great dependency of results on the initial groups defined and their number.

The unsupervised classification procedure can be divided into five basic steps (Ferligoj 1989; Theodoridis and Koutroumbas 2006):

- Step 1: selecting the units;
- Step 2: selecting the variables;
- Step 3: computing the similarities (and differences) between units;
- Step 4: selecting and carrying out the classification method; and
- Step 5: assessing the final classification, which can only be done by an expert in the relevant field.

Various relatively detailed digital data on natural geographical factors are available for Slovenia (Ciglič et al. 2016). Among these, over forty variables or data layers were selected and then normalized to values from 0 to 100, and adjusted to a uniform resolution of 200 m (the resolution of the least accurate layer), which means that Slovenia was divided into 506,450 units or cells. This completed the step 1 (selecting the units).

Step 2 entailed an assessment of all data layers in terms of their usefulness for landscape typology modeling (Ciglič 2012, 2013, 2014; Ciglič and Perko 2017). The following three criteria were applied: correlation between data layers, correlation between data layers and available landscape typologies, and suitability of data layers in terms of the classification level or scale (the scales were determined at which an individual data layer was still sufficiently diverse to be suitable for classification).

Eliminating less important data layers can reduce the time and costs of implementation, while also simplifying the understanding of modeling procedures (Jiang et al. 2008; Tirelli and Passani 2011). Based on the criteria mentioned above, the following four data layers were selected for landscape typology modeling: elevation, slope, rock permeability, and precipitation regime (the ratio between summer and fall precipitation).

Steps 3 and 4 already depend on the individual methods selected. Several unsupervised classification methods and their versions and settings in various software were tested for modeling the typologies of Slovenia. Four methods from the *TerrSet* software (the former Idrisi) were selected for presentation in this article: the histogram peak analysis method, the iterative self-organizing unsupervised classifier method, the *k*-means method, and the iterative self-organizing data analysis method.

3.1 Histogram peak analysis

The histogram peak analysis method is based on frequency distribution and classifies cells in groups using a multidimensional histogram (Richards and Jia 2006). It first looks for peaks in a multidimensional histogram (i.e., the values with the highest frequency) and then assigns every cell to its nearest peak, forming groups. The areas between the peaks (i.e., valleys) have values with the lowest frequency, creating boundaries between groups (Eastman 2016).

In the *TerrSet* program, this method is available as part of the CLUSTER module (TerrSet … 2015), in which the user can set the following parameters: number of data layers, number of classes for each data layer or gray levels, cutoffs for excluding extreme values or the saturation percentage, generalization level (broad or fine) for identifying peaks, and clustering rule, through which the user can drop less significant clusters, set the maximum number of clusters, or retain all clusters.

The following settings were selected: gray levels = 6, saturation percentage = 1%, generalization level = fine, and clustering rule = maximum nine groups.

3.2 The iterative self-organizing unsupervised classifier method

In *TerrSet*, the iterative self-organizing unsupervised classifier method is available as part of the ISOCLUST module (TerrSet … 2015), which in fact uses three other modules for this method. With the CLUSTER module it first derives the initial clusters (or seeds) using a multidimensional histogram (like with the histogram peak analysis; see Section 3.1), after which it employs the modules MAKESIG and MAXLIKE to automatically define the training sites and perform a supervised classification. It repeats the procedure several times using new training cells from individual clusters. Because of the efficiency of the seeding step, very few iterations are usually required to achieve a stable cluster.

The user first selects the data layers and then specifies the number of iterations, the desired number of clusters, and the minimum sample size per class.

The following settings were selected: number of iterations = 99, number of clusters desired = 9, and minimum sample size per class = 40.

3.3 *K*-means

Classification following the *k*-means method is based on distances between cells in multidimensional space. The final classification strongly depends on the definition of the number of clusters (*k)* and the initialization of centroids (centers) – that is, central cells around which other cells gather. First, the user specifies the number of clusters and the methods (rules) for initializing the cluster centroids, after which new, more appropriate centroids are calculated. This procedure is repeated until the new centroids are the same as the centroids from the previous iteration (Ferligoj 1989; Richards and Jia 2006). Initial centroids can also be selected randomly or dispersed evenly between cells (Ferligoj 1989).

In *TerrSet*, this method is available as part of the KMEANS module (TerrSet … 2015), in which different rules for initializing the centroids can be selected:

- The random partition rule randomly assigns each cell to one of the *k* clusters and then determines the initial centroids;
- The random seed rule randomly selects *k* cells as the initial centroids and then assigns each cell to one of the *k* clusters according to the minimum-distance rule; and
- The diagonal axis rule systematically sorts *k* centroids from the *n*-dimensional space from the minimum to the maximum value of *n* data layers.

In addition to specifying the rule for initializing the cluster centroids, the user selects the maximum number of output clusters and the option to merge (overly) small clusters, which do not exceed the selected percentage of the entire image cells, with larger ones. The user also specifies two stopping criteria to terminate the clustering process. With the first one, the process is terminated if during the last iteration the percentage of migrating cells is less than a specified percentage of all cells, and, with the second criterion, the process stops when a specified number of iterations has been reached.

The following settings were selected for this study: maximum number of output clusters = 9, cluster centroid initialization rule = random seed, merge clusters with proportions less than or equal to 1%, and stopping criteria = percentage of migration cells (pixels) less than or equal to 1% and maximum iterations 999.

3.4 Iterative self-organizing data analysis

The iterative self-organizing data analysis (ISODATA) is an improved *k*-means method. It can merge clusters, just like the *k*-means technique, but it can also split them. It determines the initial centroids and clusters the same way as the *k*-means method, after which it calculates the standard deviation within each cluster and the distances between cluster centroids. It splits a cluster into two if the standard deviation is higher than the one specified by the user, or it merges two clusters if the distance between two cluster centroids is smaller than the one specified by the user. It repeats the process with new clusters and new centroids. The process is terminated if the standard deviation and distances between centroids no longer make it possible to merge or split clusters, if during the last iteration the percentage of migrating pixels is less than that specified by the user or if the process reaches the number of iterations specified.

In *TerrSet*, this method is available as part of the ISODATA module (TerrSet … 2015). The following settings were specified for this study: initial number of clusters = 9, maximum number of output clusters = 9, cluster centroid initialization rule = random seed, stopping criteria = percentage of migration cells (pixels) less than or equal to 1% and maximum iterations 999, minimum cluster size = 100, standard deviation within a cluster for splitting = 25, Euclidean distance between clusters for merging = 12.5, and maximum number of pairs to merge within an iteration = 2.

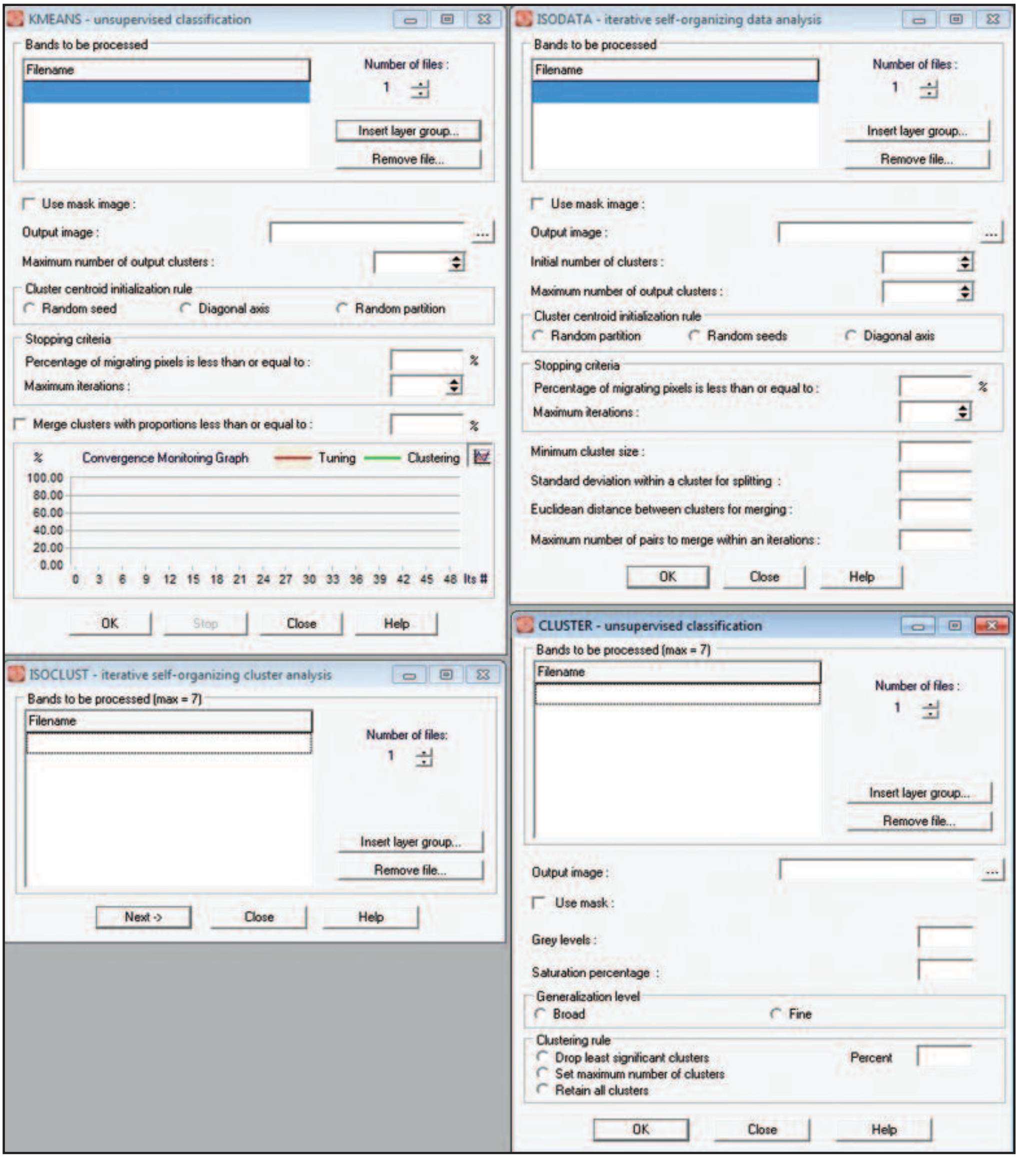

Figure 1: CLUSTER, ISOCLUST, KMEANS, and ISODATA modules in the TerrSet program.

4 Landscape typology modeling using unsupervised classification methods

Each of the four methods presented was used to produce typologies with various numbers of classes. This article describes in detail modeled landscape typologies with nine classes, which were compared against the best-established landscape typology of Slovenia of 1996, which contains nine landscape types combined into four landscape type groups.

The process of creating the 1996 landscape typology started in 1995. Perko (1998) entered the following four data layers into the geographic information system: surface elevation, surface inclination, lithology, and vegetation types. The inclination and elevation data were based on a 100 m digital elevation model, and the lithology and vegetation data were obtained through digitization of a 1:250,000 lithological map with thirty-seven basic units (Verbič 1998) and a vegetation map with sixty-two basic units (Zupančič et al. 1998) converted to a 100 m raster grid. All four layers were then generalized and simplified into seven classes.

Perko overlaid (intersected) all four layers. Altogether 2,401 different combinations were theoretically possible. Perko filtered the intersected layer three times using the modus inside of a moving 11 × 11 cell square window, obtaining forty-eight larger and spatially separate homogenous cores with the same combination of elevation, inclination, lithology, and vegetation. He printed the cores on a 1:250,000 map and, with the help of experts for individual parts of Slovenia, manually plotted the boundaries, mostly in morphological boundaries and larger watercourses. In the end, he combined these forty-eight manually delineated landscape units into nine landscape types, which he merged further into four landscape type groups.

The nine landscape types are: Alpine mountains, Alpine hills, Alpine plains, Pannonian low hills, Pannonian plains, Dinaric plateaus, Dinaric lowlands, Mediterranean low hills, and Mediterranean plateaus.

The four landscape type groups are Alpine landscapes, Pannonian landscapes, Dinaric landscapes, and Mediterranean landscapes.

This was the first partly computerized typology of Slovenia. Its research bases were first presented in 1998 (Perko 1998). It has been published in all major geographical works on Slovenia issued after Slovenia's independence. Since 2008, it has also been part of Slovenian tax legislation and has been used for rating agricultural land according to the Rules on Determining and Administering Land Rating.

As already described in Chapter 3 the CLUSTER, ISOCLUST, KMEANS, and ISODATA modules in the *TerrSet* software were used for modeling. The modeled typologies were compared against the original 1996 typology in terms of the correlation coefficient between the modeled typologies and the original typology, the cluster density in the modeled typologies by landscape type of the original typology, and the ratio between the actual and theoretical cluster frequency in the modeled typologies by landscape type of the original typology.

The first indicator was **cluster density** by landscape type of the original typology – that is, the number of cells in an individual cluster per 100 cells of a specific landscape type. The maximum value of density possible is 100, which is when all the cells of an individual cluster lie within a specific landscape type, and the minimum value is 0, when a specific landscape type does not contain even a single cell of this cluster.

If the cells of all nine clusters were evenly distributed across the nine landscape types of the original typology in the modeled typologies, the density of all clusters would be 11. A cluster with a density of at least twice as much (i.e., at least 22) was defined as a typical representative of this landscape type. If a modeled typology was completely the same as the original typology, each of the nine clusters would have a density of 100 in only one landscape type, whereas the density in the remaining eight landscape types would be 0. If, for instance, Cluster 7 of a modeled typology had thirty-three cells per one hundred cells of Dinaric plateaus, Cluster 7 would be a good representative or approximation of the Dinaric plateaus in the original typology.

The indicator **ratio between the actual and theoretical cluster frequency** in the modeled typologies by landscape type of the original typology relies on contingency tables, in which the rows and columns represent clusters and landscape types, and the cells contain the actual frequency (number) of cells in individual clusters by individual landscape type. Clusters that had their actual frequency in a specific landscape type at least twice the theoretical frequency were defined as typical representatives of this landscape type.

For example, in Table 1, at the intersection of Cluster 9, which was specified using the ISODATA method, and the Alpine mountains landscape type the actual frequency – that is, the number of cells of Cluster 9 that lie within the Alpine mountains (their total is 27,975) – is provided. The theoretical frequency of that table cell is 4,811 and equals the total of all cells of Cluster 9 in the last column (31,835) and all cells of the Alpine mountains in the last row (76,533) divided by the number of all cells (506,450). Because the ratio between the actual and theoretical frequency (5.82) is greater than 2, Cluster 9 is a good representative of the Alpine mountains.

The **correlation coefficient** between the modeled typologies and the original typology also relies on contingency tables. Cramer's *V* was selected for the study; it has lower values than the Pearson correlation coefficient, but it does not depend on the size of the tables and therefore allows comparisons between tables with different numbers of columns and rows or between typologies with different numbers of classes.

Table 1: Example of arranging cells of a nine-cluster typology modeled using the ISODATA module by nine landscape types of the original typology.

ISODATA module	Alpine mountains	Alpine hills	Alpine plains	Pannonian low hills	Pannonian plains	Dinaric plateaus	Dinaric lowlands	Mediterranean low hills	Mediterranean plateaus	Total
Cluster 1	5,288	34,123	2,382	31,609	1,264	3,747	5,448	0	0	83,861
Cluster 2	250	6,543	2,435	30,360	25,360	0	0	0	0	64,948
Cluster 3	5,762	29,497	143	593	11	78	88	0	0	36,172
Cluster 4	8,365	1,395	224	0	0	33,590	9,724	5,654	13,885	72,837
Cluster 5	4,516	10,161	888	0	0	12,956	6,570	18,477	2,738	56,306
Cluster 6	14,932	8,997	115	5	0	11,493	366	663	183	36,754
Cluster 7	2,379	4,470	13,832	3,349	5,545	20,106	20,861	1,681	27	72,250
Cluster 8	7,066	20,840	447	8,803	156	9,845	4,330	0	0	51,487
Cluster 9	27,975	452	15	0	0	3,375	0	15	3	31,835
Total	76,533	116,478	20,481	74,719	32,336	95,190	47,387	26,490	16,836	506,450

4.1 Modeling using nine clusters

A graphic presentation of cluster distribution according to the four selected unsupervised classification methods using nine clusters is provided in Figure 2. The original typology with nine landscape types and the original typology with four landscape type groups are added for comparison.

The **correlation coefficients** between the original classification and the classifications produced using the four modules presented above are as follows: 0.4489 for the CLUSTER classification, 0.4159 for the ISOCLUST classification (the lowest among all four classifications), 0.4609 for the KMEANS classification (the highest among all classifications), and 0.4518 for the ISODATA classification.

The **density** of cells in an individual cluster by nine landscape types (Table 2) shows how well the clusters spatially match the landscape types. Clusters with a density of 22 or more are good representatives or approximations of a specific landscape type.

In the CLUSTER classification, Cluster 1 is a good approximation of the Alpine hills and the Pannonian low hills, Cluster 2 is a good approximation of the Alpine plains, Pannonian plains, Pannonian low hills, and Dinaric lowlands, Cluster 3 of the Alpine mountains and Dinaric plateaus, Cluster 5 of the Pannonian plains, and Clusters 6 and 9 of the Mediterranean low hills and Mediterranean plateaus, whereas Clusters 4, 7, and 8 are not a good approximation of even a single landscape type. Cluster 4 demonstrates the highest cell density (18) in the Alpine hills, Cluster 7 in the Alpine mountains (18), and Cluster 8 in the Dinaric plateaus (15). Thus, Cluster 1 has a density over 22 in two landscape types, Cluster 2 in four types, Cluster 3 in two types, Cluster 5 in one type, and both Clusters 6 and 9 in two types. All landscape types are represented: five types in one cluster and four types in two clusters, which means that these clusters are a good spatial match with two landscape types, not just one.

In the ISOCLUST classification, Cluster 1 is a good approximation of the Alpine hills, Cluster 2 of the Dinaric plateaus, Cluster 3 of the Dinaric plateaus, Dinaric lowlands, and Mediterranean plateaus, Cluster 4 of the Mediterranean low hills, Cluster 7 of the Pannonian low hills and Pannonian plains, Cluster 8 of the Alpine plains and Pannonian plains, and Cluster 9 of the Alpine hills and Pannonian low hills, whereas Clusters 5 and 6 are not a good approximation of even a single landscape type. Cluster 5 has the highest density (17) in the Alpine hills and Cluster 6 in the Pannonian low hills (20). Thus, Cluster 1 has a density over 22 in one landscape type of the original typology, Cluster 2 the same, Cluster 3 in four types, and Clusters 7, 8 and 9 in two types. All landscape types are represented: six in one cluster and three in two clusters.

In the KMEANS classification, Cluster 1 is a good approximation of the Alpine hills and Pannonian low hills, Cluster 3 of the Alpine plains and Dinaric lowlands, Cluster 4 of the Alpine mountains, Cluster 6 of the Alpine hills, Cluster 7 of the Mediterranean low hills, Cluster 8 of the Pannonian low hills and Pannonian plains, and Cluster 9 of the Dinaric plateaus, Dinaric lowlands, and Mediterranean plateaus,

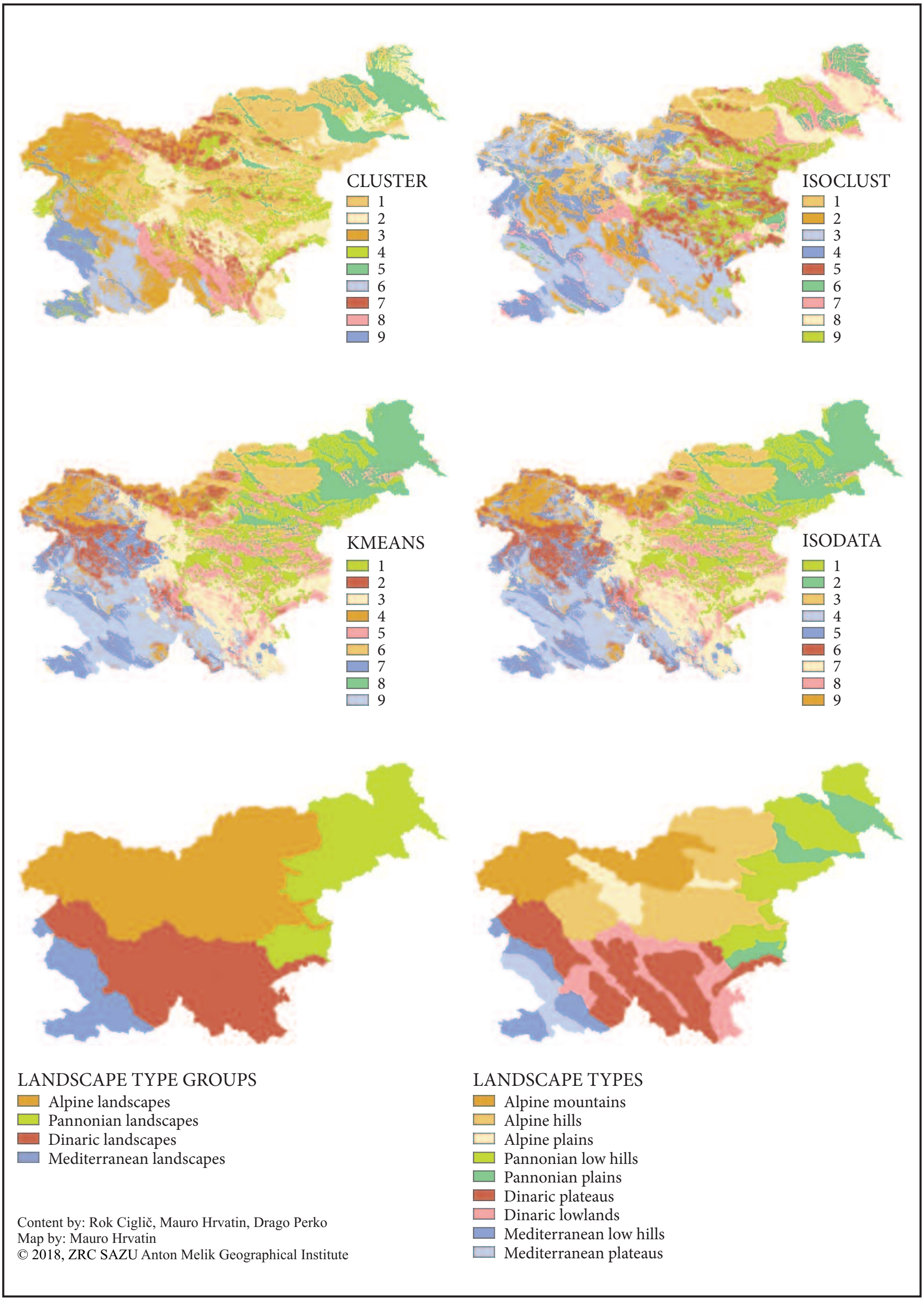

Figure 2: Nine-cluster typologies modeled using the unsupervised classification methods (in the key the clusters are ordered based on the percentage of cells in an individual cluster: the one with the highest percentage is at the top and the one with the lowest percentage is at the bottom).

whereas Clusters 2 and 5 are not a good approximation of even a single landscape type. Cluster 2 displays the highest density (21) in the Alpine mountains and Cluster 5 in the Alpine hills (18). Thus, Cluster 1 has a density above 22 in two landscape types of the original typology, as does Cluster 3, Clusters 4, 6, and 7 in one type, Cluster 8 in two types, and Cluster 9 in three types. All landscape types are represented: six in one cluster and three in two clusters.

In the ISODATA classification, Cluster 1 is a good approximation of the Alpine hills and Pannonian low hills, Cluster 2 of the Pannonian low hills and Pannonian plains, Cluster 3 of the Alpine hills, Cluster 4 of the Dinaric plateaus and Mediterranean plateaus, Cluster 5 of the Mediterranean low hills, Cluster 7 of the Alpine plains and Dinaric lowlands, and Cluster 9 of the Alpine mountains, whereas Clusters 6 and 8 are not a good approximation of even a single landscape type. Cluster 6 has the highest density (20) in the Alpine mountains and Cluster 8 in the Alpine hills (18). Thus, Cluster 1 has a density of over 22 in two landscape types, Cluster 2 the same, Cluster 3 in one type, Cluster 4 in two types, Cluster 5 in one type, Cluster 7 in two types, and Cluster 9 in one. All landscape types are represented: seven types in one cluster and two in two clusters.

The indicator **ratio between the actual and theoretical cluster frequency** in the modeled typologies by landscape type of the original typology (Table 3) shows which clusters are good representatives of a specific landscape type. Good representatives are the clusters whose actual frequency is at least twice their theoretical frequency.

In the CLUSTER classification, Cluster 1 is a good approximation of the Alpine hills (a ratio of 2.37), Cluster 2 of the Alpine plains (3.93) and Dinaric lowlands (2.45), Cluster 3 of the Alpine mountains (3.08), Cluster 5 of the Pannonian plains (as much as 8.99), Cluster 6 of the Dinaric lowlands (3.03), Mediterranean low hills (3.66), and Mediterranean plateaus (5.83), Cluster 7 of the Alpine mountains (3.09), Cluster 8 of the Dinaric plateaus (3.02) and Dinaric lowlands (2.78), and Cluster 9 of the Mediterranean low hills (as much as 9.78) and Mediterranean plateaus (even 10.79), and Cluster 4 has a ratio below 2 with all the landscape types. Its ratio is the highest with the Alpine hills (1.44). Three landscape types with a ratio above 2 appear in one cluster, four in two clusters, the Dinaric lowlands even in three clusters, and the Pannonian low hills in none. The ratio of the Pannonian low hills is the highest in Cluster 5 (i.e., 1.79, which is close to the threshold value of 2).

In the ISOCLUST classification, Cluster 1 is a good approximation of the Alpine hills (a ratio of 3.47), Cluster 2 of the Alpine mountains (2.08) and Dinaric plateaus (2.40), Cluster 3 of the Dinaric plateaus (2.35) and Mediterranean plateaus (3.29), Cluster 4 of the Mediterranean low hills (6.01), Cluster 5 of the Alpine hills (2.11), Cluster 6 of the Pannonian low hills (4.96), Cluster 7 of the Pannonian low hills (2.65) and Pannonian plains (2.73), Cluster 8 of the Alpine plains (4.88) and Pannonian plains (6.45), and Cluster 9 of the Pannonian low hills (2.94). Four landscape types with a ratio above 2 appear in one cluster, three in two clusters, and the Pannonian hills even in three clusters.

In the KMEANS classification, Cluster 1 is a good approximation of the Pannonian low hills (a ratio of 2.58), Cluster 2 of the Alpine mountains (2.98), Cluster 3 of the Alpine plains (4.75) and Dinaric lowlands (3.13), Cluster 4 of the Alpine mountains (5.81), Cluster 6 of the Alpine hills (3.55), Cluster 7 of the Mediterranean low hills (2.65), Cluster 8 of the Pannonian low hills (3.12) and Pannonian plains (6.21), and Cluster 9 of the Dinaric plateaus and Mediterranean plateaus, and Cluster 5 has a ratio below 2 with all the landscape types. Its ratio is the highest with the Alpine hills (1.69). Seven landscape types with a ratio above 2 appear in one cluster and two in two clusters.

In the ISODATA classification, Cluster 1 is a good approximation of the Pannonian low hills (a ratio of 2.55), Cluster 2 of the Pannonian low hills (3.17) and Pannonian plains (6.12), Cluster 3 of the Alpine hills (3.55), Cluster 4 of the Dinaric plateaus (2.45) and Mediterranean plateaus (5.73), Cluster 5 of the Mediterranean low hills (6.27), Cluster 6 of the Alpine mountains (2.69), Cluster 7 of the Alpine plains (4.73) and Dinaric lowlands (3.09), and Cluster 9 of the Alpine mountains. Cluster 8 has a ratio below 2 with all the landscape types. Its ratio is the highest with the Alpine hills (1.76). Seven landscape types with a ratio above 2 appear in one cluster and two in two clusters.

Taking into account all three indicators presented, the typology modeled using the iterative self-organizing data analysis method (the ISODATA module) and the typology modeled using the *k*-means method (the KMEANS module) are the closest to the original typology of nine landscape types.

The KMEANS typology has a slightly higher correlation coefficient than the ISODATA typology but, on the other hand, the ISODATA typology displays a density above the threshold value of 22 in two clusters simultaneously only with two landscape types compared to three in the KMEANS typology.

The typology modeled using the iterative self-organizing unsupervised classifier method (the ISOCLUST module) matches the original typology the least.

Table 2: Cell density of an individual cluster in the modeled typologies by nine landscape types of the original typology (green numbers indicate a density of 22 or more).

Modules	Alpine mountains	Alpine hills	Alpine plains	Pannonian low hills	Pannonian plains	Dinaric plateaus	Dinaric lowlands	Medi-terranean low hills	Medi-terranean plateaus	Total
CLUSTER 1	17.79	62.21	13.76	42.76	3.86	4.16	14.76	0.03	0.00	26.27
CLUSTER 2	1.25	6.12	63.91	26.86	28.21	13.01	39.76	2.60	0.27	16.26
CLUSTER 3	47.27	3.55	0.06	0.00	0.00	34.81	1.63	8.47	7.97	15.37
CLUSTER 4	10.25	18.15	4.85	16.62	0.58	13.17	8.11	17.97	1.75	12.64
CLUSTER 5	0.47	3.87	6.07	13.44	67.34	0.00	0.00	0.00	0.00	7.49
CLUSTER 6	1.11	0.58	0.00	0.00	0.00	10.01	19.91	24.05	38.33	6.58
CLUSTER 7	17.77	4.68	3.22	0.32	0.01	8.50	2.27	0.16	0.00	5.76
CLUSTER 8	2.02	0.82	8.12	0.00	0.00	14.74	13.56	0.13	0.31	4.88
CLUSTER 9	2.07	0.02	0.00	0.00	0.00	1.59	0.00	46.58	51.37	4.76
ISOCLUST 1	8.25	29.96	1.43	0.81	0.03	1.42	0.39	0.04	0.11	8.63
ISOCLUST 2	19.67	5.15	0.88	0.01	0.00	22.71	6.51	0.22	11.25	9.46
ISOCLUST 3	30.42	3.31	16.48	0.14	0.09	54.97	42.06	10.07	76.94	23.40
ISOCLUST 4	20.63	11.06	2.32	0.04	0.00	8.69	6.64	71.91	5.43	11.96
ISOCLUST 5	3.70	17.18	2.65	9.28	0.64	5.23	12.08	0.00	0.00	8.14
ISOCLUST 6	1.21	1.96	0.97	20.32	1.66	0.70	0.12	0.31	4.80	4.10
ISOCLUST 7	0.16	4.19	13.36	25.94	26.69	1.52	18.32	13.40	0.79	9.79
ISOCLUST 8	13.51	5.00	50.69	1.94	66.97	1.53	0.87	4.05	0.10	10.39
ISOCLUST 9	2.45	22.18	11.23	41.53	3.91	3.23	13.00	0.00	0.58	14.15
KMEANS 1	6.73	29.41	11.18	42.73	3.91	3.91	11.29	0.00	0.00	16.58
KMEANS 2	21.05	6.55	0.64	0.10	0.00	11.58	0.87	1.06	0.98	7.07
KMEANS 3	3.36	3.53	67.39	3.75	17.05	20.48	44.39	9.21	0.43	14.19
KMEANS 4	35.81	0.39	0.08	0.00	0.00	3.50	0.00	0.04	0.02	6.17
KMEANS 5	7.93	18.11	2.47	13.21	0.58	11.81	11.00	0.00	0.00	10.70
KMEANS 6	7.26	23.70	0.41	0.79	0.03	0.00	0.00	0.00	0.00	6.68
KMEANS 7	6.99	10.95	5.06	0.00	0.00	7.20	8.59	71.25	6.52	9.88
KMEANS 8	0.35	5.50	11.94	39.43	78.43	0.00	0.00	0.00	0.00	12.62
KMEANS 9	10.52	1.86	0.82	0.00	0.00	41.52	23.86	18.44	92.05	16.11
ISODATA 1	6.91	29.30	11.63	42.30	3.91	3.94	11.50	0.00	0.00	16.56
ISODATA 2	0.33	5.62	11.89	40.63	78.43	0.00	0.00	0.00	0.00	12.82
ISODATA 3	7.53	25.32	0.70	0.79	0.03	0.08	0.19	0.00	0.00	7.14
ISODATA 4	10.93	1.20	1.09	0.00	0.00	35.29	20.52	21.34	82.47	14.38
ISODATA 5	5.90	8.72	4.34	0.00	0.00	13.61	13.86	69.75	16.26	11.12
ISODATA 6	19.51	7.72	0.56	0.01	0.00	12.07	0.77	2.50	1.09	7.26
ISODATA 7	3.11	3.84	67.54	4.48	17.15	21.12	44.02	6.35	0.16	14.27
ISODATA 8	9.23	17.89	2.18	11.78	0.48	10.34	9.14	0.00	0.00	10.17
ISODATA 9	36.55	0.39	0.07	0.00	0.00	3.55	0.00	0.06	0.02	6.29

Table 3: Ratio between the actual and theoretical cluster frequency in the modeled typologies by nine landscape types of the original typology (green numbers indicate ratios of 2 or more).

Modules	Alpine mountains	Alpine hills	Alpine plains	Pannonian low hills	Pannonian plains	Dinaric plateaus	Dinaric lowlands	Medi-terranean low hills	Medi-terranean plateaus	Total
CLUSTER 1	0.68	2.37	0.52	1.63	0.15	0.16	0.56	0.00	0.00	1.00
CLUSTER 2	0.08	0.38	3.93	1.65	1.74	0.80	2.45	0.16	0.02	1.00
CLUSTER 3	3.08	0.23	0.00	0.00	0.00	2.27	0.11	0.55	0.52	1.00
CLUSTER 4	0.81	1.44	0.38	1.31	0.05	1.04	0.64	1.42	0.14	1.00
CLUSTER 5	0.06	0.52	0.81	1.79	8.99	0.00	0.00	0.00	0.00	1.00
CLUSTER 6	0.17	0.09	0.00	0.00	0.00	1.52	3.03	3.66	5.83	1.00
CLUSTER 7	3.09	0.81	0.56	0.06	0.00	1.48	0.39	0.03	0.00	1.00
CLUSTER 8	0.41	0.17	1.67	0.00	0.00	3.02	2.78	0.03	0.06	1.00
CLUSTER 9	0.44	0.00	0.00	0.00	0.00	0.33	0.00	9.78	10.79	1.00
ISOCLUST 1	0.96	3.47	0.17	0.09	0.00	0.17	0.05	0.00	0.01	1.00
ISOCLUST 2	2.08	0.55	0.09	0.00	0.00	2.40	0.69	0.02	1.19	1.00
ISOCLUST 3	1.30	0.14	0.70	0.01	0.00	2.35	1.80	0.43	3.29	1.00
ISOCLUST 4	1.73	0.92	0.19	0.00	0.00	0.73	0.56	6.01	0.45	1.00
ISOCLUST 5	0.45	2.11	0.33	1.14	0.08	0.64	1.48	0.00	0.00	1.00
ISOCLUST 6	0.30	0.48	0.24	4.96	0.41	0.17	0.03	0.07	1.17	1.00
ISOCLUST 7	0.02	0.43	1.37	2.65	2.73	0.16	1.87	1.37	0.08	1.00
ISOCLUST 8	1.30	0.48	4.88	0.19	6.45	0.15	0.08	0.39	0.01	1.00
ISOCLUST 9	0.17	1.57	0.79	2.94	0.28	0.23	0.92	0.00	0.04	1.00
KMEANS 1	0.41	1.77	0.67	2.58	0.24	0.24	0.68	0.00	0.00	1.00
KMEANS 2	2.98	0.93	0.09	0.01	0.00	1.64	0.12	0.15	0.14	1.00
KMEANS 3	0.24	0.25	4.75	0.26	1.20	1.44	3.13	0.65	0.03	1.00
KMEANS 4	5.81	0.06	0.01	0.00	0.00	0.57	0.00	0.01	0.00	1.00
KMEANS 5	0.74	1.69	0.23	1.23	0.05	1.10	1.03	0.00	0.00	1.00
KMEANS 6	1.09	3.55	0.06	0.12	0.01	0.00	0.00	0.00	0.00	1.00
KMEANS 7	0.71	1.11	0.51	0.00	0.00	0.73	0.87	7.21	0.66	1.00
KMEANS 8	0.03	0.44	0.95	3.12	6.21	0.00	0.00	0.00	0.00	1.00
KMEANS 9	0.65	0.12	0.05	0.00	0.00	2.58	1.48	1.14	5.71	1.00
ISODATA 1	0.42	1.77	0.70	2.55	0.24	0.24	0.69	0.00	0.00	1.00
ISODATA 2	0.03	0.44	0.93	3.17	6.12	0.00	0.00	0.00	0.00	1.00
ISODATA 3	1.05	3.55	0.10	0.11	0.00	0.01	0.03	0.00	0.00	1.00
ISODATA 4	0.76	0.08	0.08	0.00	0.00	2.45	1.43	1.48	5.73	1.00
ISODATA 5	0.53	0.78	0.39	0.00	0.00	1.22	1.25	6.27	1.46	1.00
ISODATA 6	2.69	1.06	0.08	0.00	0.00	1.66	0.11	0.34	0.15	1.00
ISODATA 7	0.22	0.27	4.73	0.31	1.20	1.48	3.09	0.44	0.01	1.00
ISODATA 8	0.91	1.76	0.21	1.16	0.05	1.02	0.90	0.00	0.00	1.00
ISODATA 9	5.82	0.06	0.01	0.00	0.00	0.56	0.00	0.01	0.00	1.00

4.2 Modeling using four clusters

A graphic presentation of cluster distribution according to the four selected unsupervised classification methods using four clusters is provided in Figure 3. The original typology with four landscape type groups and the original typology with nine landscape types are added for comparison.

The four-cluster typologies modeled were also compared against the original typology. Taking into account all three indicators presented, the typology modeled using the iterative self-organizing data analysis method (the ISODATA module) is the closest to the original typology with four landscape type groups and the original typology with nine landscape types, and the typology modeled using the iterative self-organizing unsupervised classifier method (the ISOCLUST module) match the original typologies the least.

It is interesting that the correlation coefficients between the modeled typologies and the original typology with nine landscape types are approximately one-third higher than with the original typology with four landscape type groups.

5 Quality of the typologies modeled

A comparison between the nine-cluster typologies modeled showed that the ISODATA and KMEANS typologies are the closest to the original typology with nine landscape types and can therefore be regarded as the best approximations. This applies to the modeled typologies as a whole, but the question was whether this also applies to individual landscape types or the other two modules may prove to be more effective in assigning cells to the cluster that is the best approximation of a specific landscape type (e.g., the Alpine mountains).

The **Herfindahl–Hirschman Index** was used to calculate the concentration of nine landscape types of the original typology by nine clusters of the modeled typologies and vice versa (Tables 4 and 5). The value of the index ranges from 0 to 1. In the case presented, it had value 1 if all the cells of a specific landscape type were in only one cluster and it had value 0 if the cells of a specific landscape type were evenly distributed across all clusters. The higher the index value, the better a cluster of a specific module is an approximation of a specific landscape type.

Every landscape type has the highest concentration index with one module (marked green in Table 4) and the lowest with another (marked red in Table 4). In the CLUSTER typology, two landscape types – the Alpine mountains and the Alpine hills – are the most concentrated across clusters (i.e., they have the highest concentration index), and as many as four types are concentrated the least: the Dinaric plateaus, Dinaric lowlands, Mediterranean low hills, and Mediterranean plateaus. In the ISOCLUST typology, only the Dinaric plateaus are the most concentrated across clusters, whereas as many as five are concentrated the least: the Alpine mountains, Alpine hills, Alpine plains, Pannonian low hills, and Pannonian plains. In the KMEANS typology, the three types most concentrated across clusters are the Dinaric lowlands, Mediterranean low hills, and Mediterranean plateaus, whereas no type displayed a particularly low concentration. Similarly, in the ISODATA typology, three types were most concentrated across clusters (i.e., the Alpine plains, Pannonian low hills, and Pannonian plains), and no type displayed a particularly low concentration. The values of the concentration indexes show that the CLUSTER module is the best for defining Alpine landscape types, the KMEANS module for determining Mediterranean landscape types, and the ISODATA module for defining Pannonian landscape types (Table 4). Differences between the typologies modeled are also evident from the opposite perspective – that is, in terms of cluster concentration by landscape type (Table 5). Among the nine clusters used, the CLUSTER module proved to be the best for three clusters and the worst for three clusters, the ISOCLUST module was the best for one cluster, the KMEANS module was the best for two clusters and the worst for two clusters, and the ISODATA module was the best for three clusters and the worst for as many as four (Table 5).

This means that individual landscape types can be determined more effectively by other modules than the one used for a specific modeled typology; for example, the CLUSTER module for Alpine mountains and Alpine hills. The concentration index for Alpine mountains is 41% higher with the CLUSTER module than the KMEAN module, and even 93% higher for Alpine hills.

The quality of the modeled typologies is also indicated by the degree of their similarity with the original typology of 1996. According to the three indicators based on which the modeled typologies were

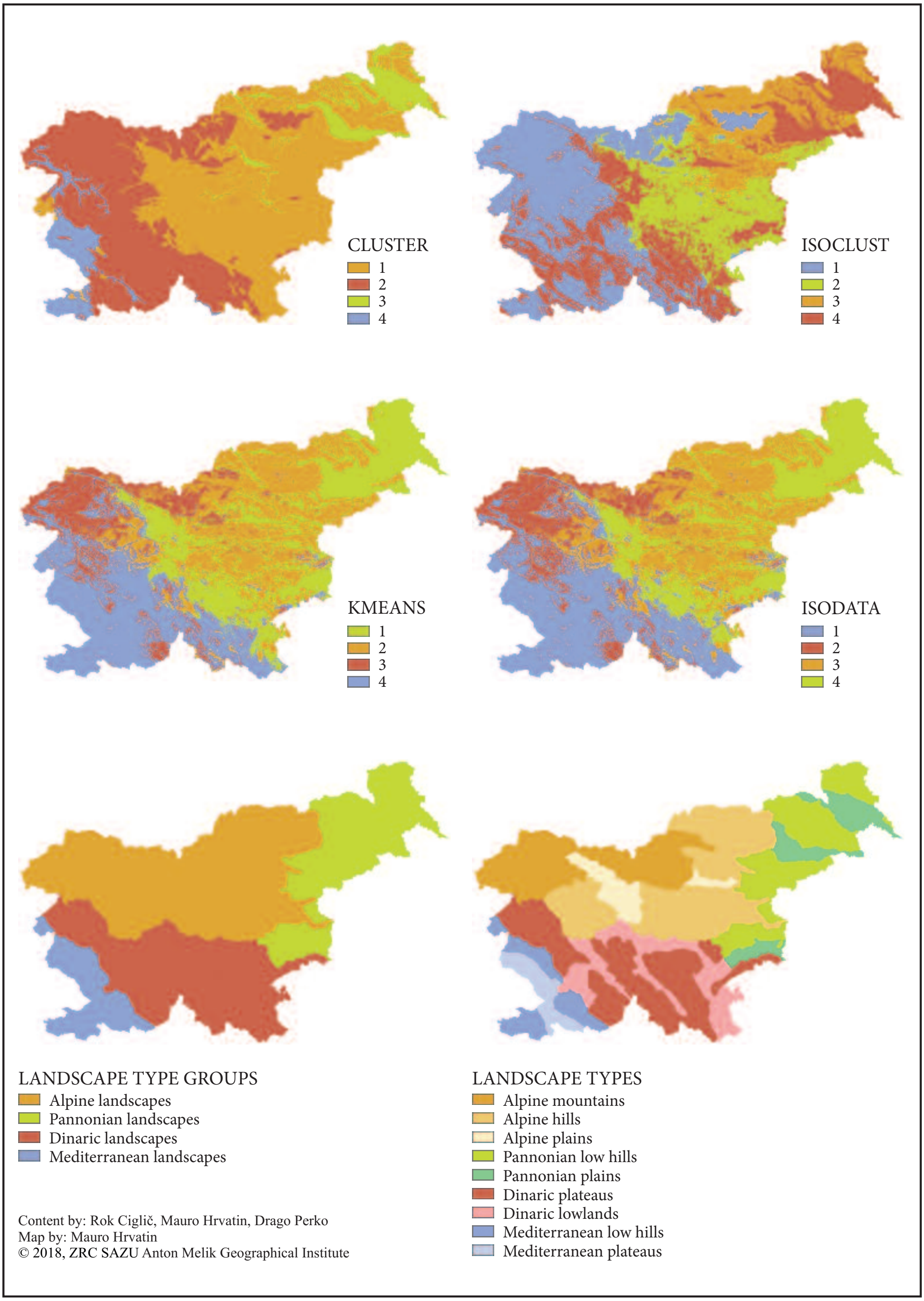

Figure 3: Four-cluster typologies modeled using the unsupervised classification method (in the key the clusters are ordered based on the percentage of cells in an individual cluster: the one with the highest percentage is at the top and the one with the lowest percentage is at the bottom).

compared against the original one, the best modeled typologies are those that have the highest correlation coefficients, very high densities by individual cells of the contingency table and at the same time very low densities by other cells of the contingency table, and very high ratios by individual cells of the contingency table and at the same time very low ratios by other cells in that table.

If the double density of cells in an individual cluster of modeled typologies by nine landscape types of the original typology (Table 2) is taken into account as a criterion and the frequencies in the cells of the contingency table that meet this condition are added up (values density of 20 or more are taken into account), the ISOCLUST module has 66% of all cells »properly« classified, the corresponding share with the KMEANS and ISODATA modules is 65%, and with the CLUSTER module it is 59%. Based on the criterion of the double ratio between the actual and theoretical cluster frequency of modeled typologies by nine landscape types of the original typology (Table 3), the ISOCLUST module has 56% of cells »properly« classified, compared to 53% in the KMEANS module and 51% in the ISODATA module. The differences between the modules are very small. In terms of density, nearly two-thirds of the cells are »properly« classified, compared to only just over half in terms of the frequency ratio.

The degree to which the typologies modeled using **unsupervised classification** methods are less correlated with the original typology of 1996 compared to the typologies modeled using **supervised classification** methods was assessed by comparing Cramer's *V* (similar to how the modeled typologies were compared against the original one). The supervised classification models were designed using four supervised classification methods: a decision tree, *k*-nearest neighbors, maximum likelihood, and minimum distance. With all four the same four data layers were used as with the unsupervised classifications. The models were designed using two sets of **training cells**. For the first set, the cells were selected **randomly** and for the second set **expert** sampling was used, which means that the most representative areas were selected based on the researcher's judgment. Thus, with all methods, random supervised classifications were distinguished from the expert ones, which yielded eight modeled typologies. Typologies using supervised classification methods were modeled in 2013 (Ciglič 2014).

At first glance, it may seem unusual that the typologies modeled using a random sample generally had a higher degree of correlation with the original typology (the correlation coefficient ranging from 0.5023

Table 4: Concentration indexes of landscape types of the original typology by clusters of modeled typologies (colors indicate the modeled typology or module where an individual landscape type is concentrated the most (green) or the least (red)).

Modules	Alpine mountains	Alpine hills	Alpine plains	Pannonian low hills	Pannonian plains	Dinaric plateaus	Dinaric lowlands	Mediterranean low hills	Mediterranean plateaus
CLUSTER	0.4589	0.5978	0.6092	0.4618	0.6902	0.3098	0.3885	0.4789	0.5871
ISOCLUST	0.3179	0.2962	0.4803	0.4488	0.6795	0.5353	0.3963	0.7001	0.7491
KMEANS	0.3263	0.3098	0.6479	0.5259	0.7755	0.3947	0.4439	0.7029	0.9128
ISODATA	0.3285	0.3168	0.6497	0.5292	0.7757	0.3431	0.4317	0.6920	0.8186
Average	0.3579	0.3801	0.5968	0.4914	0.7302	0.3957	0.4151	0.6435	0.7669

Table 5: Cluster concentration indexes of modeled typologies by landscape type of the original typology (colors indicate the modeled typology or module where an individual cluster is concentrated the most (green) or the least (red)).

Modules	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9
CLUSTER	0.5385	0.2778	0.5715	0.3326	0.5847	0.3768	0.4979	0.5700	0.5689
ISOCLUST	0.7859	0.4893	0.4308	0.3715	0.4642	0.7050	0.3698	0.4110	0.4951
KMEANS	0.4869	0.5102	0.3325	0.8686	0.3949	0.8086	0.3881	0.5512	0.4658
ISODATA	0.4834	0.5526	0.8075	0.4441	0.3433	0.4885	0.3351	0.4032	0.8698
Average	0.5737	0.4575	0.5356	0.5042	0.4468	0.5947	0.3977	0.4838	0.5999

with the minimum distance method to 0.7261 with the *k*-nearest neighbors method) than the ones for which an expert sample was used (0.5153 with the minimum distance method and 0.6020 with the *k*-nearest neighbors method). The reason is that in expert-sample modeling some of the most typical areas of individual types (based on the researcher's subjective judgment) were selected, and therefore the modeling did not cover the entire variability of a landscape type or at least not to the same extent as the random-sample modeling, where, given the more generalized classification rules, the sample was more evenly distributed across a landscape type. Hence, with expert-sample modeling one can speak of **over-fitting**. This is also proven by the analysis of testing the success rate of modeling the training cells, where (precisely to the contrary) expert sampling achieved significantly higher scores than random sampling (Ciglič 2014).

The correlation coefficients between the typologies modeled using unsupervised classification methods and the original typology range from 0.4159 with the ISOCLUSTER module to 0.4609 with the KMEANS module. This means they are approximately one-fifth lower than the correlation coefficients between the original typology and the typologies modeled using expert supervised classification methods, and a third lower than the correlation coefficients between the original typology and the typologies modeled using random supervised classification methods.

6 Conclusion

The typologies modeled using the unsupervised classification methods presented only roughly approximate the original typology of Slovenia and to a lesser degree than the supervised classification models (Ciglič 2014). This is expected because typologies modeled using supervised classification methods are based on a referential or training classification or, in this case, the 1996 typology of Slovenia. On the other hand, the statistically significant correlation between the original typology of 1996 and the typologies modeled using unsupervised classification methods (i.e., completely independently of already identified landscape types) confirms that the original landscape typology (at least in terms of the data layers that were taken into account) is fairly appropriate.

However, because unsupervised classification methods have certain advantages over supervised classification methods and because the number and diversity of data covering all of Slovenian territory is growing, it can be expected that the differences between the quality of supervised and unsupervised classifications will become smaller and that modeled typologies will better approximate the actual situation, thus effectively replacing typologies produced using traditional procedures, which are usually more time-consuming and therefore more expensive.

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HOUSEHOLD EARTHQUAKE PREPAREDNESS IN SERBIA: A STUDY OF SELECTED MUNICIPALITIES

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MILOŠ CVETKOVIĆ

Aftermath of the Kraljevo earthquake.

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Household earthquake preparedness in Serbia: A study of selected municipalities

ABSTRACT: This article presents the results of a qualitative study of household earthquake and community-level preparedness in Serbia and its relationship to various demographic factors. A series of 1,018 face-to-face interviews were conducted at the beginning of 2017 in eight Serbian municipalities. The results show that the population is generally unprepared, with low percentages of reported enhanced preparedness levels. In addition to presenting its findings, the study also considers future research directions, including using this study as a basis for more detailed research and to assist in facilitating community-led programs and strategies to increase earthquake safety.

KEY WORDS: geography, natural hazards, earthquake, preparedness, household, survey, Serbia

Pripravljenost gospodinjstev na potrese v Srbiji: Študija izbranih občin

IZVLEČEK: V članku so predstavljeni rezultati kvalitativne študije pripravljenosti na potres v gospodinjstvih in na občinski ravni v Srbiji in njeni povezanosti različnimi demografskimi dejavniki. Članek temelji na 1018 intervjujih, ki so bili izvedeni na začetku leta 2017 v osmih srbskih občinah. Rezultati kažejo, da je prebivalstvo na splošno nepripravljeno, z nizkim deležem izboljšane ravni pripravljenosti. Poleg lastnih ugotovitev študija obravnava tudi prihodnje smeri raziskovanja, vključno z uporabo te študije kot temelja za podrobnejše raziskave in za pomoč pri programih, ki jih vodijo skupnosti, ter strategij za povečanje potresne varnosti.

KLJUČNE BESEDE: geografija, naravne nesreče, potres, pripravljenost, gospodinjstvo, raziskovanje, Srbija

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1 Introduction

Disasters caused by earthquakes present various threats to human society and are generally seen as processes resulting from the interaction between natural and anthropogenic systems (Lukić et al. 2013). The preparedness of individuals, households, and communities is very important for improving community resilience in the face of any natural hazards, especially with regard to modern society's great vulnerability to earthquakes (Komac et al. 2013). Disaster preparedness is defined as self-protective or precautionary behavior (Mishra and Suar 2012), but preparedness activities are usually not engaged in at the household level (e.g., Eisenman et al. 2006; Kapucu 2008; Bethel, Foreman, and Burke 2011; Marti et al. 2018). More recent studies have highlighted the factors associated with earthquake preparedness at the household and community levels (Murphy et al. 2009; FEMA 2009; Johnston, Becker and Paton 2012; Muttarak and Pothisiri 2013; Paton et al. 2015; Cvetković et al. 2015; Deyoung and Peters 2016; Johnson and Nakayachi 2017; Fox et al. 2017). First, demographic and socioeconomic variables are a central set of characteristics linked to preparedness. Older, female, and better-educated heads of households, as well as residence duration, tend to be associated with better household preparedness (Duval and Mulilis 1999; Shaw et al. 2004). On the other hand, better community preparedness has been associated with non-single status and farming occupations (Tomio et al. 2014; Ashida et al. 2017). Second, recent studies (Kirschenbaum 2006; Tomio et al. 2014) have found that the relationship between household and community preparedness is not complementary, and, as a result, a large proportion of households are unprepared at both the community and household levels (Kirschenbaum, Rapaport and Canetti 2017). In practice, disaster management authorities often do not implement any activities related to earthquake preparedness at local levels, and they focus more on reactive and top-down approaches (Ainuddin and Routray 2012).

This study gathered basic data necessary for understanding preparedness and for use in preparedness planning and programs. Proceeding from this basis, it examined preparedness perceptions, knowledge, and behaviors, including investigation of the role of demographic factors (sex, age, education level, marital status, and household income) influencing household earthquake preparedness in Serbia. Such variations reflect the extent to which factors can shape community-driven efforts and education, supporting efforts to prepare for and cope with an earthquake. Based on the findings, the article suggests some specific initiatives that can be taken to improve preparedness in Serbia.

2 Study area

Serbia belongs to a region with moderate seismic activity in terms of the number and frequency of earthquakes as well as their magnitude, and it is characterized by an irregular distribution of epicenters, which makes it difficult to distinguish seismically active faults (Marović et al. 2002; Abolmasov et al. 2011; Dragicević et al. 2011). Marović et al. (2002) found that, from 1900 to 1970, stronger-intensity earthquakes (determined as I = VIII–IX) were registered at the following locations: Rudnik (a mountain), Lazarevac (a municipality of the city of Belgrade), Juhor (a mountain), Krupanj (a town and municipality in the Mačva district of western Serbia), Jagodina (a city and the administrative center of the Pomoravlje district in central Serbia), Vranje (a city and the administrative center of the Pčinja district in southern Serbia), and Vitina (a town and municipality in eastern Kosovo), and, from 1970 onwards, only three moderate-intensity earthquakes have occurred: at Kopaonik (a mountain), Mionica (a town and municipality in the Kolubara district of western Serbia), and Trstenik (a town and municipality in the Rasina district of central Serbia).

The most seismically threatened is Lazarevac, where an extreme earthquake (M = 6.1) was recorded in 1922. Near the city of Kraljevo, Serbia, with a population of more than 100,000, an M = 5.4 earthquake occurred on November 3rd, 2010. Over the next six days, 258 earthquakes were registered, with magnitudes ranging from 1.0 to 4.4. Despite the moderate magnitude of the incident, two people were killed, many others were injured, and the total damage to the city was assessed at more than €100 million (Panić et al. 2013). By the end of March 2011, the earthquake had been followed by a sequence of more than 650 aftershocks of a magnitude greater than 1.0 (Antonijević, Arroucanu and Vlahović 2013).

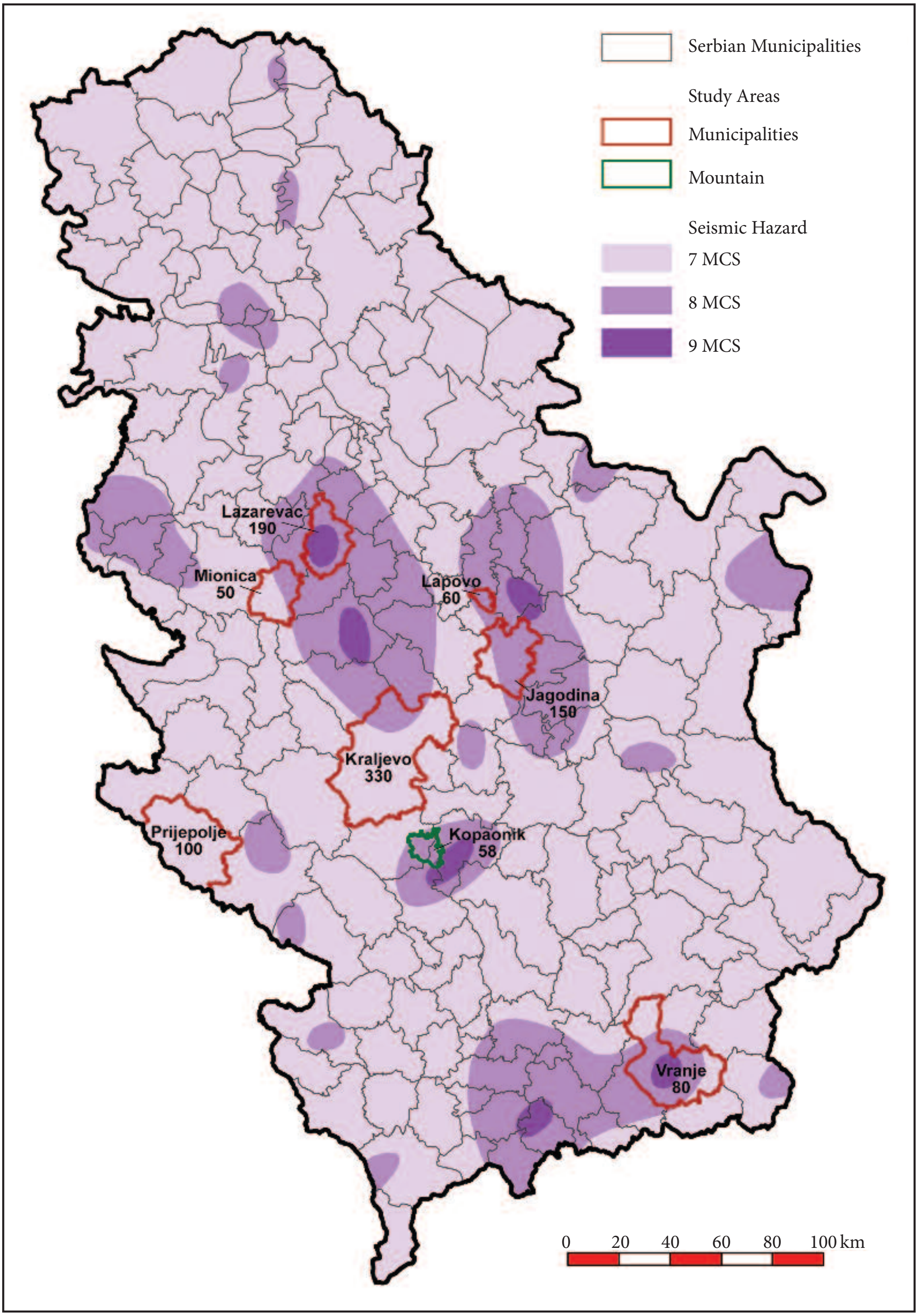

Figure 1: Earthquake intensity zones (hundred-year return period) in Serbia and the number of respondents in the municipalities studied.

3 Methods

Preparedness research investigates individuals' perceived readiness before a disaster event and takes into account all mitigation actions and response behaviors in the aftermath of the emergency (Mulilis and Lippa 1990; Paton 2003). With regard to preparedness, the following dimensions were examined: perceived preparedness and household safety (Dooley et al. 1992; Levac, Toal-Sullivan and O'Sullivan 2012), storage of emergency food and supplies (Baker 2011), knowledge and availability of shelter (Kohn et al. 2012), and special support and assistance (Flynn et al. 1999). A series of 1,018 face-to-face interviews were conducted at the beginning of 2017 in eight of Serbia's 150 municipalities. These communities were chosen with reference to the national map of seismic regionalization of Serbia with a return period of one hundred years (Vukasinović 1987) and their various demographic and social characteristics. The participants in these municipalities were selected randomly, with the number of respondents proportional to their size (0.2–0.9%), thus providing a random selection and a representative sampling approach (Paul and Bhuiyan 2010). The communities where the interviews took place were Kraljevo (330), Lazarevac (190), Jagodina (150), Mionica (fifty), Vranje (eighty), Prijepolje (one hundred), Lapovo (sixty and Kopaonik (fifty-eight; Figure 1). Using a multistage random sample, in the first stage we singled out these communities, and then in the second stage we selected particular streets and parts of the streets. Finally, we selected various households, where the survey was conducted. The respondents were determined based on a random selection procedure of adult household members, where an individual over eighteen was interviewed and presented with a structured questionnaire.

3.1 Survey instruments

A structured questionnaire was set up using a combination of qualitative (close-ended) multiple-choice questions and five-point Likert scales (Joshi et al. 2015). The first part of the questionnaire is related to the demographic and socioeconomic characteristics of the interviewees (e.g., sex, age, and level of education). Subsequent sections included questions relating to perceived preparedness and household safety (variables about household preparedness, community preparedness, geological layers under the house, earthquake-proof houses, reinforced houses, furniture secured to walls, and well-reinforced houses), essential supplies (variables about a prepared emergency kit, examination of the contents of the emergency kit, easy access to the emergency kit, possession of a sufficient emergency stock, and community-stored emergency supplies), shelter (variables about designated shelter nearby, familiarization with the route to the shelter, obstacles on the route to the shelter, alerting neighbors before evacuation, the state of the shelter, and familiarization with the management of shelters), and special support and assistance (variables about special care in cases of disaster, knowledge about situations when the dead and injured are elderly, difficulties in evacuating family members, dealing with the elderly, handicapped, and infants, knowledge about guiding the hearing or visually impaired, and familiarization with kinds of support for the elderly). Each item was rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The items here were developed after consulting several published survey approaches (Mulilis, Duval and Lippa 1990; Matsuda and Okada 2006; Spittal et al. 2006; Ardalan and Sohrabizadeh 2016). A pilot pre–test of the questionnaire was also conducted in Belgrade to check the comprehension and performance of the questionnaire.

3.2 Sample

The interviewees, 46.9% women and 50.1% men (97% fully completed the questionnaire), were representative of the sex stratification of Serbian population, with 51.3% women and 48.7% men. The average age of respondents was 36 (population average: 42.6), and the largest category was those under 36. The sample implies that the majority of respondents had a secondary education (population average: primary 20.76%, secondary 48.93%, and associate's degree 15.1%, according to Statistical Office of the Republic of Serbia). In the household sample, married people accounted for 45% of the sample (population average: single 27.91%, married 55.12%, widowed 11.64%, and divorced 4.93%). The majority of respondents were unemployed (population average: employed 29.3%), and the monthly income at the family level was reported to be up to €750 (population average: €480). The interviewees also had different homeownership statuses: family member (61.1%), owners (29.7%), and rented (8.8%; Table 1).

Table 1: Socioeconomic and demographic information of respondents (number of responders).

Variable and number of respondents	Category	*n*	%
Sex (1,016)	Male	476	46.9
	Female	540	50.1
Age (1,018)	Young (18–38)	564	46.6
	Middle-aged (39–60)	354	34.7
	Elderly (over 60)	100	9.8
Education level (644)	Primary	12	1.2
	Secondary	294	28.9
	Associate's degree	102	10.0
	Bachelor's degree	194	19.1
	Graduate degree	42	4.1
Marital status (786)	Single	294	28.9
	Married	458	45.0
	Divorced	30	2.9
	Widowed	4	0.4
Homeownership (1,014)	Personal	302	29.7
	Family member	622	61.1
	Rented	90	8.8
Employment status (1,014)	Employed	442	43.4
	Unemployed	572	56.2
Monthly family income (€, 1018)	Up to 210	152	14.9
	Up to 420	304	29.9
	Up to 630	382	37.5
	Up to 750	130	12.8
	Over 751	50	4.9

4 Results

4.1 Perceived preparedness and household safety

In terms of preparedness levels, the mean estimate of households' preparedness was 3.02 out of 5, and for the local community 2.76 out of 5. In categorical terms, these mean scores reflect approximately the midpoint on a five-point Likert scale, and in this case endorsement centered around 3, »neither prepared nor unprepared.« Thus, in terms of categorical placement, the highest percentage of respondents said that their household is neither prepared nor unprepared to respond (39.5%), 31.5% stated prepared, and 29.0% said they were unprepared to respond. Focusing on the perceptions of community preparedness and translating the mean score of 3.02 in categorical terms, the largest percentage of respondents (44.0%) reported that the local community is unprepared for reaction, 33.2% stated neither prepared nor unprepared, and 22.8% said they were prepared to respond. The largest percentage of respondents (54.9%) reported having no knowledge of the geology under the house. In terms of buildings being reinforced, 40.0% reported that they do not know whether the buildings are reinforced against an earthquake (Figure 2).

Considering differences in gender roles and responsibilities, males were found to have higher percentages in the following categories: perception that their households were prepared, that the local community was prepared, that they knew what kind of geological layers existed under the house, and that they were more likely to reinforce buildings. In contrast, women were found to have higher percentages in the following areas: they checked their houses for earthquake resilience, reinforced the house, and secured furniture (Table 2).

In terms of age, the results show that, compared to the middle-aged and elderly, young people had higher percentages in the following categories: that the household and local community was prepared, that the house was checked for earthquake resilience, that they secured furniture, and that they reinforced buildings. Compared to middle-aged and young people, elderly people reported higher percentages of awareness about what kind of geological layers were under the house (Table 2).

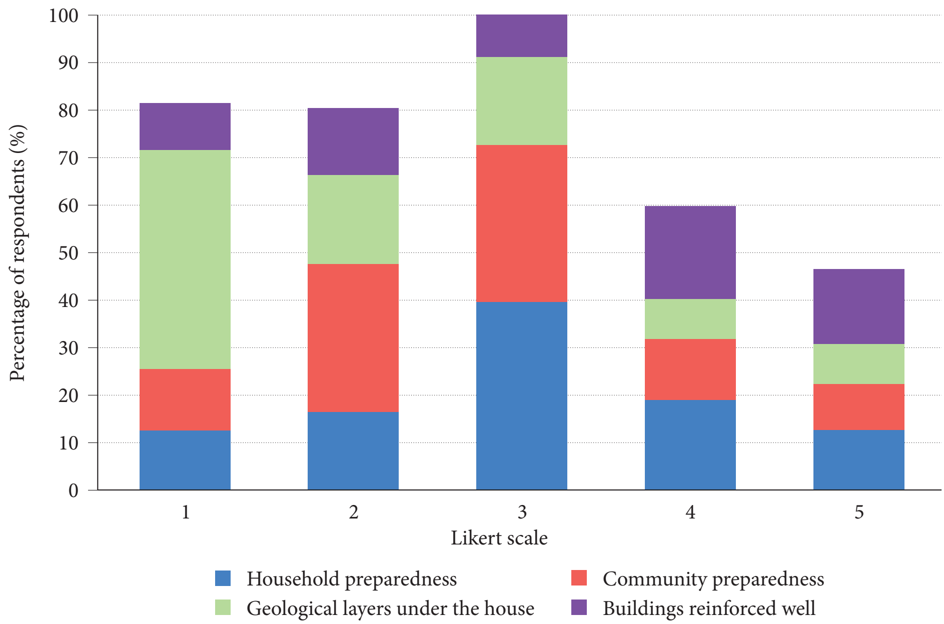

Figure 2: Percentage of respondents and related Likert scale value for perceived preparedness and household safety.

Table 2: Cross-tabulation between sex, age, and perceived preparedness and household safety variables

Variables	Descriptive		Sex				Age				
	M	*SD*	M %	F %	χ^2	*p*	χ^2	Y	MA	E	*p*
Household preparedness	3.02	1.16	32.8	30.0	10.1	**.038***	164.4	45.1	19.0	16.0	**.000****
Community preparedness	2.76	1.13	23.5	21.8	28.6	**.000****	184.5	30.4	14.1	10.0	**.000****
Geological layers under house	2.14	1.30	18.0	14.0	16.0	**.003***	136.1	15.2	26.4	28.0	**.000****
Earthquake-proof house	1.91	0.29	12.6	5.5	15.3	**.000****	39.8	14.8	8.5	2.0	**.000****
Reinforced house	1.29	0.45	64.1	76.7	20.4	**.000****	56.5	75.4	64.2	44.0	**.000****
Secured furniture to wall	1.94	0.36	22.3	8.0	41.7	**.000****	16.5	18.1	17.0	2.0	**.002***
Buildings reinforced well	3.17	1.16	36.7	24.6	15.9	**.003***	159.5	32.3	45.0	30.0	**.000****

Note: M = male, F = female, Y = young, MA = middle-aged, E = elderly.
**Correlation is significant at the 0.01 level (two-tailed).
*Correlation is significant at the 0.05 level (two-tailed).

4.2 Essential supplies

The results of the descriptive statistical analysis in this participant sample indicated that 67% of participants reported preparing an emergency kit, 49% examining the contents of the emergency kit regularly, 62% having easy access to an emergency kit, 37% having emergency stocks, 34% having sufficient stocks, and 40% that their community stored emergency supplies (Figure 3).

Chi-square analyses indicated that higher percentages of men than women reported the following: having easier access to an emergency kit, having emergency stock, and that the community stored emergency supplies. In contrast, a higher percentage of women than men reported the following: preparing an emergency kit, examining the contents of emergency kits, and ensuring stock sufficiency (Table 3). Women were again more active in carrying out preparedness, whereas men were more likely to have favorable perceptions of preparedness.

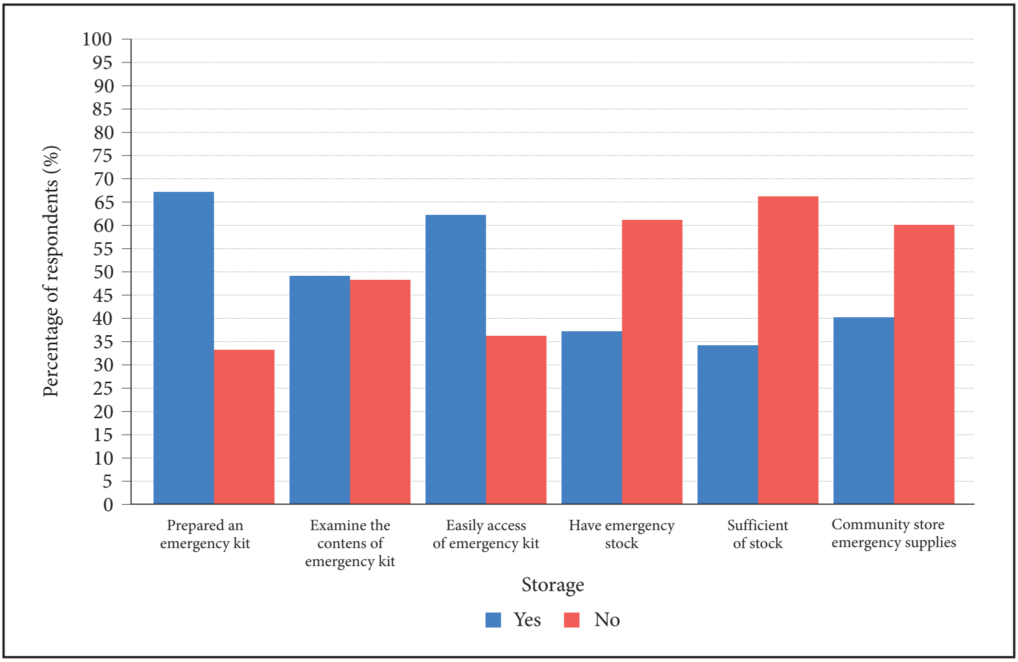

Figure 3: Descriptive statistical analysis regarding essential supplies.

Table 3: Cross-tabulation between sex, age, and essential supply variables

Variables	Descriptive		Sex				Age				
	M	*SD*	M %	F %	χ^2	*p*	χ^2	Y	MA	E	*p*
Prepared an emergency kit	1.33	0.47	61.8	70.7	24.2	**.000****	45.1	39.0	36.0	90.5	**.000****
Contents of emergency kit	1.55	0.50	47.1	52.2	4.6	.096	57.0	54.0	36.0	27.9	**.000****
Easily access of emergency kit	1.37	0.48	66.1	59.9	4.0	**.050***	68.9	64.0	55.1	26.0	**.000****
Have emergency stock	1.62	0.48	41.6	35.1	4.5	**.033***	44.7	28.0	25.0	45.2	**.000****
Sufficient stock	2.11	1.17	7.0	12.6	23.9	**.000****	28.3	44.3	36.7	292.2	**.000****
Communal emergency supplies	1.59	0.49	34.0	46.7	11.7	**.001****	57.8	20.6	17.0	119.6	**.000****

Note: M = male, F = female, Y = young, MA = middle-aged, E = elderly.
**Correlation is significant at the 0.01 level (two-tailed).
*Correlation is significant at the 0.05 level (two-tailed).

This study found that higher percentages of young people reported the following: preparing an emergency kit, having easy access to an emergency kit, having an emergency stock, and that their community stored emergency supplies. In contrast, a higher percentage of middle-aged people reported the following: examining the contents of emergency kits and ensuring stock sufficiency (Table 3).

4.3 Shelter following an earthquake

In terms of sex differences, a higher percentage of males than females reported the following: knowing the route to the shelter, being familiar with the obstacles on the route to the shelter, awareness of the conditions of a provided anticipated shelter, and being familiar with the shelter management. In contrast, and consistent with the pattern of findings thus far on behavior-related sex differences, a higher percentage

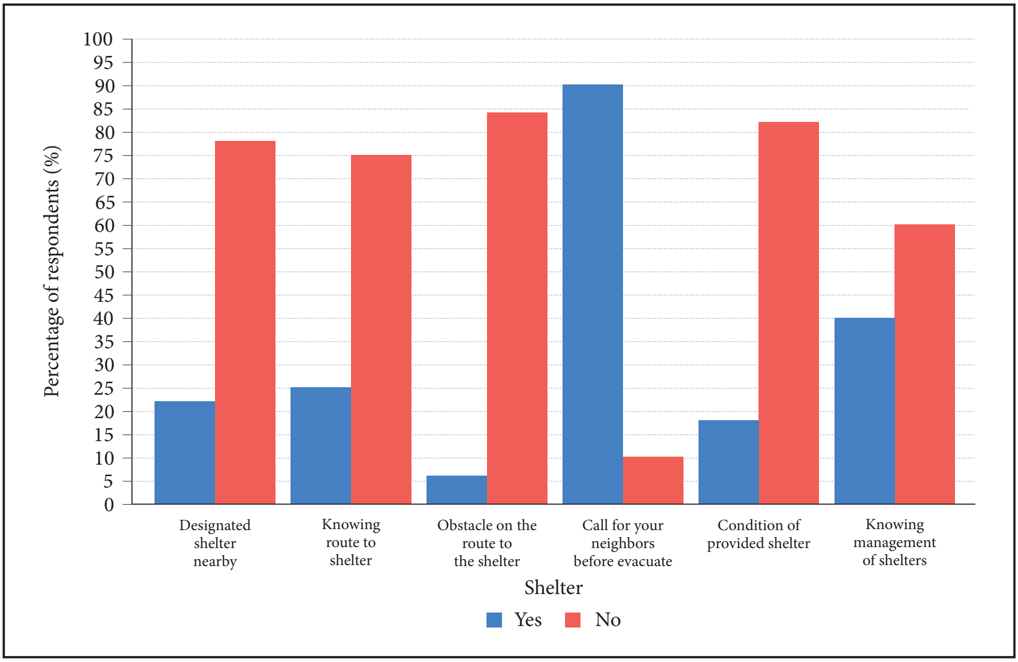

Figure 4: Descriptive statistical analysis regarding shelters.

Table 4: Cross-tabulation between sex, age, and shelter variables

Variables	Descriptive		Sex				Age				
	M	*SD*	M %	F %	χ^2	*p*	χ^2	Y	MA	E	*p*
Designated shelter nearby	1.77	0.41	24.0	21.0	1.91	.166	34.6	31.0	16.9	104.4	.000**
Route to shelter	1.76	0.42	24.8	21.2	13.5	.001**	35.9	30.0	14.0	126.3	.000**
Obstacles on route to shelter	2.61	0.59	6.4	5.2	48.6	.000**	8.4	1.0	4.1	135.2	.000**
Calling neighbors	1.29	1.45	88.0	94.0	31.5	.000**	86.9	97.0	100.0	101.5	.000**
Condition of shelter	1.85	0.98	19.3	18.1	16.6	.002*	28.3	22.2	12.7	0.3	.124
Management of shelters	2.34	2.94	13.0	7.8	51.3	.000**	19.4	1.0	2.5	84.9	.000**

Note: M = male, F = female, Y = young, MA = middle-aged, E = elderly.
**Correlation is significant at the 0.01 level (two-tailed).
*Correlation is significant at the 0.05 level (two-tailed).

of women than men reported that they would call their neighbors before evacuating. Regarding age effects, a higher percentage of young people reported knowing the route to the shelter, having a designated shelter nearby, being aware of obstacles on the route to an anticipated shelter, being aware of the conditions of an anticipated shelter, and being familiar with the shelter management. In contrast, a higher percentage of older adults reported that they would call their neighbors before evacuating (Table 4; Figure 4).

4.4 Support and assistance

Research has found that just under half (44%) could name an individual that would require special care in the event of a disaster. This included 31% of the total sample that reported having knowledge of older adults, the disabled, or infants that might require support and assistance; 26% reported having knowledge

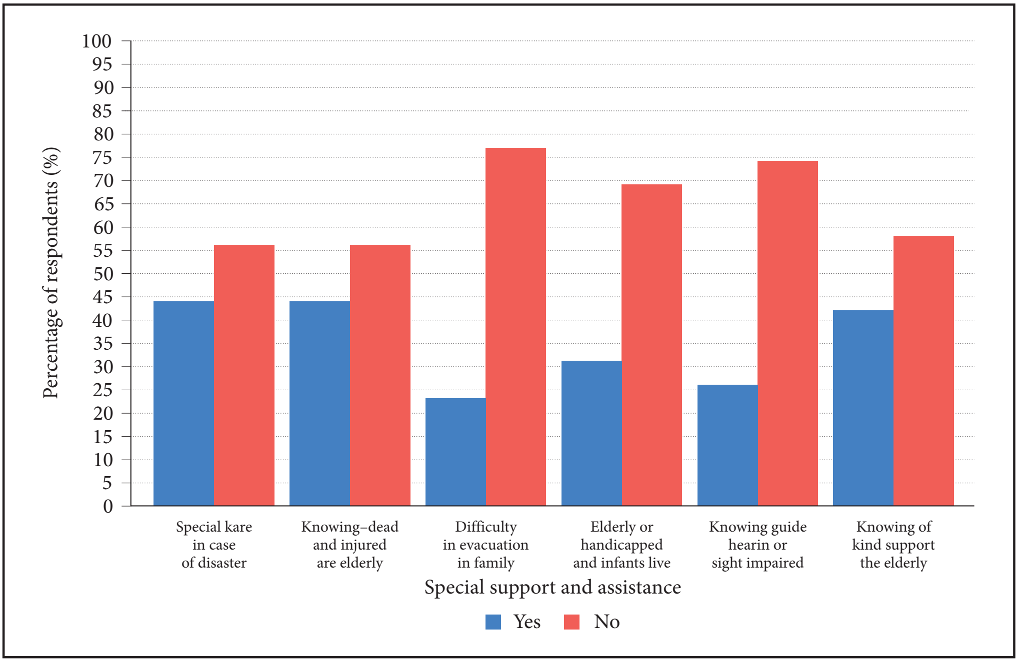

Figure 5: Descriptive statistical analysis regarding special support and assistance.

Table 5: Cross-tabulation between sex, age, and special support and assistance variables

Variables	Descriptive		Sex				Age				
	M	*SD*	M %	F %	χ^2	*p*	χ^2	Y	MA	E	*p*
Special care in a disaster	1.90	0.88	36.0	51.1	57.5	**.000****	51.5	36.8	32.0	54.1	**.000****
Dead and injured elderly	3.39	1.45	38.1	46.0	32.2	**.000****	44.0	41.0	20.0	152.6	**.000****
Difficulty in family evacuation	1.76	0.42	21.3	24.9	8.9	**.030***	21.1	34.0	6.0	61.1	**.000****
Elderly, handicapped, infants	2.75	1.50	34.0	32.0	6.6	.156	26.3	36.8	62.0	0.30	.152
Hearing or visually impaired	2.63	1.50	22.1	29.2	13.3	**.010***	27.0	28.3	46.0	191.2	**.000****
How to support the elderly	3.22	1.41	24.9	47.7	45.9	**.000****	50.1	58.5	32.0	115.6	**.000****

Note: M = male, F = female, Y = young, MA = middle-aged, E = elderly.
**Correlation is significant at the 0.01 level (two-tailed).
*Correlation is significant at the 0.05 level (two-tailed).

of individuals with hearing or visual impairments; and 23% were aware of difficulties related to family evacuation. In terms of other findings here, 42% reported knowing what kind of support is needed by the elderly and 44% knowing that the elderly are more vulnerable to life-threatening injuries (Figure 5).

In terms of sex differences in relation to assistance and support factors, a higher percentage of women than men reported the following: knowing somebody that would need special care in the event of a disaster, anticipating difficulties in family evacuation, and knowing people with hearing or visual impairments that might require assistance. They also reported better knowledge of the kind of support required by the elderly, who are also more vulnerable (Table 5). A higher percentage of young people reported knowing somebody that would need special care in the event of a disaster and knowing that older adults are more vulnerable. A higher percentage of middle-aged people reported anticipating difficulties in family evacuation and being aware of the kind of support older adults might require. Finally, a higher percentage of older adults reported knowing people with hearing or visual impairments that might require assistance (Table 5).

5 Discussion

Many countries have promoted the idea that households should prepare essential survival items, make a plan, improve survival skills, and facilitate people's ability to cope with the consequences of an earthquake (Russell, Goltz and Bourque 1995; Spittal et al. 2008; Becker et al. 2012; Jamshidi et al. 2016). However, a number of national and international studies have shown that levels of earthquake preparedness are generally low (Russell, Goltz and Bourque 1995; Mileti and Darlington 1997; Ronan and Johnston 2005; Azim and Islam 2016). Motivating people to prepare can be a difficult task, and much research has identified specific demographic, socioeconomic, and psychological factors that predict preparedness behaviors (Russell, Goltz and Bourque 1995; Rossi 1990; Paton et al. 2010; Solberg, Rossetto and Joffe 2010; Johnson and Nakayachi 2017; Cvetković, Gačić and Ristanović 2018). Lack of social responsibility (e.g., insufficient insurance policies) can also be a very important factor in the preparedness process (Zorn and Komac 2015).

The findings on the mean estimates of households' preparedness (a somewhat low level) are consistent with some other studies (Russell, Goltz and Bourque 1995; Mileti and Darlington 1997; Spittal et al. 2008; Johnson and Nakayachi 2017). For example, a study about perceptions of earthquake preparedness of households in Saudi Arabia found that residents of Jeddah were mostly not prepared (Azim and Islam 2016). Similarly, this study showed that the highest percentage of respondents said their household is neither prepared nor unprepared to respond. This could be linked to the fact that Serbia does not have education strategies, an awareness program, drills, or a campaign for earthquakes. Devi and Sharma (2015) found that less than half of adults had adequate practice in earthquake preparedness in Nepal. Becker et al. (2012) found that household earthquake preparedness still remains at modest levels despite the importance of preparing (e.g., Napier, Wanganui, & Timaru in New Zealand). Ronan and Johnston (2005) also found that overall levels of earthquake preparation are universally low, including in risk-prone areas (e.g., California, Turkey, and Japan).

Taken together, the results of descriptive analyses showed that the largest percentage of respondents reported that the local community is unprepared for reaction, lacking knowledge about the geological layers under houses and not knowing whether the buildings are reinforced or whether they are earthquake-resistant. Given the overall low levels of preparedness, including relevant knowledge, this points to identification of the factors that can assist emergency management agencies and other disaster risk reduction and safety organizations to tailor communication to enhance knowledge, motivation, and specific preparedness activities. In contrast, in lower seismicity contexts, perceptions are typically lower.

Regarding the effects of sex, the findings in our study are mixed, which is consistent with some previous studies (e.g., Able and Nelson 1990). For example, a higher percentage of men felt that their households were prepared and, in contrast, a higher percentage of women checked their houses for earthquake resistance. The results can be related to certain studies that found that women are less likely to be prepared (Hackl, Halla and Pruckner 2007). Other research and reviews have supported the notion that in many households women often take more responsibility for household matters, including disaster preparedness (Ersing et al. 2015). In Serbia, men traditionally perform more physical labor, which may then have implications for household and community preparedness (Pešić 2006). On the other hand, women are traditionally seen as housekeepers and childminders. Such findings, of course, have implications for preparedness communication, including specific guidance coupled with the notion of both women and men working together in household and community terms and possible enhanced effects of balancing levels of preparedness with reality. In addition, this combination of findings has implications for both planning shelters and preparedness communication within the community (Woersching and Snyder 2003; Liu, Ruan and Shi 2011).

Compared to middle-aged and elderly people, young people perceived the preparedness and household safety in a different way. These results are consistent with a previous study by Sattler, Kaiser, and Hittner (2000), which found a positive relationship between older age and personal disaster preparedness. Research has also found that older adults are typically more emotionally resilient to the effects of natural disasters, compared to younger people (Heller et al. 2005). Compared to middle-aged and young people, a higher percentage of elderly people also reported awareness of what kind of geological layers lie under the house. Based on this, it can be assumed that older people mostly built their own houses and as a result are more familiar with the characteristics of the area or have a fear of earthquakes.

Reasons for this may be previous experience, both general life experience as well as having experienced and coped with previous hazard events (Norris et al. 2002). Given this range of findings, emergency communication and education that features a cooperative, participatory approach may then benefit from the relative strengths and tendencies seen within different age cohorts.

Generally, the reasons for engaging in initial and sustained preparedness include people reporting a desire to be prepared and, over time, to keep their supplies fresh and/or in working order in case they have to use them. Protection motivation theory (Maddux and Rogers 1983) and theory of planned behavior (Ajzen 1991, 2011) may be used as a framework for understanding various preparedness behaviors. People that do replenish their emergency supplies report wanting to ensure they have safe drinking water and food (Page et al. 2008; Kapucu 2008; Becker et al. 2012). There are groups within any community that may require additional support and assistance following an earthquake (Tanida 1996; Matsuda and Okada 2006; WHO 2008; Cvetković, Milašinović and Lazić 2018). Often, however, marginal groups are not considered in disaster planning (Heller et al. 2005; Zorn 2018). In an urban area, earthquakes have been found to cause especially heavy damage to the inner-city housing of low-income people and the elderly (Hirayama 2000). This idea is buttressed by our findings that just under half could name an individual that would require special care during a disaster.

6 Conclusion

Taken together, this study contributes new information that can be used to assist in local and national emergency management communication to improve household earthquake preparedness. The fact that a relatively low number of participants in this study reported perceptions, knowledge, or actual preparedness behaviors suggests complacency in terms of earthquake prevention, mitigation, and preparedness in particular, and, in our opinion, low general readiness for a range of hazards. The importance of focusing on human risk perceptions, decision-making, and behavior processes in preparedness is a focal point of this study. Knowledge about the differences between social groups in terms of socioeconomic characteristics such as sex and age or health status is a precursor to tapping into the cognitive, emotional, and behavioral functioning of individuals in relation to prevention, mitigation, and preparedness for earthquakes and other hazards. Thus, these findings suggest demographic profiles in which some have relative strengths. A prominent example across the categories examined is that women reported more actual behavioral preparedness whereas men reported more perceptions and knowledge. Limitations of this study include the fact that the findings presented are mainly descriptive. Future research should evaluate not only individual factors, but also social and community factors. At the same time, the sample was reasonably large and as such it offered initial basic findings that can promote more detailed future investigations. Such future research should examine the factors that affect the preparedness for earthquakes and other events, and factors improving preparedness, including more psychological (e.g., self-efficacy and behavioral intentions) and social (e.g., collective helping) constructs. Such information might then be used as a starting point to design programs to improve household preparedness for earthquakes and other hazard events. A critical issue in emergency management education and communication is how to help a population, including those with increased vulnerability, and knowing how to respond during an earthquake to protect oneself and others. One international initiative, ShakeOut (Internet 1), could be used to help people not only learn more about protecting themselves effectively during an earthquake, but also to facilitate more effective preparedness. This initiative was used to assist over fifty-five million people more effectively prepare for earthquakes in 2016. In addition, it can be used for more extensive disaster risk reduction and education in classrooms (e.g., Johnson et al. 2014) and community settings (e.g., a national effort carried out regularly in New Zealand; Internet 2).

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SPATIAL CONFLICTS: ANALYZING A BURDEN CREATED BY DIFFERING LAND USE

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Land use in the typical landscape of Warmia and Mazury in Poland.

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Spatial conflicts: Analyzing a burden created by differing land use

ABSTRACT: The article proposes a procedure for determining the location of potential spatial conflicts. The author presents issues concerning spatial conflicts which may arise as a result of different uses of spaces adjacent to each other. The proposed procedure has been tested on one of the districts of Poland's Warmińsko-Mazurskie Voivodeship, namely Nidzicki District. In order to determine the use of the space, CLC databases made available by the Chief Environmental Protection Inspectorate were used. Based on them, the use of fragments of space, which were also differentiated due to their natural value, was determined. For the thus described space, a map of burden of potential spatial conflicts was compiled. The proposed method may be used as a tool supporting the processes of space planning and monitoring the environmental changes.

KEY WORDS: spatial planning, spatial structure, spatial conflicts, uses of spaces, CLC, natural value

Prostorski konflikti: Analiza bremena, ki nastane zaradi različne rabe prostora

POVZETEK: V članku avtorica predlaga postopek za določanje lokacije morebitnih prostorskih konfliktov. Predstavi vprašanja, povezana s prostorskimi konflikti, ki lahko nastanejo zaradi različne rabe sosednjih prostorov. Predlagani postopek je avtorica preizkusila na primeru okrožja Nidzica v Varminsko-mazurskem vojvodstvu na Poljskem. Za določitev rabe prostora je uporabila podatke CLC (Corine Land Cover), ki jih je pridobila od glavnega poljskega okoljevarstvenega inšpektorata. Na podlagi teh podatkov je določila rabo posameznih delov proučevanega prostora, ki jih je ločila tudi glede na njihovo naravno vrednost. Za tako analizirani prostor je sestavila zemljevid bremen morebitnih prostorskih konfliktov. Predlagana metoda se lahko uporablja kot podporno orodje pri postopkih prostorskega načrtovanja in spremljanja okoljskih sprememb.

KLJUČNE BESEDE: prostorsko načrtovanje, prostorska zgradba, prostorski konflikti, raba prostora, CLC, naravna vrednost

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1 Introduction

Conflicts are a common phenomenon which always occurs between at least two entities, of which one strives to achieve benefits for themselves at the expense of the other party without its approval (Braun and Wimmer 2013). The notion of a conflict can be seen in various aspects, e.g. as a social, economic process in which one of the entities strives to achieve their own goals by either eliminating the other party of the conflict or establishing own domination over it. It should be noted that the above contradiction does not have to be real, and may result from the involved parties' conviction that the other party displays a hostile attitude (Kieslich and Hilbig 2014).

A conflict cannot exist if certain conditions distinguishing it from normal competition having no negative overtone are not satisfied. These conditions include:

- The existence of at least two parties;
- The main source of a conflict is the scarcity of goods;
- Conflict behaviour is aimed at either destroying the other party or at least establishing domination over it;
- Actions of the parties of a conflict are mutually opposed;
- An important aspect of conflict relationships is power;
- Conflict relationships are a social process, and have serious social consequences;
- Conflicts are characterised by a temporary tendency towards a split in relationships between the parties;
- Conflict relationships result in a change to expectations and standards prevailing in the existing system (Mack and Snyder 1957).

The first five of the above eight conditions are considered by the authors to be the main characteristics of the phenomenon in question.

In order to identify both the existing and possible future conflicts, it is crucial to determine potential sources of conflicts. Their basic categories were systematised by Bogetoft and Pruzan (1991). These authors conclude that conflicts may arise from one or several various factors which can be divided into four basic groups:

1 »Value system« factors:
- The parties have different values and aims;
- The parties take different measures to represent their aims;
- The parties have different preference hierarchies (e.g. different weights for different solutions).

2 »Effect distribution« factors:
- The parties may incur different costs and achieve various indirect benefits associated with the expected effects of actions;
- Breakdown of costs and benefits is perceived as uneven and unfair.

3 »Uncertainty« factors:
- The parties do not agree to the probable effects of an action;
- The parties are not certain of the effects of actions;
- The evidence and rationale as regards the benefits of the effects of actions may be insufficient or incomprehensible;
- The parties may have doubts about the relations between the effects of an action and different actions.

4 »Process« factors:
- The parties have difficulties in communicating with one another in terms of presenting one's values, aims, criteria, preferences, and expectations.

All these factors have a common denominator which is manifested by the contradictory actions of the entities, with each action located in the space. A significant percentage of conflict subjects are directly or indirectly associated with the space. The conflicts in which this relationship is direct are referred to as *spatial conflicts*. In terms of theoretical bases, spatial conflicts do not differ from the general concept of this phenomenon. They only set out the subject of a conflict, which always is the space. Usually, a source of spatial conflicts is the occurrence, within a particular area, of many different possibilities for the management and/or many various interests and aims, also those associated with the use of environmental goods (Wehrmann 2008; Bob and Bronkhorst 2011).

Given the subject, spatial conflicts are of interest to spatial economy, including spatial planning (Bergstrom, Goetz and Shortle 2013). Spatial planning is a complex process. In most cases, it is associated with numerous expectations, high uncertainty level, and always a certain degree of a conflict (Alston, Libecap and Mueller 1999). Therefore, understanding the expectations, uncertainties and conflicts is necessary to reflect upon the way to improve the current planning practices (Domingo 2009; Nolon, Ferguson and Field 2013).

The planning process is usually perceived as less important than the development process (Smrekar, Hribar and Erhartič 2016). It should be borne in mind, however, that the role of a plan may be perceived as a »meeting point« for various, sometimes contradictory views, and as a framework for taking joint decisions (Hopkins 2001). Therefore, it is extremely important to identify potential spatial conflicts as early as at the planning stage. Minimisation of the probability of their occurrence leads to achieving sustainable development (Markuszewska 2018).

The main conflicts in achieving such development exhibit functional and economic, socio-cultural, or natural and ecological characteristics (Abdelgalil and Cohen 2007). Functional and economic conflicts result from the simultaneous occurrence of factors focusing and defocusing various functions of the space, which may lead to imbalance in the management (Glasson and Marshall 2007; De Groot 2006). They are usually associated with a significant disproportion in the development of adjacent areas, and thus tendencies towards excessive concentration (e.g. in towns and cities), and, at the same time, the establishment of peripheral, underdeveloped areas (Coppens 2011).

Social and cultural conflicts are associated with contradictory aspirations of managing entities as regards the use of the space (Hite 1998; Brown and Raymond 2014). Most often, these are conflicts associated with the existence or development of infrastructure, with opposition from local communities to unfavourable changes in their immediate vicinity (von der Dunk et al. 2011). A conflict situation may also arise from an opposite situation e.g. when local communities aim at the expansion of a certain type of infrastructure, and supra-local social groups benefiting from the use of the space in the existing state oppose to these aims.

A typical example of spatial conflicts are natural and environmental conflicts arising from the clash of the need for economic development and the necessity to protect the values of the natural environment (Young et al. 2005; Kennedy 2017). Such a division of conflicts is neither closed nor sharp. In many cases, these conflicts have characteristics of various groups listed in this paper. They are both social and economic conflicts, etc. (Braun and Wimmer 2013).

As has been emphasised, spatial conflicts are associated with a specific use of the space, and frequently arise from nothing else but the use of the space, or from the desire to change its use. At the stage of planning the management of the space, it is very important to recognise the fragments of the space where the probability of the occurrence of conflicts may be high (Biłozor and Renigier-Biłozor 2015). One of the factors to be analysed while searching for such spaces is an analysis of the variety of uses, and the identification of extremely different forms of the use of adjacent areas.

One of the stages in the procedure for determining the interaction of areas with different forms of use is to refer to their natural value. There are several methods for carrying out such an assessment. It may be carried out by expert research conducted directly in the field inventory of the area through fieldwork (Leedy and Ormrod 2005; Hrvatin and Perko 2008), or in-house inventory based on existing documentation of the land (Strumiłło-Rembowska, Bednarczyk and Cieślak 2014) or its aerial and satellite photographs (Joshi, de Leeuw and van Duren 2004). This is the most precise yet very laborious method, which is worth to follow for the purposes requiring research of great precision, carried out within a small area. Expert research may also concern the model of land i.e. maps and related documentation, providing knowledge of the value of the area. The assessment is based on in-house inventory of the area based on the existing documents (Figure 1). One of the ways to determine such a value is to use the existing soil valuation assessments of the natural value of an area, associated with its uses. This method is definitely less precise yet sufficient for achieving many research objectives, including those associated with spatial planning. Moreover, it provides a possibility for conducting analyses to people who are not experts in biological sciences.

An important stage of the analysis is to determine the relationships between adjacent areas, from which spatial conflicts may arise. These relationships may be determined using a description. However, for the needs of statistical analyses, and in order to simplify the inference process, the desired form is a numerical form. A reference to the steps described can be found in Figure 1.

The main objective of the research presented in the paper was to establish a procedure for identifying areas with high potential for spatial conflicts, referred to as land's burden. An important step in the work was the verification of the proposed procedure with the selected area as an example.

2 Methods

Monitoring the use of the space and the changes of occurring in this is became easier when spatial information bases began to be established. CLC (CORINE Land Cover) belongs to one of such bases.

The CORINE project (CO-ordinate of Information on Environment – Land Cover) was launched on the initiative of the European Community in 1985. In 2001, Chief Environmental Protection Inspector decided to incorporate Poland into the project (Cieslak, Szuniewicz and Czyża 2016; Corine Land Cover 2018).

The established database contains information on both the land cover and the land use. In the CLC, forms of land cover are hierarchically divided into three levels (Ciołkosz and Bielecka 2005). According to the CLC legend, five basic forms of land cover are distinguished (Table 1).

Table 1: Detailed expansion of land use forms in CLC (Internet).

LEVEL I	Description	LEVEL II
1 ARTIFICIAL SURFACES	Built-up areas used for residential, service, industrial or mining purposes, and green urban areas	1.1 Urban fabric 1.2 Industrial, commercial and transport units 1.3 Mine, dump and construction sites 1.4 Artificial, non-agricultural vegetated areas
2 AGRICULTURAL AREAS	Agricultural areas, permanent crops, meadows and pasture land as well as wooded land and bushland used for agricultural purposes	2.1 Arable land 2.2 Permanent crops 2.3 Pastures 2.4 Heterogeneous agricultural areas
3 FOREST AND SEMI-NATURAL AREAS	Areas covered with forest vegetation, or partially deprived thereof	3.1 Forests 3.2 Scrub and/or herbaceous associations 3.3 Open spaces with little or no vegetation
4 WETLANDS	Inland bogs, peatbogs, salt marshes, salines, and tidal marshes	4.1 Inland wetlands 4.2 Marine wetlands
5 WATER BODIES	Inland waters and marine waters	5.1 Inland waters 5.2 Marine waters

This paper uses data with the degree of generalisation to the 2nd CLC level. The data provided a basis for land with specific use within the area under study.

The main objective of the study was to establish a load factor for conflicting areas. The developed indicator was made dependent on the natural values of adjacent areas with different uses. The identification of areas with high potential for spatial conflicts was defined in the procedure whose diagram is provided in Figure 1.

The first stage of the procedure is to establish the limits of various forms of land use. This stage can be passed through using several methods. The most obvious appear to be field inventory, analysis of formal and legal documentation, and the use of currently broadly developed Geographical Information System databases. One of such bases is the CLC.

The second stage of research work required the differentiation of the natural values of areas with different uses. Compensation indicators which are used in the Federal Republic of Germany to determine the amounts of compensation for changes to the space use, were applied (NatSchAVO 1995). As part of the Saxony's environmental protection law, a compensation procedure aimed at both stopping the pointless degradation of the environment and ensuring high natural quality of the space was developed (SMUL 2009). As part of that procedure, on the basis of research into biodiversity and physical characteristics of the space, a scale of land assessment, assigned to specific forms of its cover, was developed (Cieślak, Szuniewicz and Gerus-Gościewska 2013). It organises the quality of an area based on the natural value, and specifies differences or proportions between the values of areas with different uses. The indicator (*ix*) taken from the planning system of Saxony, marked for the needs of the study as *ix*, are a simplified assessment of the quality of natural environment which result from the use of that space. The assessment in question (Table 2) may be useful while preparing a simplified assessment of the environmental value of the space; however, it should be borne in mind that it is based on a very simplistic approach, and its results are only illustrative.

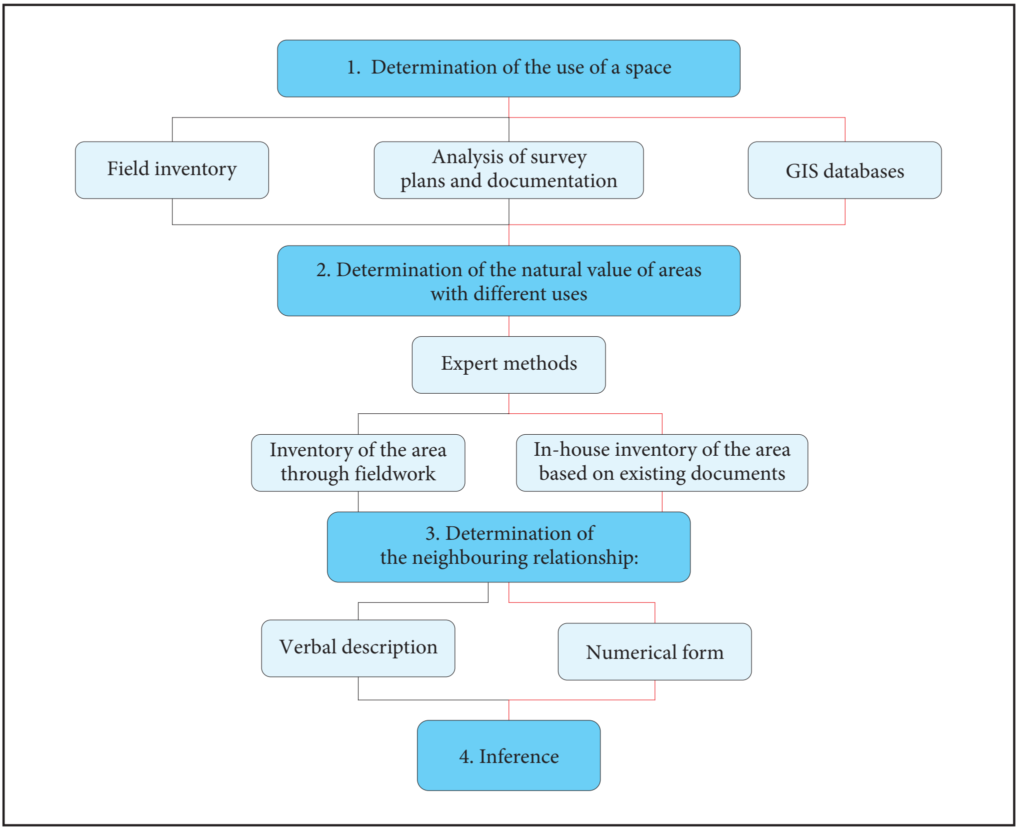


Figure 1: Two different concepts in analysing and procedure for the determination of the burden of potential conflicts within the space under study.

Table 2: The value of the environmental coefficient.

Category of land	Land use	Coefficient *ix*	CLC
A0	Built-up area, impervious to water (roads, buildings, paved areas)	0.10	1.1; 1.2; 1.3
A1	Permeable surfaces, areas of greenery around buildings	0.10	– -
A2	Areas of greenery in residential quarters, allotments, orchards, greens	0.20	1.4
A3	Intensively cultivated agricultural land (arable land)	0.30	2.1
A4	Other intensively used areas (orchard plantations)	0.40	2.3; 2.4
A5	Watercourses and standing waters with a poor natural structure (regulated watercourses, fish farming ponds), including riparian and shallow-water vegetation and open spaces with little or no vegetation	0.50	2.3; 3.3
A6	Forest areas with an unnatural tree species composition, shrub vegetation communities	0.60	3.2
A7	Extensive land use areas (e.g. extensive grassland, extensive vineyards, areas which can be intensively cultivated in the long term), or succession areas	0.70	2.2
A8	Forest areas with a natural tree, forests on an open space, green areas with old trees, parks, pedestrian pathways, single trees	0.80	3.1
A9	Flowing and standing waters with a rich natural structure	0.90	5.1; 5.2. 4.1; 4.2
A10	A biotope as defined by environmental protection regulations (National Parks, nature reserves)	1.00	–

However, the use of such a grading scale may provide a basis for determining the location of many spatial phenomena, including the location of potential spatial conflicts (Cieślak 2012).

The assessment presented in Table 2 was transformed to include the forms of land cover available at the 2nd level of the CLC database (Cieślak et al. 2017).It was necessary to supplement both lists so that all forms of land cover could be evaluated during the analysis. Protected areas are not included in the CLC inventoried forms of land cover. Such an inventory is not possible with the use of an orthophotomap on which the CLC is based.

The 3rd stage of research work required the determination of relationships between adjacent areas, which could indicate an adverse interaction. For the purposes of the study, a conflict matrix was developed (Figure 2), which presents theoretical intensity of the contradiction in the use of a space marked as P^0_{Kp}. This contradiction may determine the occurrence of spatial conflicts for adjacent areas. The value of the indicator was calculated as a ratio of *ix* of a lower value to *ix* of a higher value for adjacent fields. Conditions for the calculation of particular matrix values are provided in the following equation:

$$If\ ix_i < ix_n\ then\ P^0_{Kpn} = \frac{ix_n}{ix_i}$$

$$If\ ix_i > ix_n\ then\ P^0_{Kpn} = \frac{ix_i}{ix_n}$$

where:
P^0_{Kpn} – an indicator of the intensity of a potential conflict between areas *i* and *n*,
ix_i – value of *ix* for field *i*,
ix_n – value of *ix* for field *n*.

The conflict matrix is a symmetric matrix. The indicator values presented in the matrix may range from 1.00 to 10.00. At a value of 1.00, the burden of a potential conflict does not, in principle, exist. When P^0_{Kp} is equal to 10.00, the neighbourhood of an area is extremely contradictory to its natural value, which may generate spatial conflicts. The developed matrix is a theoretical matrix which can be used universally. In the presented study, the values of P^0_{Kp} indicator may only range from 1.00 to 9.00. This results from no possibility of identification based on the CLC data concerning protected areas with *ix* equal to 1.00.

The values found in the matrix were divided into three classes of intensity of potential conflicts. The first class comprises areas for which the mutual neighbourhood results in a hazard of the occurrence of spatial conflicts at a minimum level (values ranging from 1.00 to 1.50). The second class of values was determined for areas with a medium level of the hazard of the occurrence of conflicts due to their mutual neighbourhood (values ranging from 1.60 to 3.50). The third class was determined for the values with high probability of the occurrence of spatial conflicts due to the extremely different natural values of the adjacent areas (values ranging from 4.00 to 10.00).

Based on the conflict matrix, real values of the burden of occurrence of spatial conflicts P_{Kp} were determined, which, in addition to the immediate neighbourhood of areas with different uses, takes their surface into account. P_{Kpi} for a selected area *i* is equal to the ratio of the sum of products of the surface of *N* areas adjacent to it, and the product of indicators *ix* consistent with the form of use of area *i* and areas *n*, to the total surface of areas *n* adjacent to *i*:

$$P_{Kpi} = \frac{\sum_{n=1}^{N} P^0_{Kpn} \cdot P_n}{\sum_{n=1}^{N} P_n}$$

where:
P_{Kp} – external burden of a spatial conflict;
i – the area of use under study;
n – the number of the area adjacent to area *i*;
N – number of the areas of use adjacent to area *i*;
P_n – the surface of the *n*-th area adjacent to area *i*;
ix – indicator of the natural value of area *i* or *n*.

Figure 2: The conflict matrix of the contradiction in the use of a space. ➤ p. 50

ix		1.00	0.90	0.90	0.80	0.80	0.70	0.60	0.50	0.40	0.40	0.40	0.30	0.20	0.10	0.09	0.09
	clc	**6,0**	**5,2**	**5,1**	**4,2**	**4,1**	**3,1**	**3,2**	**3,3**	**2,4**	**2,3**	**2,2**	**2,1**	**1,4**	**1,3**	**1,2**	**1,1**
1.00	**6,0**	1.00	1.11	1.11	1.25	1.25	1.43	1.67	2.00	2.50	2.50	2.50	3.33	5.00	10.00	10.00	10.00
0.90	**5,2**	1.11	1.00	1.00	1.13	1.13	1.29	1.50	1.80	2.25	2.25	2.25	3.00	4.50	9.00	10.00	10.00
0.90	**5,1**	1.11	1.00	1.00	1.13	1.13	1.29	1.50	1.80	2.25	2.25	2.25	3.00	4.50	9.00	10.00	10.00
0.80	**4,2**	1.25	1.13	1.13	1.00	1.00	1.14	1.33	1.60	2.00	2.00	2.00	2.67	4.00	8.00	8.89	8.89
0.80	**4,1**	1.25	1.13	1.13	1.00	1.00	1.14	1.33	1.60	2.00	2.00	2.00	2.67	4.00	8.00	8.89	8.89
0.70	**3,1**	1.43	1.29	1.29	1.14	1.14	1.00	1.17	1.40	1.75	1.75	1.75	2.33	3.50	7.00	7.78	7.78
0.60	**3,2**	1.67	1.50	1.50	1.33	1.33	1.17	1.00	1.20	1.50	1.50	1.50	2.00	3.00	6.00	6.67	6.67
0.50	**3,3**	2.00	1.80	1.80	1.60	1.60	1.40	1.20	1.00	1.25	1.25	1.25	1.67	2.50	5.00	5.56	5.56
0.40	**2,4**	2.50	2.25	2.25	2.00	2.00	1.75	1.50	1.25	1.00	1.00	1.00	1.33	2.00	4.00	4.44	4.44
0.40	**2,3**	2.50	2.25	2.25	2.00	2.00	1.75	1.50	1.25	1.00	1.00	1.00	1.33	2.00	4.00	4.44	4.44
0.40	**2,2**	2.50	2.25	2.25	2.00	2.00	1.75	1.50	1.25	1.00	1.00	1.00	1.33	2.00	4.00	4.44	4.44
0.30	**2,1**	3.33	3.00	3.00	2.67	2.67	2.33	2.00	1.67	1.33	1.33	1.33	1.00	1.50	3.00	3.33	3.33
0.20	1,4	5.00	4.50	4.50	4.00	4.00	3.50	3.00	2.50	2.00	2.00	2.00	1.50	1.00	2.00	2.22	2.22
0.10	1,3	10.00	9.00	9.00	8.00	8.00	7.00	6.00	5.00	4.00	4.00	4.00	3.00	2.00	1.00	1.11	1.11
0.10	1,2	10.00	10.00	10.00	8.89	8.89	7.78	6.67	5.56	4.44	4.44	4.44	3.33	2.22	1.11	1.00	1.00
0.10	1,1	10.00	10.00	10.00	8.89	8.89	7.78	6.67	5.56	4.44	4.44	4.44	3.33	2.22	1.11	1.00	1.00

An example of the arrangement of adjacent fields is presented in Figure 3. The Figure is linked to Table 3. The Table also contains subsequent calculations which enable the determination of the final value P_{Kpi} for field No 7 ($i = 7$), and for field No 324 ($i = 324$) (Figure 3).

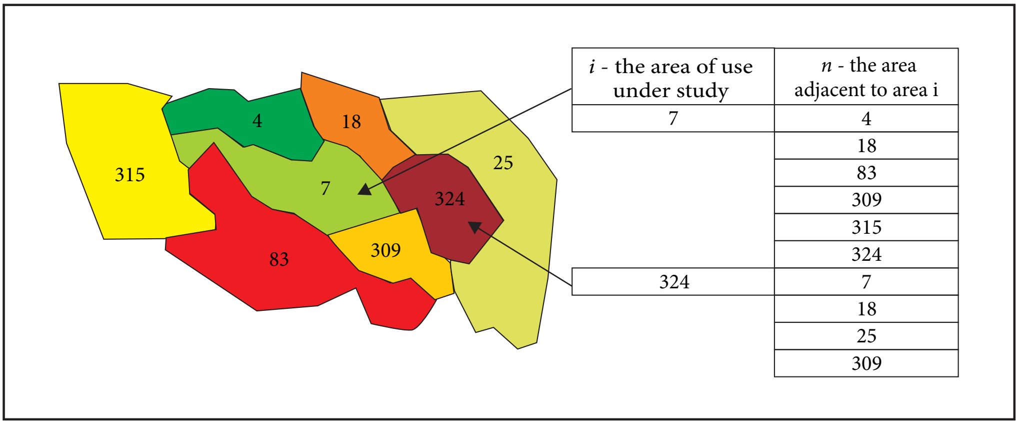


Figure 3: An example of the adjacency defined for fields No 7 and 324.

Table 3: An example of the calculation of the value P_{Kpi} for fields No 7 and 324 (Figure 3).

i	ix_i	N	n	ix_n	P_n	P^0_{Kpn}	$P^0_{Kpn} * P_n$	$\sum_{n=1}^{N} P^0_{kpn} \cdot P_n$	$\sum_{n=1}^{N} P_n$	P_{Kpi}
7	0.6	6	*4*	0.8	30.80	1.33	41.07	695.75	239.76	2.90
			18	0.3	17.08	2.00	34.16			
			83	0.4	63.49	6.00	380.94			
			309	0.4	27.11	1.50	40.67			
			315	0.5	58.29	1.20	69.95			
			324	0.3	42.99	3.00	128.97			
324	0.5	4	7	0.6	56.24	3.00	168.72	419.36	168.75	2.48
			18	0.3	17.08	1.50	25.62			
			25	0.5	68.32	2.50	170.80			
			309	0.4	27.11	2.00	54.22			

In this way determined indicator indicates the intensity of contradiction in the use of adjacent areas. If these are areas of high natural values, the impact of adjacent areas with more intense pattern of use needs to be mitigated.

The procedure described was tested within the area of Nidzicki District situated in Warmińsko-Mazurskie Voivodeship. The district covers an area of 961 km^2. This is a very interesting area as in addition to its significant natural values, it is a rapidly developing administrative unit of the voivodeship.

ArcGis software tools were used to complete the calculation stages, and to present the analysis results.

3 Results

The Nidzicki District belongs to the Mazurian Lake District. The area is characterised by a hilly landscape with numerous post-glacial lakes, and heavily wooded. Because of the natural and cultural assets, many nature reserves and landscape parks have been established within the district. On the other hand, the district has many attributes conducive to the development of the economy. The area is very well connected internally. Economic entities operate there in the trade, service, and manufacturing sectors, yet it is agriculture that is the main branch of the economy. Due to the natural and economic determinants, the spatial structure of the district is very varied, and susceptible to spatial conflicts. In accordance with the proposed procedure, 411 areas with various uses consistent with the 2nd CLC level were identified within the district. Their area varies from 0.25 m^2 to 4327.31 m^2. Based on the analysis of the cover of these areas, natural values *ix* were assigned to them in accordance with the rule provided in Table 2. Even though the area under study includes protected areas, it was possible to assign the maximum value of 0.9 to them based on the forms of land cover identified using the CLC.

The results of this operation are presented in a chorogram (Figure 4).

The chorogram indicates intensely used locations (shades of red) indicate those used by humans, which are mainly located in the urbanised space. It can also be noted that within the area under study, many naturally valuable areas are located (shades of green).

In the next step, for each of 411 areas marked as *i*, areas which are directly adjacent to them were identified (*n*). Based on the data, indicator P_{Kp} was calculated for each area. This indicator illustrates the area's burden of potential spatial conflicts resulting from different uses of the adjacent areas, with account taken of their surface. The value of indicator P_{Kp} within the area under study ranged from 1.00 to 8.00. An average value for the area is 2.07 at a standard deviation of 1.14.

The values of the indicator were classified in accordance with the procedure presented in the Methods. The thus calculated area's burden of the occurrence of conflicts for all fields enabled the development of a chorogram of the potential occurrence of spatial conflicts for the area under study (Figure 5).

An analysis of the chorogram provides a possibility for the identification of areas with high potential for spatial conflicts (3rd class) as well as areas for which such a hazard does not exist (1st class).

For 411 analysed areas, the indicator values were ranging from 1.00 to 8.00. They were divided into three classes in accordance with the adopted procedure described in section 2. In class 1, for which the burden of conflict is not significant, 127 areas are included. 79 of them are such areas for which the values of indicator *ix* took values of 0.4, 0.5, and 0.6. Therefore, their natural value is average. For 48 areas of this class, indicator *ix* is very high (0.8, 0.9).

In the second class, 272 areas are included. In this class, the differentiation of the natural value was high. The areas were described by indicator *ix* within a range from 0.1 to 0.9.

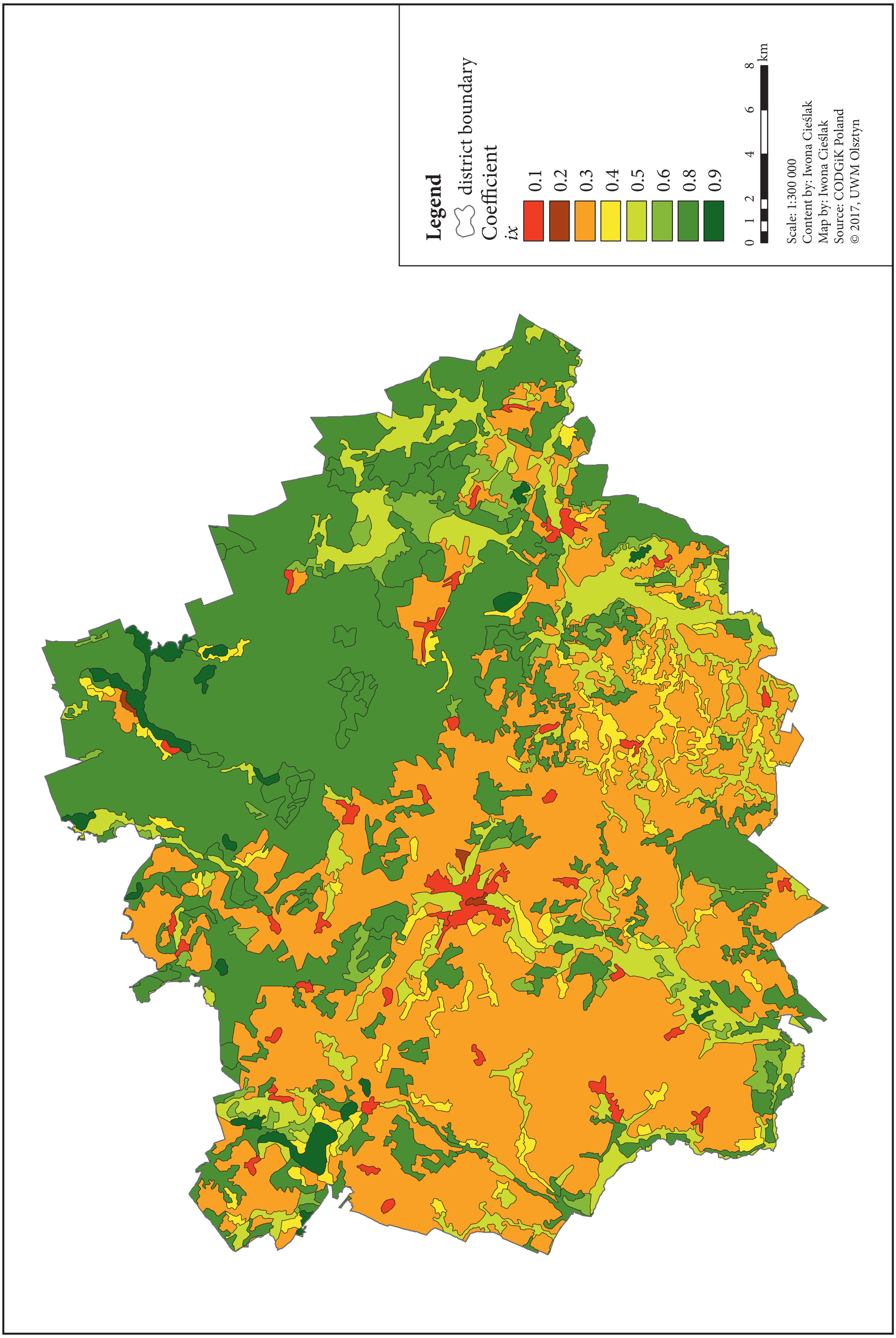
The smallest class in terms of numbers was the third class including only 13 areas. An interesting fact is that all of them have a relatively small surface area, and a very low natural value. All of them are described with indicator *ix* having a value of 0.1.

4 Discussion

While pursuing the main aim of the research, which was to establish a procedure for identifying areas with high potential for spatial conflicts, referred to as land's burden, a study was conducted, which enabled the establishment of a procedure for identification of the location of potential spatial conflicts resulting from the proximity of different forms of space use. To this end, the index of external burden of a spatial conflict P_{Kp} was determined.The obtained results confirm that the CLC can be used to identify potential spatial conflicts resulting from the immediate vicinity of areas with adverse impact. An important advantage of these data is their universal nature. These data have a uniform structure and present large areas. This makes the analysis results comparable for various areas and on variety of scales. However, their significant disadvantage is their low validity (the latest data are for 2012), and limitations resulting from the method of obtaining these data (orthophotomaps). While using such results it should be borne in mind, that the databases obtained based on satellite images do not contain information on the legal aspects of land use. Therefore, the obtained results cannot indicate conflicts concerning areas which are e.g. legally protected.

We can conclude that the space in question is relatively well used. This is evidenced by the average value of indicator P_{Kp} obtained for the entire area (2.07), and its standard deviation (1.14). Within the district,

Figure 4: Chorogram with various indicators of the natural value *ix* for the area under study. ➤ p. 53
Figure 5: Chorogram of the potential occurrence of spatial conflicts for the area under study. ➤ p. 54


Legend
district boundary
Coefficient
ix
0.1
0.2
0.3
0.4
0.5
0.6
0.8
0.9
0 1 2 4 6 8 km
Scale: 1:300 000
Content by: Iwona Cieślak
Map by: Iwona Cieślak
Source: CODGiK Poland
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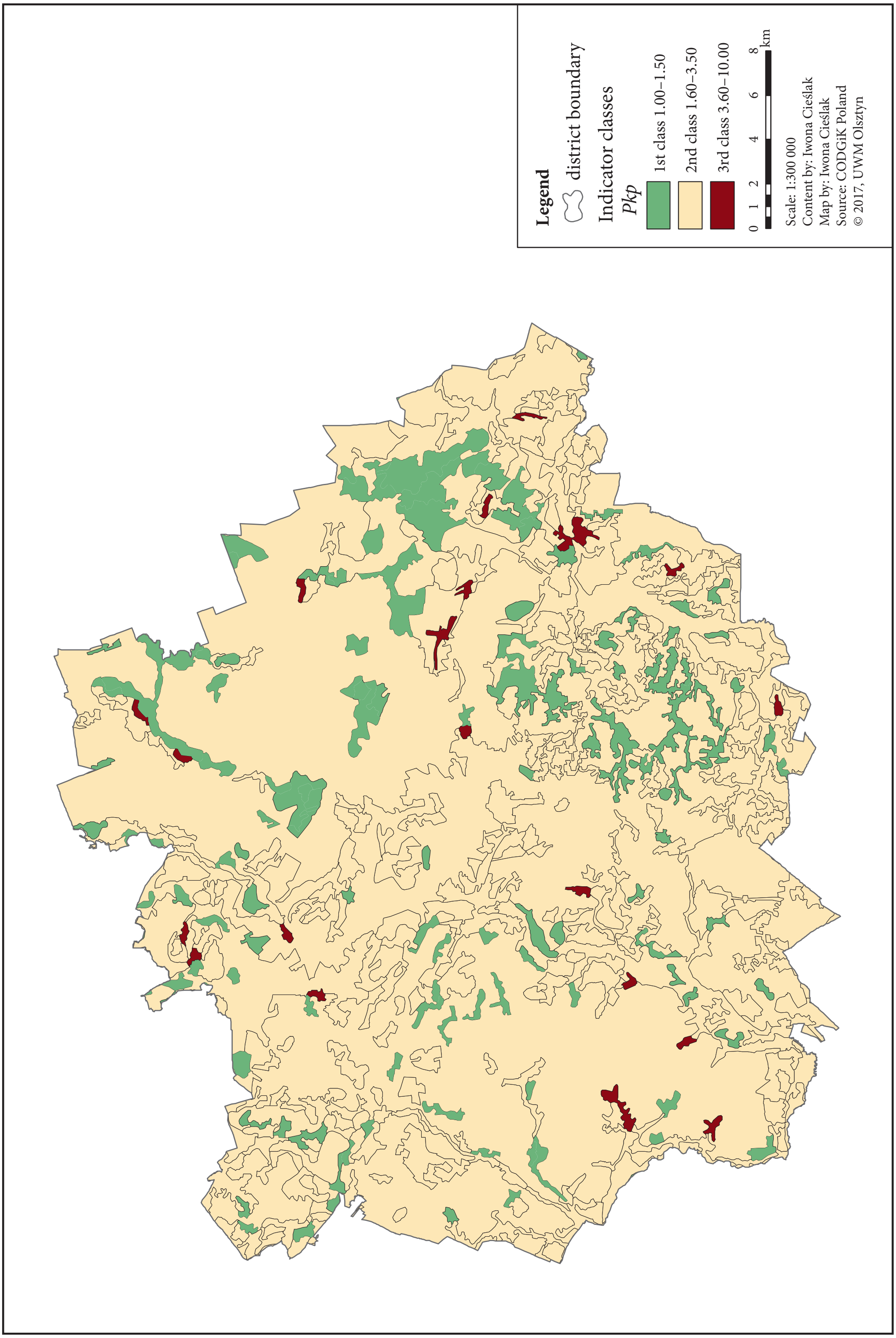
Legend
district boundary
Indicator classes
Pkp
1st class 1.00–1.50
2nd class 1.60–3.50
3rd class 3.60–10.00
0 1 2 4 6 8 km
Scale: 1:300 000
Content by: Iwona Cieślak
Map by: Iwona Cieślak
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there are not many places for which the probability of the occurrence of a spatial conflict due to extremely different forms of use of adjacent spaces is very high. For most of the area under study, the burden of the occurrence of conflicts is heightened yet not very high (the second class).

An interesting result concerns locations of spatial conflicts. They are only formed in proximity to very intensely used areas (a natural indicator for the third class of the external burden of spatial conflicts amounts to 0.1 for all areas). It follows that such areas appear frequently in the immediate neighborhood of naturally valuable areas. The indication of such places enables the location of areas in need of special attention, which should be permanently monitored.

The developed procedure for the determination of indicator P_{Kp} is an useful tool supporting of spatial planning, and for monitoring the implementation of the assumptions outlined in the process.

5 Conclusion

In accordance with the established and described procedure, it was found that the most efficient method for obtaining data on the diversity of uses of the district land was the use of the existing spatial databases. This is a method that does not require a lot of work and time, which determines its high level of efficiency. However, the conducted study proves that based on monitoring the forms of land cover, it is possible to determine the location of potential conflicts resulting from their inadequate neighbourhood. This provides an opportunity for the identification of areas for which a thorough and in-depth analysis should be conducted in order to identify the adverse impact of neighbouring areas. This confirms the need for maintaining such databases, their updating and integration with other geoinformation databases.

Results of the conducted analysis demonstrated that within the analysed space there is a risk of the occurrence of spatial conflicts, mainly due to the immediate neighbourhood of areas intensely used by humans and naturally valuable areas. The indication of the location of areas for which this neighbourhood may be particularly controversial can become an important element of preventing conflicts through improving the spatial planning process.

The proposed method for identifying areas with high potential for spatial conflicts is a novel approach in the description of the phenomenon of conflicts. It is based on the values of indices which are a good carrier of information on the phenomena occurring within the space. Not only do they provide an opportunity to identify places with an elevated risk of the emergence of conflicts but also to dynamically monitor such phenomena.

However, the access to spatial data may become a threat to such an approach. The data used in the described research are rarely updated. What is more, geodatabases are characterised by a low level of homogeneity. For various spaces, they are collected and described in a different way.

However, it is necessary to take into account the development of methods for collecting and processing data, which will certainly contribute to an improvement of this situation, thus providing an opportunity to deepen and improve the established procedure.

The rate of spatial phenomena requires that tools for identifying adverse events within a space, to which spatial conflicts certainly belong, should be developed.

The proposed procedure may certainly be modified depending on the objective of analyses, the nature of the area under study, and the access to spatial data bases. On the other hand, it can be a tool supporting the processes of planning and monitoring sustainable development of the space.

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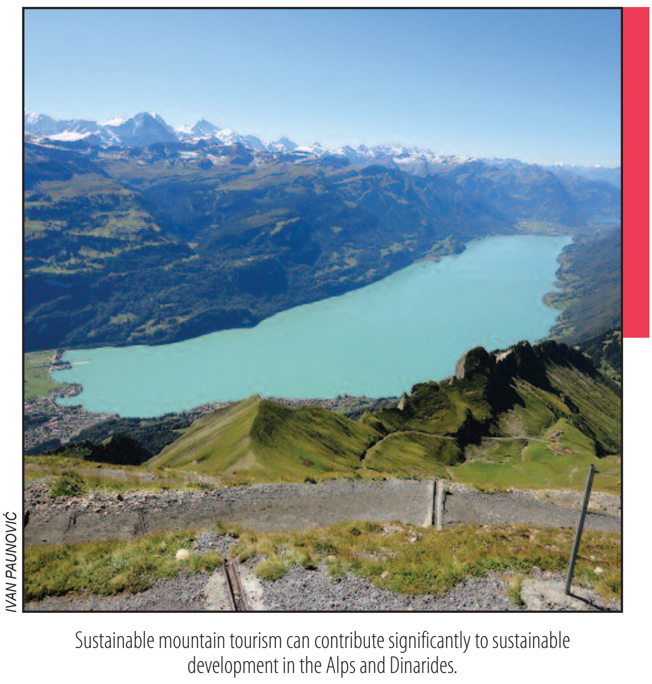
SUSTAINABLE MOUNTAIN TOURISM IN WORD AND DEED: A COMPARATIVE ANALYSIS IN THE MACRO REGIONS OF THE ALPS AND THE DINARIDES

Ivan Paunović, Verka Jovanović



Sustainable mountain tourism can contribute significantly to sustainable development in the Alps and Dinarides.

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Sustainable mountain tourism in word and deed: A comparative analysis in the macro regions of the Alps and the Dinarides

ABSTRACT: This article examines similarities and differences in the attitudes and social representations of destination managers towards implementing sustainable tourism between the mountain regions of the Alps and the Dinarides. Bearing in mind the transnational impacts (i.e., environmental, economic and social) of the tourism industry the research methodology adopted an international perspective by sending a questionnaire to tourism organizations in fourteen different countries in the Alps and the Dinarides. The research is interdisciplinary in nature, because it integrates knowledge from sustainability and management science with tourism geography and social psychology. The findings confirm that social representations of sustainable tourism differ significantly in the two mountain regions.

KEY WORDS: Sustainability, tourism geography, governance, mountain tourism, social representations of tourism, Alps, Dinarides

Trajnostni gorski turizem v besedi in dejanju: primerjalna analiza v makroregijah Alp in Dinarskega gorstva

IZVLEČEK: V članku avtorja preučujeta podobnosti in razlike v odnosu destinacijskih menedžerjev do izvajanja trajnostnega turizma na gorskih območjih Alp in Dinaridov oziroma primerjata socialne reprezentacije trajnostnega turizma na teh dveh območjih. Ker ima turistična dejavnost transnacionalne (okoljske, ekonomske in socialne) vplive, sta avtorja opravila mednarodno raziskavo, v kateri sta vprašalnike poslala turističnim organizacijam v 14 različnih državah na območju Alp in Dinarskega gorstva. Raziskava je interdisciplinarna, saj združuje znanja s področij trajnostnega razvoja, managementa, turistične geografije in socialne psihologije. Njeni izsledki potrjujejo, da se socialne reprezentacije trajnostnega turizma med obema preučevanima gorskima območjema precej razlikujejo.

KLJUČNE BESEDE: trajnostnost, turistična geografija, upravljanje, gorski turizem, socialne reprezentacije turizma, Alpe, Dinarsko

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1 Introduction

In the Alps, sustainable development became an important paradigm at the level of the macro region soon after the publication of the report »*Our Common Future*« by the Brundtland Commission, through the first Alpine conference in Berchtesgaden in 1989, and ever since a coordinated transnational research has been conducted in the Alps through the Alpine Convention. (Borsdorf et al. 2015; WCED 1987). In the Dinarides however, there are still no strong transnational and cross-disciplinary political initiatives or research on sustainable development. This situation points to the potential differences in the social representations of sustainable tourism in the Dinarides. This article therefore opens a discussion on the governance and sustainability of tourism from the perspective of the mountain destination managers in the two macro regions: the Alps and the Dinarides. The Alps are a natural benchmark for the Dinarides not only as their closest neighbor but also as one of the leading mountain chains regarding research on the environmental and social impacts of mountain tourism. The article investigates the phenomenon of sustainable tourism in the Alps and the Dinarides as an interdisciplinary field of research between tourism geography, social psychology, sustainability science and management science.

The Brundtland Commission has defined *sustainable development* as: »… development that meets the needs of the present without compromising the ability of the future generations to meet their own needs« (WCED 1987), and other institutions (UNEP and UNWTO 2005) emphasize that at the center of sustainable development are interdisciplinary perspectives (involving the economy, society, and environment) and global perspectives as well as ethical conduct. This means that sustainable destination planning and development are directly connected to destination values and leadership. Elaković (2011) correctly notes that a critical-realistic approach to destination development (with humanistic values at its core) marks the mature phase of tourist destination development. The author further clarifies that improving leadership and management values is a task for every ethical manager in order to improve the full scope of organisational activites and lessen their negative impacts on the environment. In this sense, there is very little research on *the social representations of tourism* (Moscardo 2011), and none has been conducted on sustainable mountain tourism. Social representations are a specific way of understanding and communicating existing knowledge, somewhere between the raw concepts and percepts, which give meaning to the world around us (Moscovici and Duveen 2000). In short, representation is an image or a meaning. Social representations in tourism are what communities and other *stakeholders* believe or interpret about tourism and its impacts (Moscardo 2011). The central actor, whose social representation of sustainable tourism has been studied in this article are the destination management organizations (DMO) in the Alps and the Dinarides. DMO's are a central actor in coordination of various tourism stakeholders and as such they usually have the most knowledge about different types of destination stakeholders.

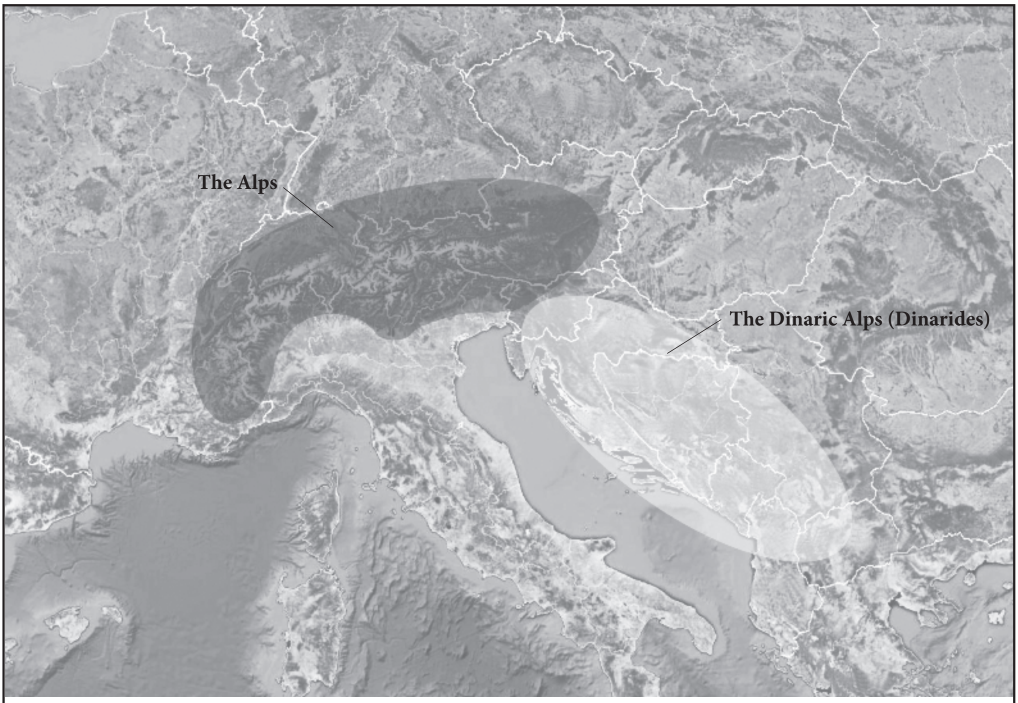
Moscardo's (2011) analysis of *tourism planning* models in emerging destinations demonstrated that the predominant paradigm is a business approach, whereas sustainability issues have been totally neglected in most cases. Government planning has been considered by many as partly outdated and partly unnecessary, but effective management systems for sustainable tourism very often need government planning (Bramwell and Lane 2011). The two main factors shaping the planning of mountain and ski tourism are demographic change-as the most important factor, and climate change-as the second most important factor (Gössling and Scott 2012). However, this order is predicted to shift by the end of the century, when climate change will become the most important factor, and demographic change the second most important factor. Organizational approaches to this changes can vary from total rejection of a sustainability agenda and non-responsiveness, through compliance, eco-efficiency or strategic sustainability, all the way to ideological commitment (Dunphy and Benveniste 2000).

Destination values and strategic directions always directly reflect destination leadership which is set in an inter-organizational context through distributed and systemic leadership (Pechlaner, Kozak and Volgger 2014). Leadership is considered by many to be a missing link in destination management theory (Bieger and Beritelli 2013). This is because the concepts of governance and networking go hand in hand, but are only able to resolve the issues of processes and how things are done, whereas the question of goals and strategies should be addressed through a framework of leadership or generally a more humanistic approach (Volgger and Pechlaner 2015). Having all this in mind, Waligo, Clarke and Hawkings (2013) note that leadership is essential in creating a common understanding about the values of sustainable development and its implementation at the destination. However, according to Yasarata et al. (2010), a pressurized political context as well as politicians' attitudes and values in some countries can significantly alter the implementation of sustainable development policies, compared to the original plans.

The destination actors that have the power to choose or change the nature of *tourism development* can have a key impact on spreading the benefits of tourism development to the development of the entire destination and local community (Moscardo 2005). The most important aspect of this power is whether and how much it is based on knowledge. However, the problem with many developing destinations is that destination residents have a small or limited role in tourism planning, whereas the development is directed by foreign tour operators, often power-distant government departments and destination management organisations (Moscardo 2011). Mountain destinations in most of the Dinarides are definitely developing destinations where these kinds of issues are present, which is why development priorities should be compared to those of more developed mountain destinations, such as those in the Alps.

The main goal of this article is to determine whether there are any differences in the social representations of sustainable tourism that affect the realization of sustainable tourism in the Alps compared to the Dinarides. The goal is also to identify the triggers of destination management differences that result in various problems in implementating sustainable tourism development. In this sense, the following four research questions have been developed:

1. How great is the importance of various stakeholders to destination management?
2. How great is the implementation of sustainability principles in destination planning?
3. What are the leadership or management values practiced at the destination?
4. What are the priorities of destination development?



Author of the map background: Google Image Landsat 2016; US Department of State Geographer 2016; GeoBasis–DE/BKG 2009
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Figure 1: Position of the researched mountain areas in Europe: The Alps and the Dinarides.

2 Methods

The research method used in this study was a questionnaire, and the sampling method was judgment sampling used as a nonprobability method, which means that sample was selected based on judgment. The questionnaire was translated into six languages and it used a seven-point Lickert scale for all of the questions (a five-point was not used intentionally, in order to avoid mistakes because there are, for example, differences in school grading in different countries), on which 7 was the highest score. The questionnaire was sent out via e-mail and as an online questionnaire (respondent could choose which one to use) to selected DMOs in areas over 1000m in elevation. Altogether, 1,213 organizations where included and seventy of them replied. The relatively low response rate (5.77%) was expected, given that previous research (Finkelstein, Hambrick and Cannella 2009) had indicated that professionals in management positions are not inclined to participate in research on leadership values. The distribution of the data collected is as follows: fourty-six in the Alps (six France, one in Liechtenstein, nine in Italy, seven in Germany, two in Alpine Slovenia, nine in Austria, and twelve in Switzerland) and twenty-four in the Dinarides-24 (one in Albania, ten in Bosnia and Herzegovina, three in Montenegro, one in Croatia, zero in Kosovo, four in Macedonia, one in Dinaric Slovenia, and four in Serbia). The research included the following types of organizations: tourism organizations, departments/sections for tourism and/or economic development (in charge of tourism) in local municipal institutions, regional tourism organizations, tourism societies, destination marketing organizations and regional development organizations.

In the analysis phase, MS Excel was used to calculate the descriptive statistics, as well as SPSS to calculate statistical significance using t-tests. In the graphs and tables, statistical significance at the 0.05 level is marked with two asterisks. In this sense, it is important that the two samples (the Alps and Dinarides) were relatively well-balanced, because there is no statistically significant difference between the two groups in age, level of education, or any key competency of the respondents. The only statistically significant difference was in the sex of the respondents; there were more women in the Alps sample.

3 Results

The results on the social representations of sustainable tourism in the management practice cover the following aspects of the destination management process in the two mountain regions: the importance given to the different types of stakeholders by the DMO (Figure 2), planning for sustainability at the destination (Figure 3 and Table 1), leadership/management values at the destination (Figure 4), and priorities of the destination development (Table 2). In all of the following tables and graphs, two asterisks »**« indicates statistically significant difference at the 0.05 level.

Figure 2 shows that there are significant differences in stakeholder prioritization by the destination management organizations between the Alps and the Dinarides. One very important difference is that stakeholders are more evenly ranked in the Dinarides, whereas the three most important stakeholders are clearly more important than the other stakeholders in the Alps.

As shown in Figure 3, self-evaluations about the *implementation of sustainability principles in destination planning* show a small difference. However, the differences between evaluation in word only and concrete actions become somewhat clearer in Table 1, Figure 4 and Table 2.

Table 1: Planning for sustainability.

Feature	Likert scores (rank)	
	Alps	Dinarides
Multidisciplinary sustainable development planning documents	4.17 (3rd)	3.77
Economic/tourism development documents	4.94 (1st)	4.05 (3rd)
**Environmental protection documents	4.26 (2nd)	5.64 (1st)
Separate cost-benefit analyses	2.98	3.14
**Legislation (constitutional, environmental, economic/tourism, etc.)	4.06	5.18 (2nd)
Other	1.72	1.72

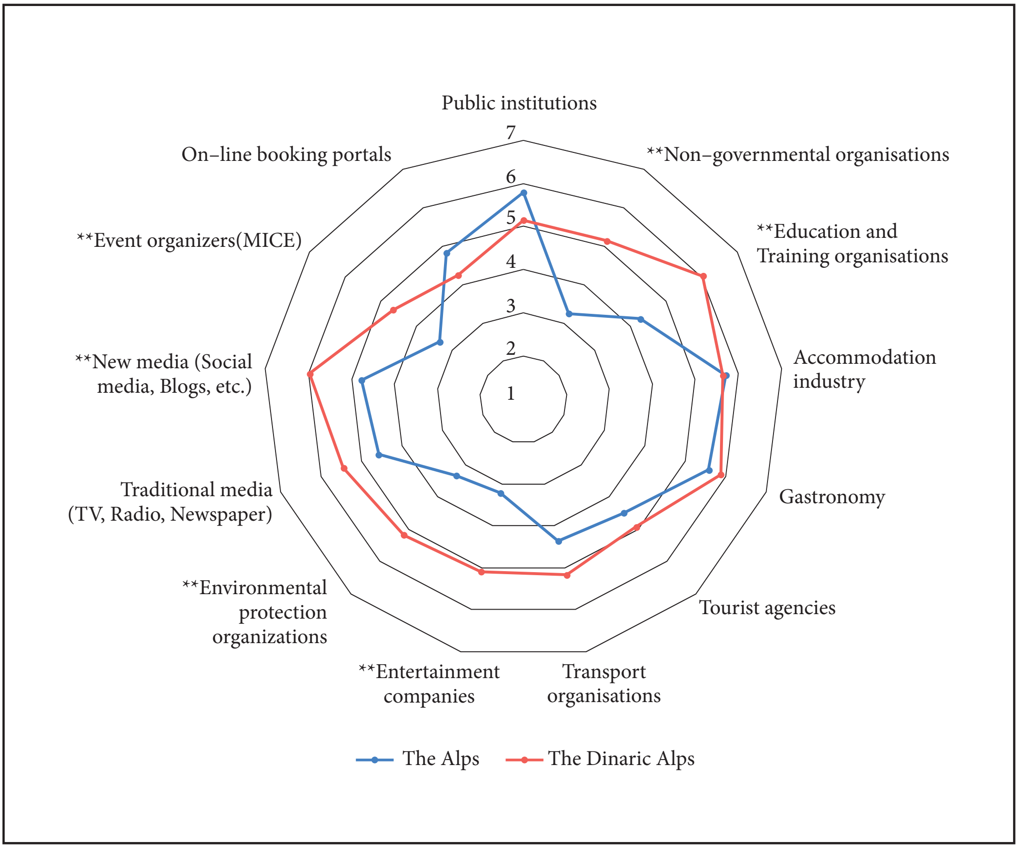

Figure 2: Importance given to different types of stakeholders by the DMO's.

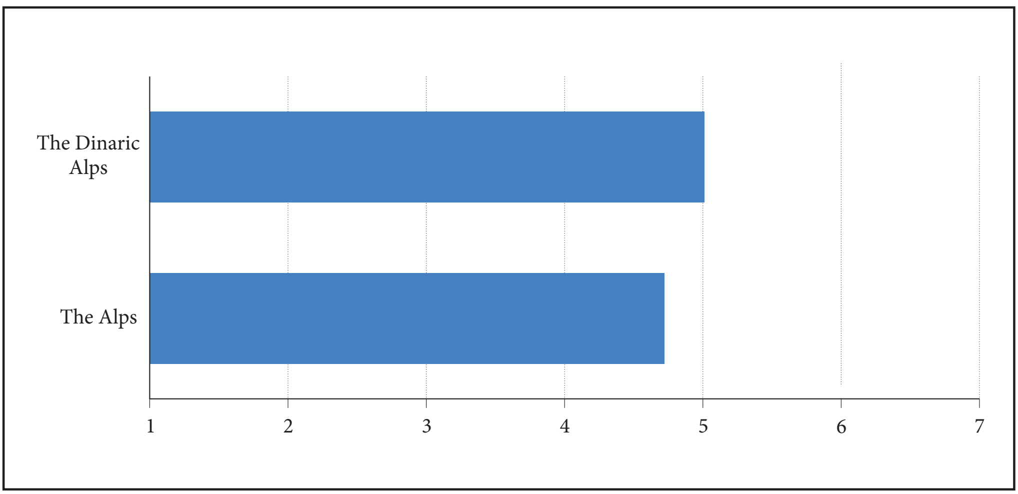

Figure 3: Implementation of sustainability principles in destination planning (self-reported by DMOs).

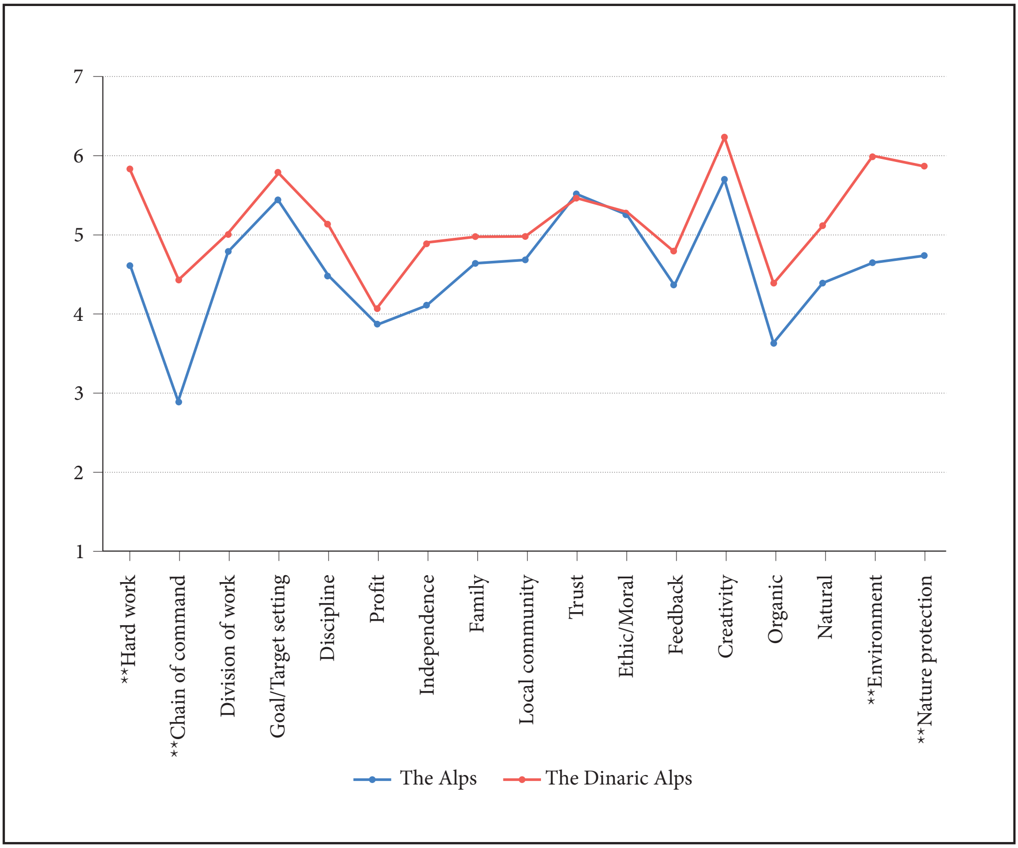

Figure 4: Leadership or management values in the destination.

There is a statistically significant difference between the two mountain regions regarding documents used for planning sustainability regarding environmental protection, as well as laws. In both cases, these were significantly more important in the Dinarides than in the Alps. As shown in Table 1, economic/tourism development documents are the single most important document in the Alps, followed by environmental protection documents and multidisciplinary sustainable development planning documents (ranked first, second and third). In the Dinarides however multidisciplinary sustainable development planning documents are ranked only as a fourth priority. This means that in the Dinarides, environmental protection goals should be put into a broader social context (social and economic). In that sense, there is space for using more multidisciplinary general planning documents of sustainable development in the Dinarides.

Top managers' choices are shown to be affected by their experiences, values and personality (Hambrick 2007; Hambrick and Mason 1984). This applies to DMOs in the same way as it does to other organizations. As shown in Figure 4, leadership or management values such as hard work, chain of command, protection of the environment and protection of nature score more importantly in the Dinarides. In this sense, for DMOs in the Dinarides there is an opportunity to create organizations that are more egalitarian (emphasizing the social equality of all co-workers) and rely less on hierarchy (or the chain of command). Similarly as with documents for planning sustainability, there is a noticeable polarization of answers towards environmental protection in the Dinarides, which also means that there is poorer integration of this aspect with other aspects of sustainability. Conversely, in the Alps, environmental protection of the destination is an aspect of sustainable development that needs additional specialized attention.

Table 2: Priorities of destination development.

Feature	Likert scores (rank)	
	Alps	Dinarides
**Tourism research	4.63	5.87
Market research	4.87	5.61
**Use of social media (LinkedIn, Facebook, Twitter)	4.83	5.87
**FDI (foreign direct investment)	2.96	5.52
Image and marketing	5.37	5.96
Tourism product development	6.11 (1st)	6.17
**Development of infrastructure	5.72 (3rd)	6.65 (1st)
**Destination stakeholder network improvement	5.09	5.91
**Environmental protection	5.22	6.61 (2nd)
**Regional or cross-border cooperation	5.02	6
**Human resources development	4.76	6.09
Development of core competencies	4.98	5.48
**SME (small and medium-sized enterprises) support	4.2	5.49
**Service quality	5.87 (2nd)	6.57 (3rd)
Innovative products	5.70	5.83
Sustainable development	5.43	6.17
Energy efficiency	4.98	5.61

Although there are some differences in terms of leadership or management values, in terms of *destination development priorities*, there are significant differences (ten out of seventeen are significantly different), as shown in Table 2. This is understandable given the two regions' different levels of economic development. Priorities rated significantly higher in the Dinarides are tourism research, social media use, foreign direct investment, destination stakeholder network improvement, regional and cross-border cooperation and development, human resource development, and SME support. This surely doesn't mean that in the Alps the destination do not have a need for improvements in this areas, but rather that they are already sufficiently developed and are not considered a priority in future development, because these areas are already functional.

When analyzed separately, the priorities of destination development (marked in parentheses) in the Alps are tourism products, service quality, and infrastructure development; in the Dinarides, they are infrastructure development, environmental protection and service quality. Infrastructure development and service quality are priorities for both destinations, but they are rated as significantly more important in the Dinarides. This finding says a great deal about the special importance of these two aspects (improvement of infrastructure and service quality) for the development of mountain destinations in the Dinarides, while at the same time trying to preserve the environment. This is a real challenge of sustainable tourism development in the Dinarides, and also something that should be studied more in future research.

There is a space for investments in accommodation capacities, as well as accompanying IT industry in the Dinarides. An equally important finding concerns DMOs themselves, which should become organizationally less hierarchical (rely less on chain of command-Figure 4), with more employee empowerment in relation to managers or leaders, especially if the same educational structure of employees in both regions is taken into account. Alpine DMOs are significantly less focused on nature protection as a development priority and as a leadership value, and organizations for nature protection have less influence on the DMOs. Bearing in mind the general importance of gastronomy as a stakeholder, and service quality development as a development priority, developing the quality of gastronomic services is recommended in the both mountain regions.

4 Discussion

Understanding the relation of the DMO to other destination actors in the mountain destinations is very important because policy changes, related to environmental, social and economic impacts can only be implemented in this DMO-stakeholders nexus. The most important difference in this sense is that in the Alps, there is a stronger division between what Franch, Martini and Buffa (2008) identified as primary and secondary stakeholders, as related to power and influence at the destination. The most important stakeholders in the Alps are public institutions, accommodation and gastronomy, whereas the most important stakeholders in the Dinarides are education and training organizations, new media (social media, blogs, etc.), and culinary providers. The relatively low importance of the social dimension in sustainable development in the Dinarides is in line with the findings of Kovačič and Brečko Grubar (2016) regarding knowledge of sustainable development among Slovenian students, who also lack awareness of the social dimension. More importantly, it also confirms the findings of Byrd, Cardenas and Greenwood (2008) in the case of North Carolina, where, the authors emphasize the need to inform destination stakeholders about social issues and how they relate to sustainable development. Consequently, there is still much space in the Dinarides for better stakeholder integration and consultation, and this must be reflected in multidisciplinary general planning documents as evidenced in the literature (Waligo, Clarke and Hawkins 2013; Brida, Osti and Barquet 2010; Shunnaq, Schwab and Reid 2008). The results confirm that in the Alps there is a good transdisciplinary development policy, because of the long tradition in transnational sustainable development, with the challenge of further improving environmental protection. This confirms the findings by Marzelli and Lintzmeyer (2015) that in the macro-region of the Alps, improvements are needed in natural resources management, although significant results have already been achieved so far.

The sustainable tourism literature recognizes that destination planning paradigms are out of date (Waligo, Clarke and Hawkins 2013; Popesku 2011; Goeldner and Ritchie 2009; Krippendorf, Zimmer and Glauber 1985), especially for mountain destinations (Trawoeger 2014; Paunović and Radojević 2014; Blasco, Guia and Prats 2014; Dawson and Scott 2013), because they do not fully take into account broader social and environmental impacts of tourism in order to lessen the impact of the tourism industry on the environment and communities. This is why the results of this study are so important for tourism geography. They demonstrate the lack of interdisciplinarity in planning sustainable tourism in the Dinarides as well as an unused potential of flexible, soft policy instruments (compared to laws) in achieving sustainable tourism.

Leadership is considered an essential part of addressing the »crisis of governance« involving the natural environment (Case et al. 2015; Young et al. 2007), an issue of great importance in mountain destinations, which are ecologically very sensitive (Prideaux 2009). Leadership values constitute an important part of the modern destination management process, in which economic, environmental and social values are all equally important. An important notion is also that not all people that declare themselves in favour of environmental protection really consider this a value because value is something that is a permanent priority and affects actual actions as well as the choice of policy instruments in the broader framework of governance (Smrekar 2011; Hall 2010). Research of declared values in the Dinarides revealed that, regarding DMO organization, hierarchies (i.e., chain of command and hard work) are much more important than in the Alps. This confirms the low priority of the social dimension of sustainability in the Dinarides (such are stakeholder involvement, social inclusion, partner networks, etc.). On the other hand, in the Alps the attitude towards the environment and nature protection at the destination could be improved, as shown in the Figure 4.

The tourism industry has a strong impact on resources at the destination, especially on the local community at the destination, and at the same time the future of the tourist destination also depends on protecting those very same resources (Prideaux 2009; Goeldner and Ritchie 2009). Therefore, research plays an important role in informing those involved in tourism about available development alternatives and priorities while maintaining a holistic and systemic approach in dealing with tourism development (Prideaux 2009; Burns and Novelli 2008). This is particularly true for ecologically sensitive mountain regions such as the Alps and the Dinarides, which is why the results presented results should serve as a basis for further discussion on sustainable tourism development priorities. Why do certain regions have certain priorities, why do these priorities differ, and how do they change over time? Although there are general differences in the social representations of sustainable tourism between the Alps and the Dinarides, individual destinations within both regions can also vary significantly depending on the specific arrangements: the type of organization responsible for coordinating destination development, institutional arrangements and the local resources available (i.e., human, geographic, infrastructure, know-how, tradition, etc.). In this sense, future research on social representations of sustainable tourism should take two directions: 1) research can be conducted on larger samples and in different regions or types of destinations, and 2) a qualitative research approach (i.e., case studies and interviews) should complement the qualitative approach in order to provide greater understanding and interpretation of the results obtained.

5 Conclusion

In order to enhance future sustainable tourism development in the Alps and Dinarides, geography and tourism research should advocate the constant communication of information and upgrading of knowledge of the entire tourism public regarding available development alternatives and priorities, especially taking into account the observed differences. Special emphasis should be put on exchange of best practices and improvement of the quality of all sustainable tourism elements. An important link in this process is understanding the social representations of sustainable mountain tourism. This is because the very same concept, such as sustainable tourism, can have completely different interpretations and social roles in different societies or communities. This study has confirmed that there are differences in this sense, and it has presented a detailed analysis of social representations of sustainable mountain tourism in the Alps and the Dinarides, as a basis for further research on implementing sustainable tourism. There are significant differences in the social representations of sustainable tourism regarding stakeholder prioritization, destination planning, leadership or management values, and destination development priorities.

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GENDER, AGE AND EDUCATION DIFFERENCES IN FOOD CONSUMPTION WITHIN A REGION: CASE STUDIES OF BELGRADE AND NOVI SAD (SERBIA)

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NATIONAL TOURISM ORGANISATION OF SERBIA

Food consumption contributes significantly to regional development.

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Gender, age and education differences in food consumption within a region: Case studies of Belgrade and Novi Sad (Serbia)

ABSTRACT: Nowadays, each tourist visits a region for certain reasons, a different type of tourism, but besides the main motives, food and beverages are an inevitable attraction. Some tourists' characteristics, such as gender, age and education of tourists, contribute significantly to food and beverages consumption. The authors recognized the importance of gender, age, and education in analyzing food and beverage consumption as an important component of tourist products. The study makes a significant conceptual contribution towards the spatial/economic development for those who are seeking to integrate local food and beverage into the tourist product.

KEY WORDS: geography, gender, age, education, food consumption, economic development, Belgrade, Novi Sad

Razlike v porabi hrane v izbrani regiji na podlagi spola, starosti in izobrazbe: Primer Beograda in Novega Sada

POVZETEK: Danes ima vsak turist svoje posebne razloge za obisk določene regije. Lahko si želi drugačne vrste turizma, poleg glavnih razlogov pa ga pritegneta zlasti lokalna hrana in pijača. Nekatere lastnosti turistov, kot so spol, starost in izobrazba, pomembno vplivajo na porabo hrane in pijače. Avtorji so pri analizi porabe hrane in pijače kot pomembne prvine turističnih proizvodov ugotovili, da imajo spol, starost in izobrazba pomembno vlogo. Raziskava ponuja pomemben konceptualni prispevek k prostorskemu/gospodarskemu razvoju tistih ponudnikov, ki poskušajo v svoje turistične proizvode vključiti lokalno hrano in pijačo.

KLJUČNE BESEDE: geografija, spol, starost, izobrazba, poraba hrane, gospodarski razvoj, Beograd, Novi Sad

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1 Introduction

Tourists with different cultural and religious backgrounds and socio-demographic characteristics, as well as with different personality traits related to food and past experience may have different motivations for the food consumption within a region. Accordingly, the destination management is now using local food and beverages through the food culture and as an aesthetic experience for tourists, which causes pleasant emotions, increases their understanding of local community and culture, satisfies their curiosity about local community and fulfils tourists' need to learn about the local culture (Chang, Kivela and Mak 2011).

The purpose of our previous research (Vuksanović et al. 2017) was to examine the differences between the demographic and socio-economic characteristics of foreign tourists, as determinants, in the perception of local gastronomy, while in this study authors analyzed gender, age, and education of foreign tourists in relation to food and beverage consumption as an important component of tourist product. The research was done in two cities, but authors recommend that for future research it would be very useful to replicate this research in other regions (mountain, spa and other forms of tourism) and cities (Subotica, Niš, Kragujevac) across the Republic of Serbia.

The scale used in previous research (Vuksanović et al. 2017) referred to local gastronomy and included three aspects (according to Jalis et al. 2009; Qing-Chi et al. 2013) of food distinctiveness and accessibility, food diversity and enjoyment, and food quality and presentation. The work of Vuksanović et al. (2017) leaves a room for new research, for example, examining whether gender, age and education of foreign tourists have an impact on food and beverages consumption within a region. The results of previous studies (Mak et al. 2012; Kim, Eves and Scarles 2009) highlighted that socio-demographic characteristics of tourists (gender, age and education) are important factor in measuring food consumption.

From the aspect of geography, food is the field of human geography. Geography deals with spatial processes in human and physical environments. Such processes have an impact on food, and they can be viewed through multiple geographical disciplines (physical, social, medical and economic geography) (Gillespie 2001). Geographers dealing with physical, economic, social, urban, rural, cultural, medical and agricultural geography have their own views on the analysis of the food system. They analyze the production, consumption, supply and distribution of food from the local to the global level (Atkins and Bowler 2001).

MIHAILO BERČEK, TOP SRBIJA

Figure 1: Serbian cuisine.

In previous studies (Buller 2014; McDonagh 2014; Tornaghi 2014; Woods 2012), many authors have dealt with research on food geographies, and other disciplinary discussions around food. Previous research (Brice 2014; Dudley 2011; Poe et al. 2014; Yeh and Lama 2013), pointed out that interconnection between space and identity is interrogated through the production and consumption of food, food places and through the broader political-economies of food ecologies and practices.

Mak et al. (2012) identified five main socio-cultural and psychological factors of tourist food consumption (motivational factors, religious and cultural influences, food-related personality traits, exposure and past experience, and socio-demographic factors). They claimed that these five factors are interconnected and that socio-demographic effects are just as important as other factors that affect the tourist's tendency toward food consumption.

A large number of studies show that food can be a major or one of the main motivators for traveling to a destination (Hall and Mitchell 2005; Long 2004; Mak et al. 2012; Hjalager and Richards 2002). In addition, Kivela and Crotts (2006) emphasized that food as a main motivation for travel is a valid construct and that food plays an important role that affects the overall tourism experience. Currently, the religion is considered to be a very important determinant affecting food selection and consumption (Sheldon and Fox 1988) while the culture is a major determinant that affects type of food that a person considers acceptable for consumption (Prescott et al. 2002). Kim, Eves and Scarles (2009) pointed out that food-related personality traits and past experience (the exposure effect) can be determinants which influence food consumption. At the same time, socio-demographic characteristics of an individual can be a determinant that affects food consumption.

In the field of tourism and hospitality research, several studies (Ignatov and Smith 2006; Kim, Eves and Scarles 2009; Khan 1981; Mitchell and Hall 2003) indicated that tourists' demographic and socio-economic characteristics influence their preferences towards local food. Some studies (Furst et al. 1996; Khan 1981; Randall and Sanjur 1981) related to food consumption recognized socio-demographic characteristics as significant variables in explaining variations in food consumption. Franklin and Crang (2001) indicated that demographic variables significantly influence choices for a region. In other way, studies that used sociodemographic variables assume that these variables are oversized (Schofield and Thompson 2007; Huh, Uysal and McCleary 2006) – i.e. they pointed out that gender and age are the least significant differentiating variables for the motivation dimensions.

Previous studies showed that female respondents, as compared to male, are more interested in and more excited about degustation of local food when they are on vacation (Kim, Eves and Scarles 2009; Ignatov and Smith 2006) and that they are more price sensitive and ready to taste new or unusual fruit and vegetables (Mitchell and Hall 2003). Thus, the following hypothesis is proposed:

H1 – There are statistically significant differences between male and female foreign tourists in relation to food and beverage consumption within a region.

In the field of tourism and hospitality research, the consumption of food is narrowed for elder respondents (Tse and Crotts 2005) and that they are more health concerned (Kim, Eves and Scarles 2009), while Olsen (2003) quotes that older tourists can be positively oriented towards consumption of sea food. Based on the above-mentioned findings, the following hypothesis is proposed:

H2 – There are statistically significant differences among foreign tourists of different age groups in relation to food and beverage consumption within a region.

A common agreement among researchers is that the respondents with higher education level are more health concerned (Kim, Eves and Scarles 2009), that higher education level increases food related sensation (Glanz et al. 1998) and that the respondents with higher education level have more tendencies towards local food consumption (Zeppel and Hall 1991). Wadolowska, Babicz-Zielinska and Czarnocinska (2008) pointed out that the respondents with primary education have a negative or neutral perception of food. Considering the results of earlier research, this study has the following hypothesis:

H3 – There are statistically significant differences among foreign tourists of different level of education in relation to food and beverage consumption within a region.

This study will focus on foreign tourists who visited Belgrade and Novi Sad (the Republic of Serbia). At the same time, the purpose of this paper was to examine the differences between the gender, age and education of foreign tourists and the cities in relation to food and beverages consumption within a region as an important component of tourist product.

2 Methods

Fieldwork for this study was carried out in Belgrade and Novi Sad in the Republic of Serbia. Both cities are the administrative, economic, political and cultural centres (Garača, Jovanović and Zakić 2011). Belgrade is located at the confluence of the Sava and Danube rivers, where the Pannonian Plain meets the Balkan Peninsula, while Novi Sad is located in the south of the Pannonian Plain. With their history, cultural assets and high quality accommodation facilities, Belgrade and Novi Sad host many domestic and international events (Internet 1; Internet 2). Thus, they are mostly considered cultural regions (Garača, Jovanović and Zakić 2011). Along with a cultural heritage deeply rooted in history, the cities offer opportunities for their visitors to taste the unique delicacies of local cuisine in the traditional restaurants scattered across the cities. Large number of restaurants allowed researchers to reach a great number of tourists and that was one of the main reasons for their selection.

The survey was conducted on-site at casual local eateries (e.g. *restoran domaće kuhinje*) and fine dining restaurants located in the streets Skadarlija (Belgrade) and Zmaj Jovina (Novi Sad). These two streets have nearly 50 restaurants with local cuisine and therefore they are mostly visited by foreign tourists (Internet 3; Internet 4).According to the data obtained from the Statistical Office of the Republic of Serbia (Internet 5), Belgrade and Novi Sad were visited mostly during these two months and in the last ten years. A team of ten researchers – previously trained graduated gastronomy and marketing students – undertook the survey during different days of the week (usually during afternoon and in the evening), over a period of two months (June–July, 2016). During the survey period, 1000 questionnaires were distributed, and 674 usable questionnaires were returned (usable response rate = 67.4%).In Table 1 presents design of the sample which includes information about sample and population, sampling error and confidence level.

Table 1: The sample design research data.

Collection method	Self-administrated questionnaire	
Sampling unit	Tourist over 18 years of age; tasted food and beverage during his/her stay in Belgrade and Novi Sad (the Republic of Serbia)	
Population size	455.957 per year	
Sample Type	Simple random sample	
	Belgrade	Novi Sad
Confidence level	95%	99%
Sampling error	3.8%	5%

The questionnaire was composed of three parts. The first part of the questionnaire was an agreement of respondents to fill in the questionnaire. The questionnaire was anonymous. The second part referred to demographic and socio-economic characteristics of respondents: gender, age, education, occupation, reason for visiting the region and country of tourist's origin. The last part contained a list of eight food and beverage attributes compiled based on previous studies (Qing-Chi et al. 2013; Verbeke and Lopez 2005). Earlier studies (Baloglu and McCleary 1999) have indicated that the term »local food« contributes to the popularity of region and tourist consumption of food. The answers were measured by using the Likert scale, as follows: 1 – Strongly disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree.

3 Results

3.1 Characteristics of the respondents

The demographic profile of the respondents is summarized in Table 2. The study included 674 respondents of which 332 were in Novi Sad and 342 in Belgrade. Out of the total number of respondents, 51.3% were male and 48.7% female. Almost half of the respondents are younger people, 18 to 30 years of age.

Table 2: Respondents' demographic data (n = 674).

Variables	Sample size	Share	Variables	Sample size	Share
Gender			**Occupation**		
Male	346	51.3%	Unemployed	43	6%
Female	328	48.7%	Retired	24	4%
			Employed	489	72.5%
			Student	118	17.5%
Age			**Reason for visit**		
18–30	316	47%	Vacation	175	26%
31–40	167	25%	Business purposes	140	21%
41–50	95	14.5%	Shopping	98	14.9%
51–60	72	10.5%	Visiting friends	100	15.1%
over 60	24	3%	Food and culture	37	5%
			Other	124	18%
Education			**Region**		
Primary Education	117	16.9%	Ex-Yugoslavian countries	306	46%
Secondary Education	232	34%	West Europe	272	40%
Higher education	120	18.1%	South Europe	47	6.9%
Master's degree	111	15.5%	East Europe	49	7.1%
Doctor's degree	94	12.5%			

In Table 3 is shown descriptive analysis of the scale items for food and beverages consumption. The scale is operationalized as the sum of responses to all items from the third part of the questionnaire. A higher score indicates better attitude towards of food and beverages consumption.

Based on the values presented in Table 4, it can be concluded that the answers of respondents at the *food and beverages consumption* scale do not deviate significantly as compared to a normal distribution. In this research, reliability coefficients expressed in Cronbach alpha are 0.82.

Table 3: Descriptive statistics of items used for research of food and beverages consumption.

Scale	Novi Sad		Belgrade	
	Mean	Standard Deviation	Mean	Standard Deviation
1. Most of local food and beverages stimulated my appetite.	4.49	0.752	4.41	0.878
2. I didn't mind eating local food and drinking beverages at any time.	4.34	1.02	4.16	1.05
3. I enjoyed most local food and beverages during my vacation.	4.56	0.70	4.55	0.78
4. I spent a lot on local food and beverages during my vacation.	4.06	1.04	4.03	1.11
5. I had local food and beverages just for the sake of tasting it.	3.74	1.27	3.61	1.29
6. I consumed just those local food and beverages that I was familiar with.	3.19	1.30	3.23	1.43
7. The taste and look of most local food and beverages are of the same taste wherever I consumed them.	3.44	1.15	3.39	1.18
8. I only consumed local food and beverages for a few days during my vacation.	3.41	1.31	3.20	1.41

Table 4: Descriptive scale indicators.

Scale	Min	Max	M	SD	Skew.	Kurt.	K-S	α
Food and beverages consumption	19.00	50.00	39.99	5.09	0.625	1.066	0.292*	0.82

*Note: *p < 0.1: Min. – minimal score; Max. – maximal score; M – arithmetic mean; SD – standard deviation; Skew. – Skewness; Kurt. – Kurtosis; K-S – Kolmogorov–Smirnov statistics; α – scale reliability measured by internal consistency.*

3.2 Differences between the cities

The results of T–test for independent samples indicate a significant difference between tourists who visited Novi Sad ($M = 40.33$, $SD = 4.88$) and those who visited Belgrade ($M = 39.64$, $SD = 5.28$). The value of T–test is 1.83, and it is statistically significant ($p < 0.05$). The results show that foreign tourists who visited Novi Sad consumed a slightly more food and beverages in relation to tourists who visited Belgrade.

3.3 Differences between gender, age and education in food and beverages consumption

The results indicate that there are differences between the variables gender, age and education (Table 5). Differences between groups were analysed by ANOVA, with the independent variables: gender, age and education, and the dependent variables are food and beverages consumption.

Table 5: ANOVA analysis for gender, age and education in food and beverages consumption.

Variables	Interaction/city	Main effects of socio-demographic	Main effect of city
Gender	$F(3, 669) = 3.04$, $\mathbf{p < 0.03}$, $\eta^2_p = 0.03$	$F(1,669) = 3.04$, $\mathbf{p < 0.01}$, $\eta^2_p = 0.02$	$F(1,669) = 4.82$, $\mathbf{p < 0.03}$, $\eta^2_p = 0.01$
Age	$F(4,662) = 4.61$, $\mathbf{p < 0.05}$, $\eta^2_p = 0.01$	$F(1,662) = 1.93$, $\mathbf{p < 0.02}$, $\eta^2_p = 0.02$	$F(4, 662) = 5.58$, $\mathbf{p < 0.00}$, $\eta^2_p = 0.02$
Education	$F(4, 662) = 3.04$, $\mathbf{p < 0.02}$, $\eta^2_p = 0.02$	$F(4, 662) = 1{,}97$, $p < 0.09$	$F(1, 662) = 18.26$, $\mathbf{p = 0.00}$, $\eta^2_p = 0.02$

*Note: *p < 0.5: post hock tests (Tukey's HSD).*

4 Discussion

The findings show that there are differences between men and women when it comes to food and beverages consumption. Male tourists from Novi Sad show a tendency towards a more positive attitude towards of food and beverages consumption, compared to other groups of respondents from Belgrade. However, the differences can be explained by physiological characteristics between man and women where man are more likely attracted with large portions and selection of meat dishes in relation to women. Also, one of the explanations can be that food choices are based on an individual level and their association with the aspects socio-economic factors (Kim, Eves and Scarles 2009; Khan 1981; Ignatov and Smith 2006; Mitchell and Hall 2003). Therefore, the hypothesis 1 has been confirmed. At one side, these differences between genders, mentioned above, are good indicators that can be used as a benchmark with previous results and be of use to marketing professionals to further enhance the offer on the region. On the other side, restaurant managers need to reduce the gender gap by applying different strategies, that will be focused on promotion – for example: special menu (both for men and women), the size of portions and different type of meals (vegetarian, vegan).

The results indicate that there is difference between respondents depending to which age group they belong. There is a significant difference between respondents from the category of 18–30 years of age and the respondents who fall into the category 51–60 years of age. Further on, the same test shows that there is a difference between respondents who are 31–40 years of age and the respondents who are 41–50 years of age, as well as in relation to respondents who fall in the category between 51–60 years of age. More precisely, respondents who belong to elderly category (51–60 years of age), more positive attitude towards food and beverages, which is in accordance with previous research (Kim, Eves and Scarles 2009; Tse and Crotts 2005; Olsen 2003). Therefore, the hypothesis 2 has been confirmed. Professionals from marketing and hospitality industry need to be familiar with differences between age groups in order to be able to form different offers for different age groups. For example, for the age group from 51 to 60, a meal offered to them can be formed so to satisfy their dietary needs (for example, low salt, low calories, allergen info) while for the age group from 18 to 30, an affordable price can be used in promotion.

The results indicate that there are differences between people with different education level when it comes to food and beverages consumption. The results show that respondents who visited Novi Sad and have master's degree differ from respondents who visited the same city but have higher education or primary education. Also, it is indicated that the same respondents differ from all other categories that visited Belgrade – from those who have completed secondary education, who have higher education, primary education, as well as from those respondents who have completed PhD. Possible differences between the groups of respondents for the variable education (respondents with university education gave more positive attitude towards of food and beverages consumption), can be explained with the fact that they were probably more informed about local food before they travelled to a region. To be more precise, the respondents who visited Novi Sad and have completed master's degree spend much more money on the food and beverage as compared to other respondents, irrespective of the city. Earlier studies (Zeppel and Hall 1991; Glanz et al. 1998) have confirmed that the respondents with higher level of education (university' degree) have more tendencies towards consumption of local food, which is in accordance with the obtained results in this research. These differences can be explained by the fact that highly educated respondents do not see local cuisine just as a way of appeasing hunger, but also as a medium to experience the region (Kim, Eves and Scarles 2009; Wadolowska, Babicz-Zielinska and Czarnocinska 2008). Therefore, the hypothesis 3 has been confirmed. Based on the results, restaurant managers need to pay more attention when comes to reservations from special group (like proffesors from University), as it turned out that consumption differs in relation to education. For example, respondents with a higher level of education are more willing to try food and beverages, and it is necessary to provide a different supply of food and beverages for them. The offer can contain an equal choice of domestic and international dishes and different sizes of portions. In addition, the promotion of food and beverages can be directed to a specific educated group. For example, tourists with a higher level of education may be offered with certain type of meals (e.g. with specific dietary needs) because previous researches (Kim, Eves and Scarles 2009; Tse and Crotts 2005) have shown that they are more concerned about health.

From a practical point of view, this study provides valuable information for tourism and hospitality managers. Although tourists have expressed positive attitude on food and beverage, it is necessary to improve the efficiency of regulatory institutions, including the Food Safety Agency and the Nacional tourist organization of the Republic of Serbia. In accordance to that, the responsible goverment bodies should monitor the work of tourist companies at all levels. Monitoring is necessary in order to avoid and prevent inappropriate enterprise behaviour, to publish information related to local cuisine and to solve tourists' complaints. Also, monitoring reduces tourist dissatisfaction and improves positive evaluation of local cuisine perception. At the same time, this can increase the overall satisfaction of tourists with chosen destinations.

5 Conclusion

The study advances literature on the use of tourists' socio-demographic characteristics in region, by examining the attitude towards food and beverage consumption in the spatial geographical context. The results indicate that gender, age and education within a region are an important antecedent of tourist consumption and an important component of the tourist products.

This study provides valuable insight to practitioners who are seeking to integrate local food and beverage into the tourist product and how to improve acceptability to foreign tourists. In addition, this research makes it possible for the sectors of economy and government to understand better the significance of food and beverages consumption as part of the region, and towards the spatial/economic development.

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ACTA GEOGRAPHICA
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SPECIAL ISSUE

Franciscean cadaster as a source of studying landscape changes

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LAND REGISTERS AS A SOURCE OF STUDYING LONG-TERM LAND-USE CHANGES

Matej Gabrovec, Ivan Bičík, Blaž Komac

ARCHIVES OF THE REPUBLIC OF SLOVENIA

Land pattern with very narrow plots is clearly visible on the section of the 1823 Franciscean cadastral map of the municipality of Žerovnica in Slovenia.

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Land registers as a source of studying long-term land-use changes

ABSTRACT: Land registers, or cadasters, contain information on land use because this is vital for land assessment and taxation. Some European countries produced land registers covering their entire territories as early as the nineteenth century. In the first half of the nineteenth century, the Habsburg Monarchy produced the Franciscean Cadaster, also known as the Stable Cadaster, which shows the traditional preindustrial cultural landscape and makes it possible to analyze land-use changes or the transformation of the traditional cultural landscape. This special issue is the result of collaboration between Slovenian and Czech geographers, and it features six articles covering land-use changes from the perspective of natural geography, political geography, ecosystems, farms, and metrics. The articles, which explore the processes of changes at the national and regional levels, are based on the textual part of the Franciscan Cadaster, and the local studies are based on the cartographic part of the cadaster.

KEY WORDS: geography, agrarian geography, historical geography, land-use changes, Franciscean cadaster, Europe

Zemljiški kataster kot vir proučevanja dolgoročnih sprememb rabe zemljišč

POVZETEK: Zemljiški kataster vsebuje podatek o rabi zemljišč, ker je ta podatek pomemben za njihovo vrednotenje in obdavčitev. Nekatere evropske države so že v 19. stoletju izdelale kataster za območje celotne države. Habsburška monarhija je v prvi polovici 19. stoletja izdelala tako imenovani franciscejski ali stabilen kataster. Kataster prikazuje tradicionalno, predindustrijsko kulturno pokrajino in omogoča analize spremembe rabe zemljišč oziroma preobrazbo tradicionalne kulturne pokrajine. Posebna številka je rezultat sodelovanja med slovenskimi in češkimi geografi, obsega šest prispevkov, ki obravnavajo spremembe rabe zemljišč z naravno- ter političnogeografskega, ekosistemskega, kmetijskogospodarskega in metričnega vidika. Članki, ki obravnavajo procese sprememb na državni ali regionalni ravni, temeljijo na pisnem delu, krajevne študije pa na kartografskem delu franciscejskega katastra.

KLJUČNE BESEDE: geografija, agrarna geografija, historična geografija, spremembe rabe zemljišč, franciscejski kataster, Evropa

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1 Introduction

This special issue of *Acta geographica Slovenica* features articles dealing with land-use changes. The series of articles presented continues the long-standing tradition of exploring land-use changes in Slovenian geography (Ilešič 1950; Medved 1970; Gabrovec and Kladnik 1997; Gabrovec and Kumer 2019), and the collaboration with fellow researchers from the Czech Republic (Bičík, Jeleček and Štěpánek 2001; Bičík et al. 2015) extends this research into other parts of central Europe. The six articles featured in this special issue are presented in greater detail in Section 3 of this article but here it is sufficient to say that land-use changes are discussed from the perspective of natural geography, political geography, ecosystems, farms, and metrics.

Land use is an important human footprint (Komac 2009) in a landscape, and landscape changes reveal a great deal about the geographical processes shaping it (Šmid Hribar et al. 2017; Špulerová et al. 2017; Geršič Gabrovec and Zwitter 2018). Just as territoriality is the primary expression of social power, land-use changes are an important aspect of the historical relationships between society and space. Land-use changes in Europe reflect a combination of traces of feudal, industrial, and postindustrial processes, including settlement, whereas elsewhere the influences of precolonial land use on later processes can be observed. For example, the earliest European settlers in the Americas had a clear preference for sites with a long history of Native American occupation located on productive wide floodplains (Coughlan and Nelson 2018).

Surprisingly, even in today's technology- and information-based society, agriculture remains the most important factor in land-use change on Earth, considering that approximately a third of its surface is used for growing crops or grazing. Agricultural land transformation has been especially rapid in the past three hundred years (Ramankutty et al. 2006).

Various types of sources are available for determining land use and its changes. Remote sensing has been at the forefront in recent decades, and various textual and cartographic historical sources are available for older periods. Land registers, or cadasters, are key among these and their introduction is connected with the economic transformation mentioned above. Land registers usually entail parcel-based information systems featuring information on land use and the related rights and restrictions (Foški et al. 2018). They include a textual part and a graphic section or cadastral maps, which show the relative and absolute locations of parcels in a specific area (usually a cadastral district). Maps are produced at a scale of one to several hundred up to one to several tens of thousands. Historically, there were two reasons for maintaining records on land use: fiscal and legal. Income and the related taxation depend on land use, which is hence the key piece of information of any land register. The land register itself is a useful tool for recognizing and controlling land rights, such as ownership (Lisec and Navratil 2014).

The applicability of land-register data to analyses conducted at the regional level depends on the method of publishing these data and varies by country and historical period. If land use is marked on cadastral maps in different colors, scanning and georeferencing these maps makes it possible to include land-use data in geographical information systems and analyze land-use changes (Petek and Urbanc 2004; Yang et al. 2014). The publication of summary tables on land use at the municipal level by year allows comparative studies of long-term land-use changes (Bičík, Jeleček and Štěpánek 2001; Petek and Urbanc 2004; Bičík et al. 2015; Gabrovec and Kumer 2019).

2 Brief historical overview

Landed properties were represented on a map to a limited extent in ancient Mesopotamia. The Royal Registry of ancient Egypt was created in about 3000 BC (Kain and Baigent 1992), and in China the taxation system based on land survey records was established in AD 700. The Romans carried out a land survey in AD 300, and they held regular and detailed censuses, such as Emperor Vespasian's AD 77 survey map in Campania (Larsson 1996; Kain and Baigent 1992). Since the Classical period, accurate cadastral records have been an important tool for proving ownership of land, which in turn earned people substantial privileges such as citizenship (Manville 1990); this predominated until the twentieth century (Heater 1990; Vilfan 1996).

The demise of the Roman Empire also saw the end of property registration. Land registers at the level of regions and countries began to be reestablished in Europe during the sixteenth century. European countries that stand out in terms of either an early introduction of the land register or its quality, which makes it possible to study land use at least from the nineteenth century onward, are presented below. The Netherlands was among the first to introduce a land register, and its introduction was connected with collecting taxes for the maintenance of dikes in the polders and acquiring new land. On 1:3,000 to 1:5,000 cadastral maps from the first third of the sixteenth century showing the area north of the town of Alkmaar, different colors were also used to indicate land use (Kain and Baigent 1992). A land register covering the entire national territory was produced in the first half of the nineteenth century, featuring 1:1,250 to 1:5,000 maps and providing information on the owner, land use, quality, and yield for each parcel (Kain and Baigent 1992).

A very long tradition of property taxation and assessment is typical of Sweden (Mansberger 2015). The Swedish land survey was established in 1628 under King Gustavus Adolphus. The 1636 instructions gave surveyors a detailed color scheme in order to standardize presentation on the maps: »Cultivated fields were to be colored gray, meadows green, mosses yellow, fences black, lakes light blue, rivers dark blue, boundaries red, forests dark green, and stony slopes white« (Kain and Baigent 1992, 54). The maps were produced at a scale of 1:5,000 and 1:3,333. The forests and wasteland around the villages were not included, and therefore a large part of the national territory was not surveyed (Kain and Baigent 1992). At the time it was created, the Swedish land register was the most extensive cartographic work in Europe. Unlike modern aerial photos, the cadastral maps it contained make it possible to analyze land-use changes over a period of three hundred years. Cousins (2001) conducted such an analysis on a 2.2 × 2.8 km area in Nynäs south of Stockholm.

In France, discussions on designing a land register began as early as the end of the eighteenth century and systematic work began in 1807 after the relevant law was adopted. Work was completed in 1850. Cadastral maps used various scales, ranging from 1:500 to 1:5,000, and the textual part of the land register also contained summary tables on land use in individual municipalities. The land register has been used as a source for several studies of changes in land use as well as visible aspects of the rural landscape (Clout and Sutton 1969). Perpilou was the first researcher in France to base his analyses of land-use changes on cadastral maps, such as the one presented in his study of the Limousin region, which he conducted based on summary tables on land use in nine hundred municipalities (Perpilou 1959). Juillard and Angrand (1961) produced maps of nineteenth- and twentieth-century land use in eastern France based on the textual part of the land register. A comprehensive volume about land-use changes in nineteenth-century France was authored by Clout (1983). Gabet (1965) used the cadastral maps for geomorphological research – specifically, for measuring cliff retreats.

In Denmark, many of the attributes and history of the Napoleonic land registers can be observed. The Danish land register was established in 1844. Its text and maps have been updated continually ever since. The first Danish land register was created in 1688 but it contained no maps. The land was surveyed at a scale of 1:4,000 in the last two decades of the eighteenth century. Each map included a village and the associated cultivated areas. The land register is still used to collect land taxes, but to a much smaller extent because the property tax has been based on the market value of the individual properties since 1903 (Enemark 1992; 1994).

In Norway, the most extensive body of historical maps is made up of the cadastral maps designed after the 1857 Land Consolidation Act, which brought about an extensive reorganization of agricultural areas. These 1:2,000 maps make it possible to analyze changes in the cultural landscape (Domaas 2007; Hamre, Domaas and Austad 2007).

Unlike France and the Scandinavian countries, during the nineteenth century Germany was not yet united, but consisted of many smaller states. Land-register development varied by state and was influenced by French, Dutch, and Scandinavian models (Kain and Baigent 1992). Based on the cartographic and textual parts of the Bavarian land register, which has been kept continually since the mid-nineteenth century, Bender et al. (2005) analyzed cultural landscape changes and used them to produce a scenario of future development.

The Milan land register is the predecessor of the Habsburg land register. Lombardy and the Duchy of Milan were part of the Habsburg Monarchy at that time, and the survey there was carried out from 1720 to 1723, with maps produced at a scale of 1:2,000. During the 1750s, the Theresian Cadaster was designed in the monarchy, followed by the Josephinian Cadaster between 1785 and 1788. It was completed in four years; however, the surveys were conducted hurriedly with the main objective of determining the areas of land parcels, and no or only limited graphical documentation was provided (Lisec and Navratil 2014). The Josephinian Cadaster provided the basis for the Franciscean Cadaster, which is examined by the articles featured in this special issue and presented below.

3 Articles

What all the articles in this special issue have in common is the Franciscean Cadaster, often also referred to as the Stable Cadaster. It was created in the Habsburg hereditary lands between 1818 and 1828 following the reforms introduced by Emperor Francis I and it succeeded the Josephinian Cadaster. This cadaster is the key data source for the territory of the former Habsburg Monarchy. It was produced in the first half of the nineteenth century for the Austrian part of the empire, which included what is now Austria, Czechia, and Slovenia, and parts of what is now Italy, Croatia, Poland, Ukraine, and Romania, and in the second half of the nineteenth century for the Hungarian part, which included what is now Hungary and Croatia, and parts of Romania, Serbia, and Slovenia (Lisec and Ferlan 2017). The importance of this cadaster as the source for studying the nineteenth-century cultural landscape and its later transformations is demonstrated by Petek and Urbanc (2004), and Bičík et al. (2015), and an overview of literature on land-use changes based on this source was prepared by Gabrovec and Kumer (2019).

The first article in this special issue of *Acta geographica Slovenica*, titled »Long-term land-use changes: A comparison between Czechia and Slovenia « (Bičík, Gabrovec and Kupková 2019), is the first comparative study of land-use changes in two central European countries over a period of two centuries using uniform quantitative methods. The driving forces of land-use change have been comparable in both countries. However, the Czech cultural landscape was more significantly transformed due to nationalization and collectivization, whereas in Slovenia fragmented private property contributed to preserving nineteenth-century cultural landscape elements. The article helps better understand past, present and future land-use changes in central Europe.

The second article, titled »Long-term land-use / land-cover changes in Czech border regions« (Bičík, Kupková and Boudný 2019), discusses the long-term impact of borders and border regimes on land use. The authors used the Czech–German and Czech–Austrian border to present land-use changes in nine thousand territorial units between 1845 and 2012, and they also conducted a pilot study of a locality in the eastern part of the Krkonoše Mountains. They established a significant increase in forests and grasslands accompanied by an extreme decrease in arable land in the second half of the twentieth century, driven by the political changes after 1945 and 1989. After 1990, the landscape changes in the Czech Republic were greater than those in Austria and Germany.

The article »Land-use changes in Slovenian terraced landscapes« (Kladnik et al. 2019) presents long-term land-use changes in eight areas of various Slovenian landscapes. It offers a comparison of changes on terraced and non-terraced land from the early nineteenth century to the present and a typological classification of land-use change; specifically, extensification, afforestation, grass overgrowth, intensification, and urbanization. It demonstrates large differences in influencing factors and the rate of land-use change between terraced and non-terraced land, which reflect both economic growth and the general economic and political-administrative situation in Slovenian regions.

In the article »Assessment of land-use changes and their impacts on ecosystem services in two Slovenian rural landscapes« (Ribeiro and Šmid Hribar 2019), the authors use two pilot areas to explore the links between land use, landscape changes, and ecosystem services. They state that, from the perspective of ecosystem services, intensification and overgrowth should be restricted. The paper presents an approach that can be used as a support tool for decision-making in managing and governing landscapes.

The article »Monitoring land-use change using selected indices« (Foški and Zavodnik Lamovšek 2019) presents various land-use change indices developed by the authors or derived from landscape metrics. They were calculated for five selected sites in agricultural land (i.e., fields) for the time when the Franciscean Cadaster was introduced and for 2015. It was found that the numerical values mostly reflect the visually detected land-use changes well and show land-use fragmentation. The indices could be used as an objective approach in systems monitoring land-use change.

4 Conclusion

National authorities introduce land registers to assess and tax property. Information on land use, which is an important cultural landscape element, is an integral part of these registers. Except for rare previous examples in smaller areas, European countries began introducing land registers at the national level during the eighteenth century, but it was not until the nineteenth century that the first countries began introducing land registers with appertaining maps for their entire national territory. The Habsburg Monarchy stands out among these for having produced the high-quality Franciscean Cadaster, or Stable Cadaster, for the Austrian part of the monarchy in the first half of the nineteenth century. This cadaster thus shows the cultural landscape at a preindustrial stage, which is why it can also be described as a traditional cultural landscape. The central topic covered in this issue is land-use change or the transformation of the traditional cultural landscape, with all articles using the Franciscean Cadaster as their primary data source. Cases are presented from Slovenia and Czechia. The authors used data from both the textual and cartographic parts of the cadaster. The textual part was used in articles dealing with the national and regional levels, and the cartographic part was used in case studies at the level of individual municipalities. All the articles deal with the countryside, which predominated in the nineteenth century. Agricultural land use is thus at the forefront of the studies presented, with authors interested not only in the changes in the area and share of individual land-use types, but also the fragmentation of land use and its connection with other factors, such as relief characteristics, cultivated terraces, and state borders. Land use is connected with the ecosystem services and the level of biodiversity in individual landscapes, both of which can increase or decrease with changes in land use.

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LONG-TERM LAND-USE CHANGES: A COMPARISON BETWEEN CZECHIA AND SLOVENIA

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Many elements of the 19th century land use patterns are preserved at Sorško polje Plain in Slovenia.

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Long-term land-use changes: A comparison between Czechia and Slovenia

ABSTRACT: Detailed information about land use is available from the mid-nineteenth century onward for the countries of the former Habsburg Monarchy. For Slovenia and Czechia, databases have been created that make it possible to analyze the period from the first half of the nineteenth century to the beginning of the twenty-first century. The processes of changing land use were comparable during the period examined. Nonetheless, the cultural landscape in Czechia was significantly more transformed. Because of the nationalization of land after the Second World War and the establishment of state-owned collective farms and cooperatives, today large complexes of farmland predominate, whereas in Slovenia fragmented properties still predominate, and the cultural landscape therefore preserves many more elements from the nineteenth century.

KEY WORDS: geography, agrarian geography, historical geography, land-use changes, Franciscean cadaster, Slovenia, Czechia

Dolgoročne spremembe rabe zemljišč: Primerjava med Češko in Slovenijo

POVZETEK: Za države nekdanje Habsburške monarhije so podrobni podatki o rabi zemljišč na voljo od sredine 19. stoletja. V Sloveniji in na Češkem je urejena podatkovna baza, ki omogoča analize za obdobje od prve polovice 19. do začetka 21. stoletja. Procesi sprememb rabe zemljišč so bili v obravnavanem obdobju primerljivi. Kljub temu pa se je kulturna pokrajina na Češkem bistveno bolj preobrazila. Zaradi podržavljenja zemljišč po 2. svetovni vojni in ustanavljanja državnih kmetijskih posestev in zadrug danes prevladujejo veliki kompleksi kmetijskih zemljišč, medtem ko v Sloveniji še vedno prevladuje razdrobljena posest, v kulturni pokrajini je zato ohranjenih mnogo več elementov iz 19. stoletja.

KLJUČNE BESEDE: geografija, agrarna geografija, historična geografija, spremembe rabe zemljišč, franciscejski kataster, Slovenija, Češka

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1 Introduction

Analyses to date of changes in long-term land use, which cover a period of at least two hundred years, are limited to the territories of individual countries (Himiyama et al. 2001; Gillmor 2001; Bičík et al. 2015; Gabrovec and Kumer 2019). There is a lack of studies comparing changes in land use across multiple countries for such a timespan. This article addresses this research gap by comparing long-term land-use changes in Slovenia and Czechia. These two countries were selected because databases on land use are available for their territories; these databases were created based on archival cadastral material and they cover the period from the first half of the nineteenth century to the beginning of the twenty-first century. The data are available at the level of cadastral units, and analyses of land-use changes during this period have also been published (Bičík, Jeleček and Štěpánek 2001; Bičík et al. 2015; Gabrovec and Kumer 2019). These publications have shown the processes of land-use change using various statistical methods, supplemented by extensive cartographic material. These findings are only conditionally comparable because of the use of different methods. In this article, the databases for both countries are arranged in the same manner, which means that various land-use categories have been combined into the same groups. For the period from the first half of the nineteenth century to the beginning of the twenty-first century, a typology developed by Czech geographers (Bičík and Jeleček 2009) was used to show land-use changes, and an index of change was calculated that has also already been used multiple times in Czechia (Bičík et al. 2015). This makes direct comparisons possible, and the differences are explained below through various driving forces behind the changes resulting from differences in both countries' economic and political development, as well as their natural features.

Outside of Slovenia and Czechia, studies of land-use changes based on detailed cadastral data for the time period studied are available only at the level of individual case studies (Cousins 2001; Kanianska et al. 2014; Harvey, Kaim and Gajda 2014; Prokop 2018), which make it possible to identify individual processes, but do not allow analyses or determination of patterns at the country level. Many case studies have also been carried out in Slovenia and Czechia (Ažman Momirski and Gabrovec 2014; Bičík, Kupková and Štych 2012; Gabrovec 1995; Gabrovec, Komac and Zorn 2012; Mares, Rasin and Pipan 2013; Paušič and Čarni 2012; Petek and Urbanc 2004; Rašín and Chromý 2010; Šmid Hribar 2016; Štych et al. 2012; Geršič, Gabrovec and Zwitter; Žiberna 2018), and these allow a more detailed explanation of the driving forces behind land-use changes.

2 Methods

The index of change (Bičík and Kupková 2002; Bičík et al. 2015) was used in our study. It is an aggregate index and indicates the intensity of land-use changes (in %) over a certain period of time; it does not, however, assess the »quality« (structure) of such changes.

$$IC_{A-B} = 100 \cdot \frac{\sum_{i=1}^{n} \left| P_{iB} - P_{iA} \right|}{2}$$

IC_{A-B} is the index of change between year A and year B; n indicates the number of land-use classes; P_{iA} is the proportion of relevant land-use class at the beginning of the period examined, and P_{iB} is the same proportion at the end. The higher the index of change, the more intensive the land-use change in the area examined. This index ranges from 0 to 100 and – put in a simple way – indicates the proportion of area where any land-use change occurred, based on a comparison of the beginning and end (changes that may occur during the period examined are not reflected). Territorial »shifts« without a change in size are also ignored, although these are relatively frequent, especially in the case of agricultural land.

In this article, five land-use classes are taken into consideration: arable land, permanent cultures, permanent grassland, forested areas, and other areas. The unit of analysis is cadastral municipalities or, in the Czech case, basic territorial units, which are comprised of one or more cadastral municipalities. The Slovenian and Czech land-use categories differ somewhat in their details. Nonetheless, there are no major difficulties in combining them into five identical land-use classes. The greatest difference between the Slovenian and Czech categorization (Bičík et al. 2015; LUCC Czechia 2018) is in protected areas. This was a special category in the Czech case in 2010 that was included among other areas, and in Slovenia this category does not exist; with regard to land cover, protected areas are included among the other areas only in the case of land above the tree line, otherwise they are primarily classified as permanent grassland or forest areas.

Aggregate changes in land-use structure can be presented in a number of typologies. The one used in this article is based on areal increases (or decreases) in selected land-use classes (Bičík and Kupková 2002; Bičík et al. 2015). The classes that show an increase or decrease over the period of time examined are marked + or −; by using combinations of increases and decreases (related to different classes), various types are created. Changes in the three aggregate classes (agricultural land, forest areas, and other areas) over time are compared in this manner. To sum up, this typology is a simple one and indicates directions only, but not any significance of the changes observed.

3 Driving forces of land-use changes

»*Change in land use and land cover can be conceptualized as the result of the operation of pressures or driving forces: an impulse is applied, and a change of state results*« (Mather 2006, 179). Five factors commonly appear: population, economic development, technology, institutions, and culture (Mather 2006). In the case of Slovenia and Czechia, the driving forces were similar in certain historical periods and different in others. Similar processes were characteristic until the First World War, when both countries were part of the Austrian Monarchy, and after 2004, when both countries joined the European Union. The driving forces differred the most in the second half of the twentieth century. Even though both countries had a communist government, their economic policies and especially their agricultural policies differed significantly. The most important trend during the period examined was the growing importance of economic and social factors in the context of rapidly spreading technological and social innovations. Regarding the value of land as a natural resource, in fertile regions the economic aspects prevailed, and in less fertile areas the environmental aspect was the most important one (Bičík and Jeleček 2005; Bičík et al. 2015).

3.1 From the nineteenth century to the First World War

The land-use data from the first half of the nineteenth century show land-use structure as a result of centuries-long gradual agricultural use before industrialization. The economic and technological limits of the preindustrial production mode were behind the relatively low regional differences. Transport remained slow and costly, and long-distance trade and competition were limited. Most products were consumed locally, and the spatial division of labor and specialization remained weak. Most material goods, energy, and so on circulated within a limited space only (i.e., farms and villages). Consequently, different land-use types had to be spatially interconnected. Everywhere, including in mountainous regions, it was essential to possess enough arable land (to provide food), grassland (for livestock), and forests (to provide fuel and construction material) (Hampl 2000; Jepsen et al. 2015; Krausmann et al. 2003; Bičík et al. 2015). The revolutionary movements of 1848–1849 resulted in the end of feudalism: serfdom was abolished, the industrial revolution was accomplished, and the path toward a new social and economic organization, free-market capitalism, was opened. Much of the land that had previously been owned (and rented out) by landlords became the property of small farmers (Bičík et al. 2015). The long-term increase in arable land came to an end in both countries at the end of the nineteenth century. Industrialization took place more slowly in Slovenian territory than in Czech territory, and so with the growing population there was an increase in agrarian overpopulation in Slovenia, which reached its apex at the end of the nineteenth century (Petek 2005). In Slovenia, at the end of nineteenth century most of the population still earned a living through agriculture, standing at 76% in 1890. Despite labor-intensive agricultural production, it was impossible to feed the entire population and there were not many jobs outside of farming, and so there was significant emigration, especially to North America (Kladnik and Andrič 2013). Industrialization and agricultural intensification in Czech territory on the contrary caused development of urbanization, movement of rural population to the cities and increase of working class in the cities.

3.2 The interwar period

Following the war, Czechoslovakia was among the newly emerged nation states. Slovenia became part of the new Kingdom of Serbs, Croats, and Slovenes, which was renamed the Kingdom of Yugoslavia in 1929. One quarter of the territory of present-day Slovenia belonged to Italy until the end of the Second World War.

The structure of Czech (or Czechoslovak) agriculture changed significantly after the country's independence. The Land Reform Act was passed in 1919, and transfers of land started in 1920. The new laws stipulated that landowners could possess a maximum of 150 hectares of agricultural land, or 250 hectares of land altogether. The excess land was purchased by the state. The land reform of the 1920s fundamentally changed the land ownership patterns and tenure in rural areas. In the past, the large estates in general had been focused on cash crops. In contrast, most new landowners were forced to become subsistence farmers and had to labor intensively in the fields. This is why the amount of arable land slightly increased and permanent grassland decreased in terms of size in the mid-1920s. The driving forces that influenced the economy and society also underwent substantial changes. Agriculture was less important; industry and to some extent also services became the leading sectors. These trends are reflected in the changing structure of the workforce by sectors. Residential and industrial developments were booming, especially in urban areas. Consequently, built-up and remaining areas increased. However, this was a regionally unbalanced process (Bičík et al. 2015).

In Slovenia, agriculture was characterized by land fragmentation, as seen in the smaller average size of farms and the growing number of plots of land on farms. In 1931 the average farm measured 8.3 hectares. Market production was modest. The most market-oriented sectors were viticulture and fruit growing, and hop production continued to remain profitable, whereas silk production died out during this period. The entire period was also characterized by considerable industrialization in Slovenia (Kladnik and Andrič 2013).

3.3 From the Second World War to 1990

From 1948 to 1990, Czechoslovakia was ruled by a communist government. It is important to understand that all crucial decisions were de facto made by the Central Committee of the Czechoslovak Communist Party, which influenced the social and economic conditions, including land-use patterns. The most important land-use changes during the last 170 years took place between 1948 and 1960. This was a time of major economic and social changes, which included the effects of the expulsion of ethnic Germans, a new political and geopolitical orientation and economic system, large-scale industrialization, introduction of collective farming, emergence of military training areas, and the depopulation of rural areas (Bičík and Jeleček 2005). The communist government relied on outdated, inefficient energy and raw materials, and a very demanding industrial structure that could not compete with advanced western European countries. Shortly after the communist coup d'état (in February 1948), the Iron Curtain fell across the western border, large tracts of land became inaccessible, and in many cases new settlers had to move back. In this case, the effects on land-use patterns were great and almost immediate. Farming was severely restricted in areas along the border (only state-owned farms were allowed) and was often completely forbidden. Much of the western border is located at rather high elevations (25% of border regions are over 700 m), despite the fact that the German-speaking population had formerly intensively cultivated these regions. After the expulsion of the German population from 1945 to 1947, hundreds of villages and towns (up to 1,200) ceased to exist, and much of the arable land was completely abandoned. Communist reforms of Czechoslovak agriculture were carried out in three stages. First, the land previously owned by ethnic Germans and Nazi sympathizers was confiscated. In 1947 and 1948, mostly forests were nationalized. Finally, the new land reform that started in March 1948 confiscated all properties over fifty hectares. Even after these dramatic shifts, some 60% of farmland was still owned by private farmers – until the rise of cooperatives. Private farmers were encouraged, often violently, to join cooperatives and state farms; this process happened virtually in every single village. Later, cooperatives were gradually amalgamated into large units. Collectivization was rapid in the early 1950s, slowed down after 1955/1956, and came to an end in 1960. By the end of the 1980s, cooperatives and state farms managed 98.5% of all agricultural land. Cooperatives and state farms gradually introduced large-scale agricultural production on amalgamated fields. Settlement patterns changed fundamentally after the Second World War, and the state reacted by introducing a new official settlement network.

Starting in the early 1970s, it attempted to concentrate the dispersed population into so-called central settlements. Large-scale industrialization and intensive exploitation of raw materials were among the most important driving forces in the landscape during this period. Large residential projects, usually prefabricated blocks of flats, were built in mining and industrial regions to provide accommodation for the workforce, mostly migrating from rural areas. These new massive urban developments appeared almost exclusively on greenfields (Bičík et al. 2015).

In Slovenia, agricultural and rural development following the Second World War resulted from the impact of diffuse industrialization, which fostered urbanization. This urbanization remained hidden to some degree, however, due to extensive daily commuting. The split with the Soviet Union and its satellites in 1948 had a significant impact on Yugoslavia's development of an independent approach to communism. Despite agrarian reform pressures and other ongoing pressures for nationalization, in Yugoslavia nationalization was only carried out on a small scale, and in Slovenia the proportion of private land never fell below 85%. The agrarian reform act of December 1945 enacted the seizure without compensation of all land owned by »capitalist« landowners (i.e., banks, companies, joint-stock companies, monasteries, and churches) that encompassed more than twenty-five hectares of cultivated land. Other farm owners with more than twenty-five hectares of land received monetary compensation for their surplus land that was seized, as did nonfarming households, which were allowed to keep only three hectares of cultivated land. It was envisaged that compensation for the seized land would be paid out in the amount of one year's yield per hectare. Half of the land acquired in this way was allotted to people without land and other poor farmers with less than 2.5 hectares of land. The size of private farms was limited to ten hectares of cultivated land after 1953 (Kladnik and Andrič 2013; Čepič 1995). In the 1973, the maximum permitted landholding in Slovenia was increased to twenty hectares in mountain and karst areas (Avsec 1988). Because of the small and fragmented properties, income from farming was not sufficient to make a living, and so farmers started to take jobs in industry, working their land in the afternoon and on weekends. An increasingly large stratum of part-time farmers took shape. Their income from nonagricultural activity was largely invested in modernizing the farms. Job opportunities in industry and other activities for the rural population prevented the abandonment of farmland and made it possible to preserve farming activity and the rural cultural landscape (Klemenčič 1968; Klemenčič 1974; Logar 2013; Razpotnik Visković 2013; 2015). In an effort to offset the negative impact of permanent land loss due to urbanization, an extensive program of land reclamation was begun in the 1970s, the centerpiece of which was irrigation and drainage, which was ecologically highly controversial (Kladnik and Andrič 2013). Due to these processes, in 1990 the Slovenian rural landscape was completely different from the Czech one. Whereas large state-owned properties predominated in what is now the Czech Republic, in Slovenia a fragmented property composition was preserved that did not differ significantly from that of the nineteenth century.

3.4 After 1990

After 1990, full-scale political and economic liberalization was achieved, the central European countries became EU and NATO members, and standard capitalist and democratic regimes were established based on a market economy. In Czechia, the former state-owned farms have been transformed into limited companies through privatization. The communist-style collective farms have been transformed into cooperatives managed by landowners that nowadays constitute relatively functional units. People do not have an affiliation with the land. In most cases, the new owners that regained their land through restitution did not start farming but instead rented the land out. The greatest share of agricultural land is managed either by limited companies (46%) or by transformed cooperatives (23%). In the European context, these companies are rather large, which allows cost-effective farming and competitiveness. As Havlíček (2018) points out also a large part of land seized by communist regime from churches between 1948 and 1989 was returned to the churches mainly in 2014 and 2015. Overall, the period after 1990 was characterized by a decline in total agricultural production. Czech agriculture as a whole continues to profit from EU membership and from the subsidies in the framework of the Common Agricultural Policy. The continuing decrease in arable land is the most important land-use change after 1990. In most cases, arable land was converted into permanent grassland, also (sub)urbanization was important process of landscape change in this period (Bičík et al. 2015).

Slovenia has been caught up in a storm of rapid tertiarization and, in the past two decades, also globalization, which has exposed the great vulnerability of Slovenian agriculture that does not meet the agricultural production standards in developed countries around the world. With accession to the European Union, state protectionism was also dropped, and Slovenian farmers found themselves in a tough battle to survive on the global market. This started with independence of Slovenia (in 1990). By far the most important incentive that still motivates farmers to continue their rural way of life is preserving their farm tradition, something that has usually provided work for several generations. Other reasons include enjoyment of farm work, the desire to have one's own produce, and attachment to the land. Regardless of these motives to preserve agricultural land use, financial instruments as part of European Union rural development measures have a significant impact. One of the mega-drivers preventing more efficient use of farmland remains land fragmentation, but nonetheless there is a slow decrease in the number of farms and an increase in the concentration of land. There is also growing interest in land consolidation and agglomeration (Kladnik and Andrič 2013; Lampič et al. 2017).

4 Results

4.1 Overview of land use changes

A comparison of land-use changes in Slovenia and Czechia (Figures 1 and 2) shows that the processes in both countries were similar. During individual periods, the shares of individual types of use changed in the same direction and in comparable dimensions. However, the initial composition of land use already significantly differed in the nineteenth century, which was a result of natural geographical conditions. Thus, in Czechia the share of arable land is approximately twice as large as in Slovenia, and the share of forested land and permanent grasslands is correspondingly smaller (Gabrovec and Kladnik 1997; Gabrovec, Petek and Kladnik 2001; Bičík et al. 2015).

4.2 Index of change

In both countries, the index of change (Figures 3 and 4) shows a similar picture, with the highest values in two types of areas. It seems reasonable that the highest values are recorded in the core areas with intensive social and economic development. However, the majority of peripheral, mountainous border regions have also witnessed rather intensive changes. In both countries, the greatest changes took place in areas from which the ethnic German population moved or was expelled during or immediately after the Second World War. In Slovenia this is the Kočevje area in the southeast part of the country (Mares, Rasin and Pipan 2013), and in Czechia the hilly Sudetenland along the border with Germany. In addition, in Slovenia the Kras Plateau in the southwest part of the country should be highlighted. The Franciscean cadaster shows that among all Slovenian regions natural forest vegetation was cleared the most on the Kras Plateau, which was at that time synonymous with the barren and desolate karst landscape. Today forest covers more than half of the Kras Plateau, which is the result of planned reforestation at the end of the nineteenth century (Kladnik, Petek and Urbanc 2008; Kladnik 2011; Zorn, Kumer and Ferk 2015) followed by natural succession of meadows and pastures.

4.3 Typology of land-use changes

The maps of the typology of land-use changes in Slovenia (Figure 5) and Czechia (Figure 6) show a roughly similar picture, in which Class C predominates in both, showing a simultaneous increase in forested areas and other areas; that is, a combination of urbanization and afforestation. The next, with a much smaller share of cadastral municipalities, is Class A, corresponding to an increase in other areas – that is, primarily built-up land, and at the same time a decrease in farmland and forested areas. In Slovenia, in contrast to Czechia, Class B – which indicates the expansion of forested areas and a simultaneous decrease in farmland and built-up land – corresponds to just under a tenth of cadastral municipalities. In Slovenia, in addition to the Kočevje region, which the ethnic German population was expelled from, this class includes some

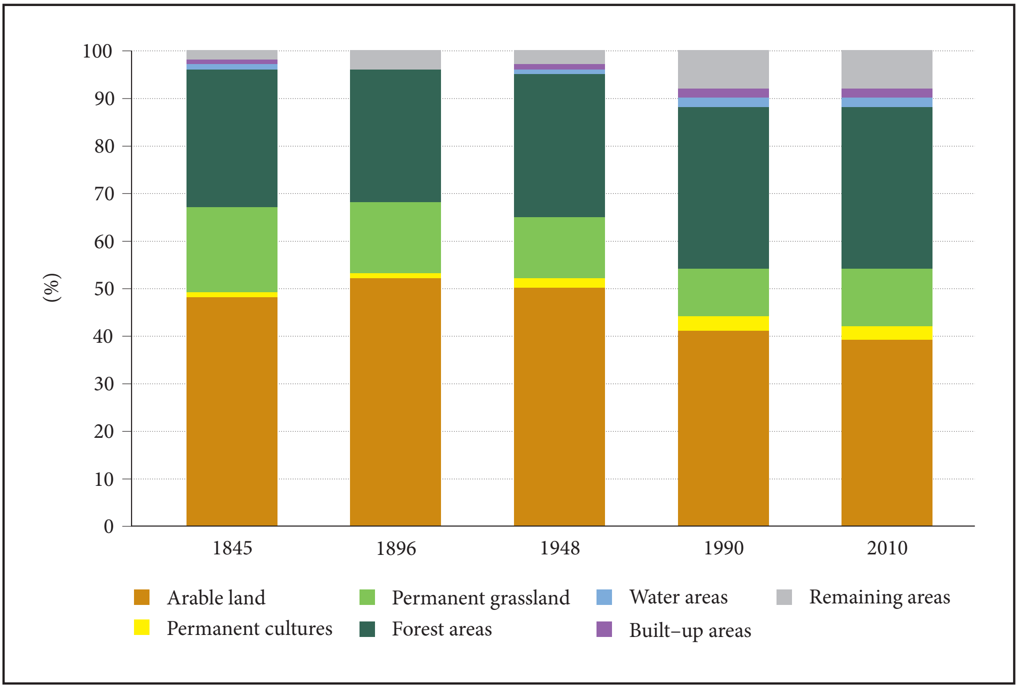

Figure 1: Czech land use between 1845 and 2010.

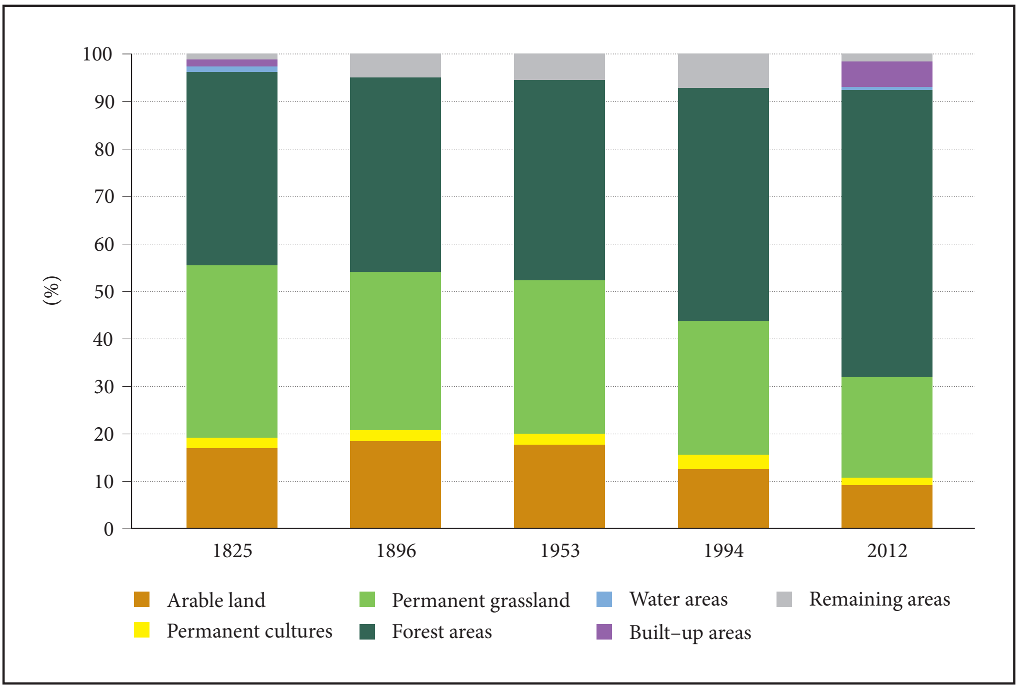

Figure 2: Slovenian land use between 1825 and 2012.

sparsely settled depopulation areas, especially in western Slovenia. This class would also include hilly border areas in Czechia, but in terms of land use much of the forested land there has been classified as protected areas (as mentioned in Section 2), which was included among other areas. In the typology of land-use change these areas are therefore mostly included in Class C.

5 Discussion and conclusion

This article is the first comparative study of land-use changes in two central European countries over a period of two centuries using uniform quantitative methods. It uses the index of change and typology of changes based on the calculated increase or decrease in farmland, forested land, and other land. The processes of land-use change were based on the driving forces behind the changes from the first half of the nineteenth century to the present, and these differed the most between the two countries during the twentieth century. The consequence of different agricultural policies in the period after the Second World War is not reflected so much in different land use, but in the different sizes of parcels and the diversity of land use.

Although the driving forces behind the changes are presented in the framework of short time periods, land-use changes are cartographically presented and analyzed only between the beginning of their study in the nineteenth century and 2010 or 2012. In the future it would therefore make sense to examine the second half of the twentieth century in greater detail because the processes of change were most intense during this period and at the same time there were also the greatest differences between the two countries. As a result, one would expect greater differences in the processes of land-use changes, but the analysis showed that these were comparable during the period analyzed. Nonetheless, the cultural landscape in the Czech Republic has been visually transformed to a significantly greater extent. Because of the nationalization of land after the Second World War and the establishment of state-owned collective farms and cooperatives, today large complexes of farmland predominate, whereas Slovenia is still characterized by fragmented properties and the cultural landscape therefore preserves many more elements from the nineteenth century.

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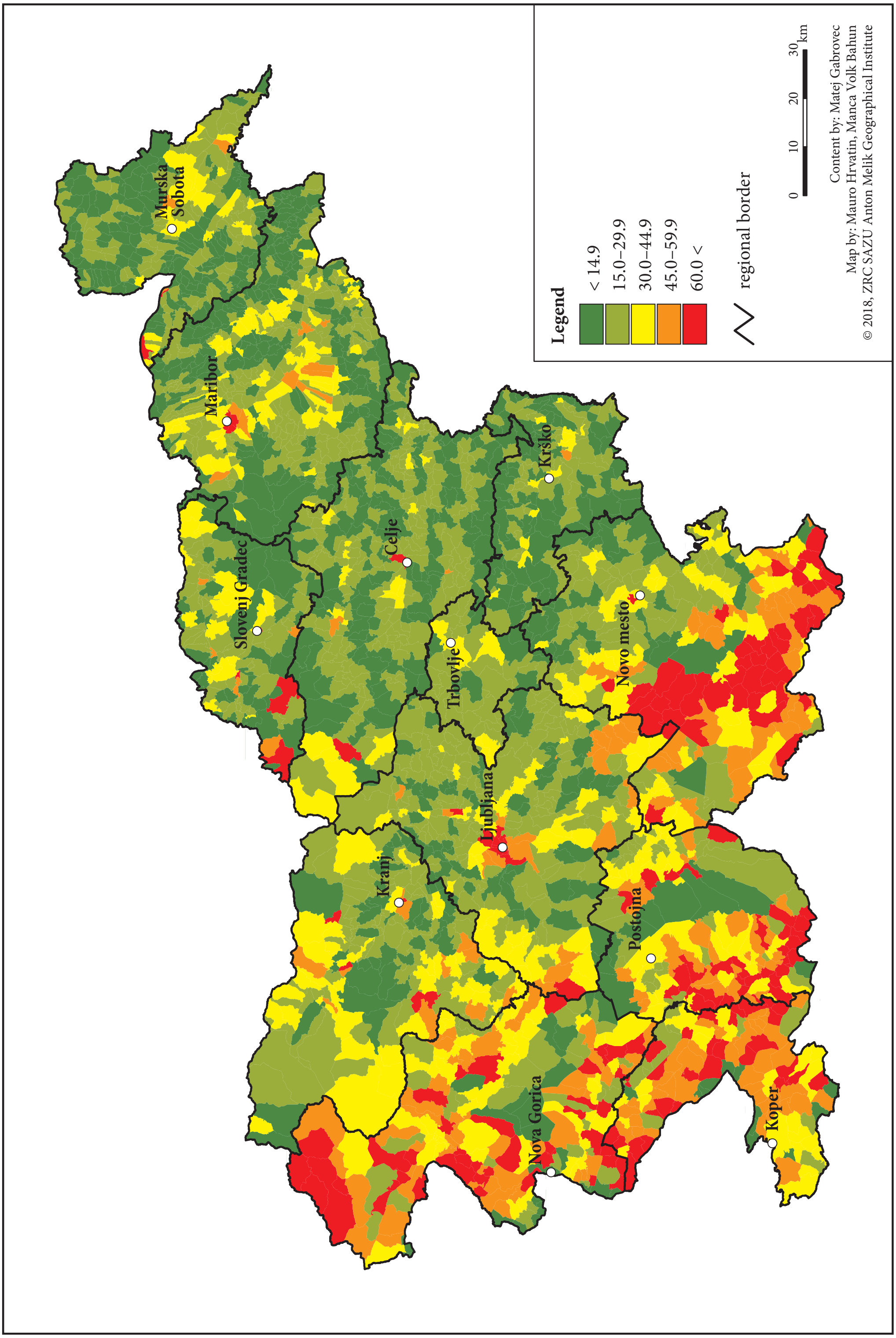
Figure 3: Index of change between 1825 and 2012 in Slovenian territory. ➤ p. 100
Figure 4: Index of change between 1825 and 2012 in Czech territory. ➤ p. 101
Figure 5: Typology of land-use change in Slovenian territory (1825–2012). ➤ p. 102
Figure 6: Typology of land-use change in Czech territory (1845–2010) (LUCC Czechia 2018). ➤ p. 103


Murska Sobota
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Novo mesto
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Map by: Mauro Hrvatin, Manca Volk Bahun
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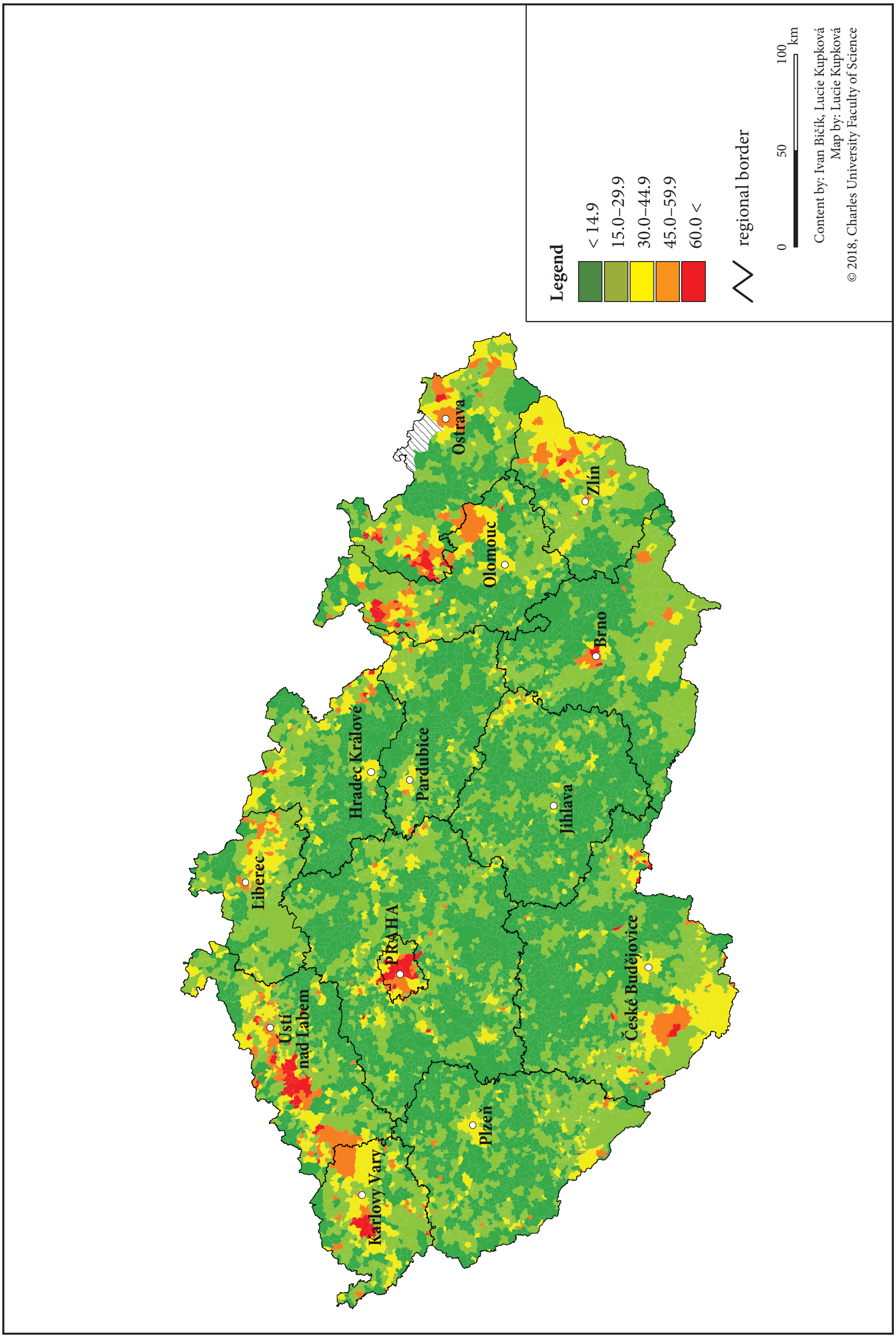
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Liberec
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Karlovy Vary
PRAHA
Hradec Králové
Pardubice
Plzeň
Jihlava
České Budějovice
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Olomouc
Ostrava
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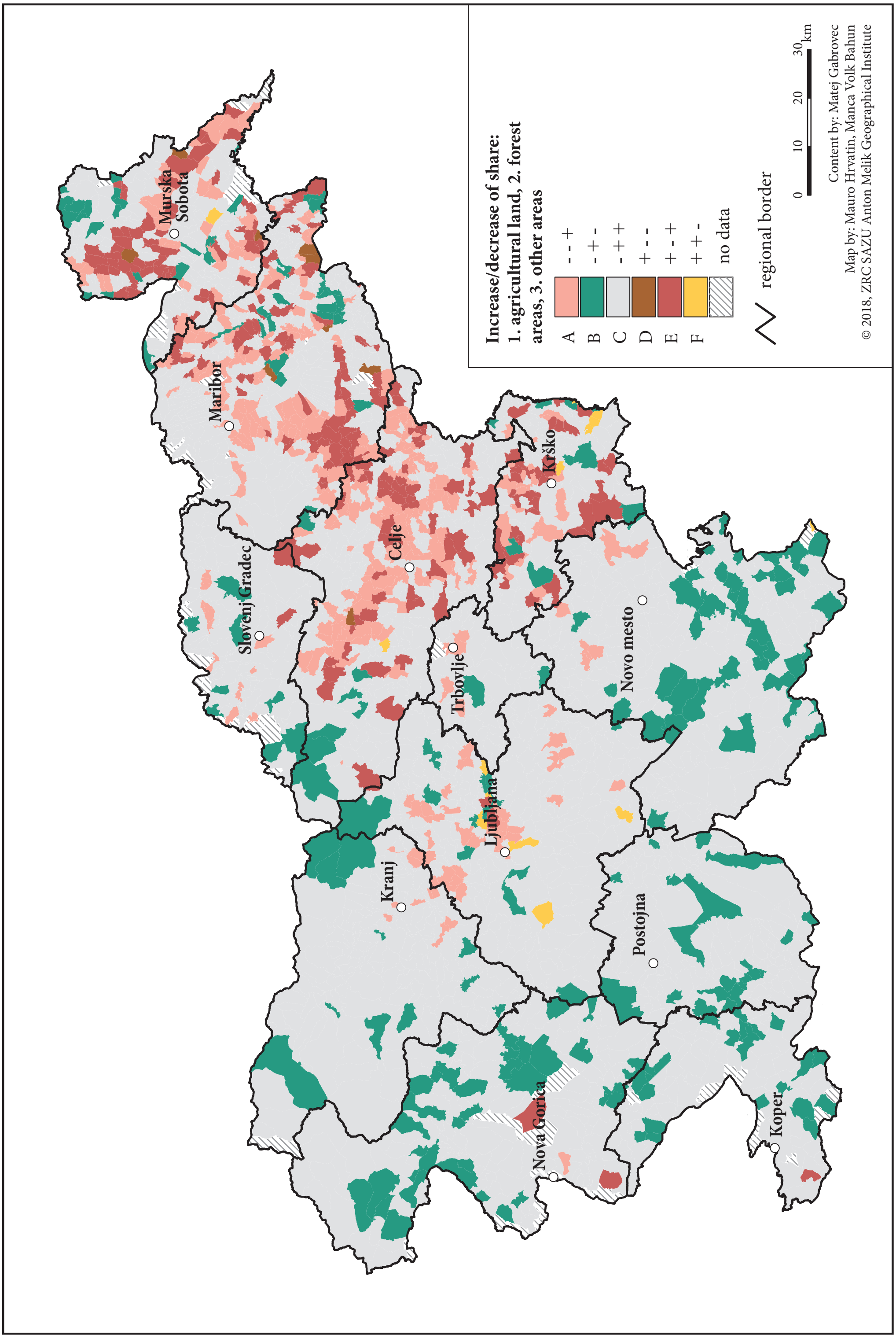
Increase/decrease of share:
1. agricultural land, 2. forest areas, 3. other areas
A - - +
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C - + +
D + - -
E + - +
F + + -
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Murska Sobota
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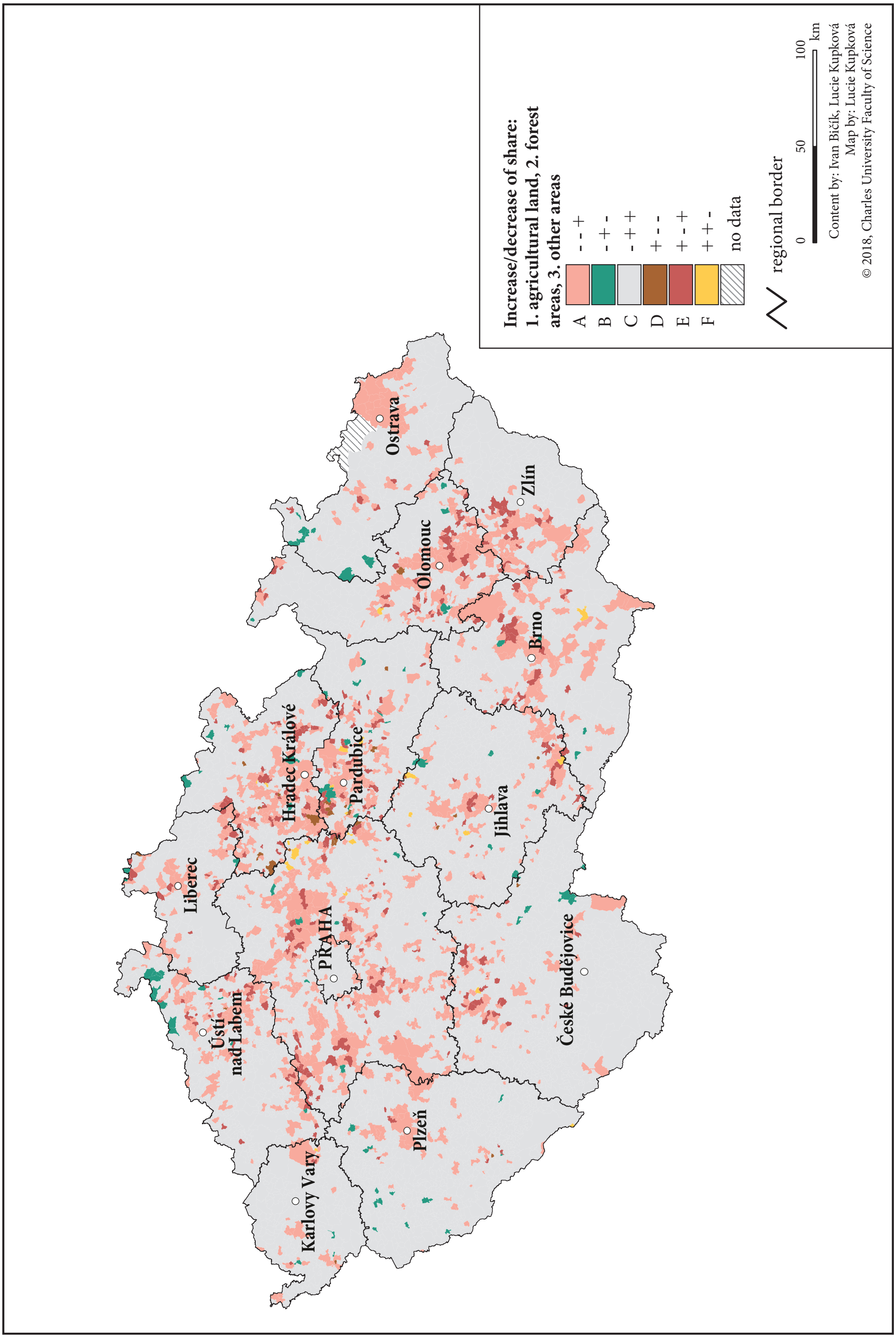
Increase/decrease of share:
1. agricultural land, 2. forest areas, 3. other areas
A - - +
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Ostrava
Zlín
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Jihlava
České Budějovice
Plzeň
Karlovy Vary
PRAHA
Ústí nad Labem
Liberec
Hradec Králové
Pardubice

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LONG-TERM LAND-USE / LAND-COVER CHANGES IN CZECH BORDER REGIONS

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Čížov (German: *Zaisa*), Moravia: the only remaining part of the Iron Curtain in Czechia.

DOI: https://doi.org/10.3986/AGS.7191
UDC: 913:711.14(437.3)«1845/2012«
COBISS: 1.02

Long-term land-use / land-cover changes in Czech border regions

ABSTRACT: This article describes the long-term development of land use and land cover in Czech border regions from 1845 to 2015. It provides an overview of the main works involving Czech border regions and findings by the Faculty of Science at Charles University. The study used the Land Use / Land Cover Changes Czechia (LUCC Czechia 2018) database with six time horizons (1845, 1896, 1948, 1990, 2000, and 2010) and eight categories of land use for approximately nine thousand territorial units, and CORINE Land Cover data for 1990, 2000, and 2006. It also presents a detailed analysis of land-use and land-cover change in one locality in the eastern part of the Krkonoše (Giant Mountains) range, based on land-registry and field-survey data. Development of the LUCC was influenced by the expulsion of ethnic Germans along the western border after the Second World War. The natural conditions in the Czech border areas were identified as another significant factor influencing changes. Changes influenced by these two factors, in combination with several other drivers, are reflected in changes in proportions of land-use and land-cover categories. In the communist period (1948–1990), a significant increase in forests and grasslands accompanied by an extreme decrease in arable land was documented, and the trend of extensification also continued in the transition period from 1990 to 2010.

KEY WORDS: land-use / land-cover change, border regions, driving forces, Czechia

Dolgoročne spremembe rabe/pokrovnosti tal na čeških obmejnih območjih

POVZETEK: V članku je opisan dolgoročni razvoj rabe in pokrovnosti zemljišč na čeških obmejnih območjih med letoma 1845 in 2015. Predstavljen je pregled glavnih del o čeških obmejnih območjih in izsledkov, do katerih so prišli na Naravoslovni fakulteti Karlove univerze v Pragi. Avtorji so uporabili podatkovno zbirko o spremembah rabe/pokrovnosti tal na Češkem (LUCC Czechia 2018), ki vključuje podatke za šest različnih let (1845, 1896, 1948, 1990, 2000 in 2010) in osem kategorij rabe tal za približno 9000 teritorialnih enot, poleg tega pa so proučili tudi podatke iz podatkovne zbirke CORINE Land Cover za leta 1990, 2000 in 2006. Predstavljena je podrobna analiza sprememb rabe in pokrovnosti zemljišč na območju vzhodnih Krkonošev, izvedena na podlagi podatkov zemljiškega katastra in izsledkov terenske raziskave. Na spremembe rabe in pokrovnosti zemljišč na Češkem je vplival izgon čeških Nemcev z območij ob zahodni meji po drugi svetovni vojni. Drug pomemben dejavnik, ki je vplival na te spremembe, so bile naravne razmere na čeških obmejnih območjih. Spremembe, na katere sta ta dva dejavnika vplivala v kombinaciji z več drugimi dejavniki, se odražajo v spremembi deleža posameznih kategorij rabe in pokrovnosti zemljišč. V obdobju med letoma 1948 in 1990 se je močno povečal delež gozdov in travnatih površin, hkrati pa se je precej zmanjšal delež njiv. Ekstenzifikacija se je nadaljevala tudi v obdobju preobrazbe med letoma 1990 in 2010.

KLJUČNE BESEDE: spremembe rabe/pokrovnosti tal, obmejna območja, gonilne sile, Češka

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1 Introduction

The article deals with Czech border areas with Austria and Germany where the Iron Curtain was built after the Second World War. The Iron Curtain was a strictly guarded border between the democratic countries of western Europe and the communist states of eastern Europe. The protection of the border also included measures that fundamentally influenced the lives of people on both sides of the border. The fall of the Iron Curtain in 1990 created initial conditions for human migration and cross-border cooperation. These changes triggered economic development in the border regions. Consequently, land-use changes occurred in the border landscape straddling the Iron Curtain. These changes were analyzed along the entire line of the Iron Curtain in Europe by Kupková, Bičík, and Najman (2013). In the Czech lands, the changes relating to Iron Curtain were combined with those resulting from the expulsion of roughly three million ethnic Germans between 1945 and 1946 (Bičík and Kabrda 2007; Bičík and Štěpánek 1994; Rašín and Chromý 2010; Mares, Rasin and Pipan 2013). Studies of landscape changes in the Czech borderland can be divided into two groups. The first ones are based on land-registry data. Differences in land-use changes on both sides of the Iron Curtain are presented in the timespan between 1845 and 2000 (Bičík et al. 2010; Bičík and Kabrda 2007; Bičík and Štěpánek 1994; Štěpánek 1992; Kučera and Kučerová 2012; Rašín and Chromý 2010). The second ones are based on CORINE Land Cover data and deal with land-cover changes after the removal of the Iron Curtain (Najman 2008; Kupková, Bičík and Najman 2013). This article presents spatial transformation of the borderland using both methods and data. Based on an overview of the studies mentioned above, this article describes specific aspects of land-use change in the unique area of Czech border regions that were affected by several distinctive driving forces over the last two centuries.

2 Methods and data

The analysis is mainly based on a land-use database prepared at the geographic departments of the Faculty of Science at Charles University in Prague (LUCC Czechia 2018). The database is based on a cadaster (Jeleček 2006) and comprises eight land-use categories for roughly nine thousand stable territorial units (STUs; Bičík et al. 2015). The data are available for crucial time horizons that depict land use in specific, important periods of Czech social and economic development:

- 1845: the landscape at the onset of a market economy;
- 1896: the culmination of extensive development of agricultural land use, a horizon with an increasing role played by intensification of farming;
- 1948: the end of the market economy and onset of a centrally planned economy;
- 1990: the end of the centrally planned economy and return to a market economy;
- 2000: the first decade of a market economy in Czechia;
- 2010: twenty years of a market economy, influenced by admission into the European Union.

These data make it possible to survey long time sequences that provide vital information on trends in the development of individual land categories and the total land-use structure in each cadastral unit. In this database, however, it is not possible to capture the changes within a cadastral unit at the parcel level.

In order to conduct detailed research inside the cadasters at the level of parcels or ecosystems, we employ geoecological methods, fieldwork (surveys and mapping) in small model areas, and datasets derived from remote sensing data such as the CORINE Land Cover dataset (Corine Land Cover 2018). The results of the evaluation of trends in land-use changes are a starting point for examining the driving forces of these changes and their impact on local and regional development.

Similar approaches suitable for analyses of long-term land-use changes and utilizing the land registry data were applied in Slovenia (Gabrovec, Petek and Kladnik 2001; Gabrovec and Petek 2003; Gabrovec and Kumer 2019) and Austria (Haberl, Batterbury and Moran 2001; Krausmann 2001; Haberl et al. 2003).

3 Results

3.1 Land-use changes in Czech border regions based on land-registry data

Bičík and Štěpánek (1994) published one of the first studies focused on land-use changes in the borderland using the LUCC Czechia database. They used three time horizons (between 1845, 1948, and 1990) and eight land-use categories, documenting a significant decrease in the agricultural function in the borderland. The decrease was most significant in western border regions, especially in comparison with interior regions. Bičík and Kabrda (2007) conducted an analysis of the individual sections of the Czech border using the LUCC database. They examined the differences in land-use changes in four time horizons in relation to their distance from the border. They delineated three zones of STUs near the border (the first zone includes STUs touching the border: »at border zone«; the second includes STUs adjoining the first one zone: »intermediate zone«; and the third zone includes STUs adjoining the second zone: »at interior zone«; see Figures 1 and 2). They compared these three zones to each other and with all other STUs in Czechia, or the »interior.« As anticipated, the intensity of change was strongly influenced by differences in elevation, inclination, and soil fertility in individual sets, and also by the ethnic structure of the population. In border zones with a predominantly ethnic Czech population, the total intensity of changes in the landscape was smaller than in the areas primarily or fully inhabited by ethnic Germans, who were expelled after the Second World War. Figures 1 and 2 document changes in arable land and forest areas in the borderland zone compared with the interior. The share of arable land was lower in border regions compared to interior regions. In addition, it decreased significantly in the first »at border« zone, especially between 1948 and 1990. The percentage of forest areas was significantly lower in the interior and experienced little change in the years studied, whereas in the border zones, especially in the »at border« zone, forest areas increased permanently and covered more than 50% of the territory in 1990 and 2000.

3.2 Evaluation of land-use changes in Czech borderland using remote sensing data

Najman (2008) analyzed land-cover changes using Corine land cover data for 1990 and 2000 along the whole of the former Iron Curtain in Czechia. Analyzing land-cover changes in the area straddling the border between those years, he delineated a belt with a width of about 15 km along both sides of the Czech border with Germany and Austria. Kupková, Bičík, and Najman (2013) extended the dataset by using the 2006 Corine Land Cover data. Changes in land cover in two periods (1990–2000 and 2000–2006) were evaluated.

The results (Table 1) documented a considerably lower intensity of the transformation of the landscape on the Austrian side of the border (west) in comparison with larger changes that occurred on the Czech side (east) in both periods under observation. This result reflects the fact that land use has not been influenced by the border on the Austrian side, whereas the situation was different on the Czech side. Only state farms (not agricultural cooperatives or private farmers) could farm in the proximity of the Iron Curtain. They had specially trained employees, many of whom were members of the auxiliary corps of the border guard. For this reason, farming intensity was substantially lower on the Czech side of the Iron Curtain, where the land previously designated for agriculture was abandoned, often giving way to new wilderness (Lipský 1995, 2010).

The results confirm a varying representation of individual land-cover categories in 1990 in the area to the east and west of the Iron Curtain, and their differing changes between 1990 and 2006. Before 1990, the centrally planned economy and subsidy system pressured farms to use the land to the east of the Iron Curtain for agriculture, even under unfavorable conditions. To the west, the market economy made intensive agriculture untenable under unfavorable conditions, even when high subsidies were provided. The land cover was very diverse, and the land use respected more natural conditions. The analysis also confirmed a varying intensity of changes in the individual border sections examined and more intensive land-cover changes to the east of the Iron Curtain after 1990. Between 1990 and 2000, changes occurred on 3.96% of the area under study to the east of the Iron Curtain; in the west similar changes only occurred on 0.52% of the area studied. From 2000 to 2006, changes occurred on 0.61% of the area on the east side and on 0.16% of the area on the west side. The biggest changes were recorded in Czech border sections, which saw relatively large-scale agricultural extensification and reforestation. The changes occurred in over 8% of the area from 1990 to 2000. This contrasts with the border section in Austria, which was very stable throughout the period under observation (changes in both periods only occurred on 0.13% of the Austrian region).

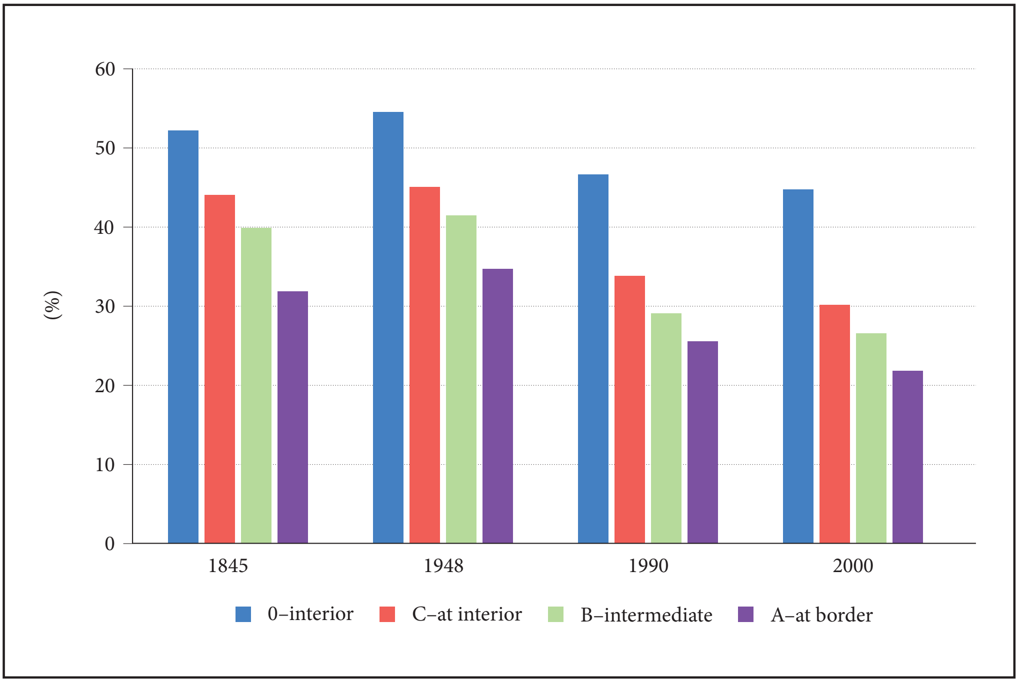


Figure 1: Percentage of arable land in various Czech border zones (Bičík and Kabrda 2007).

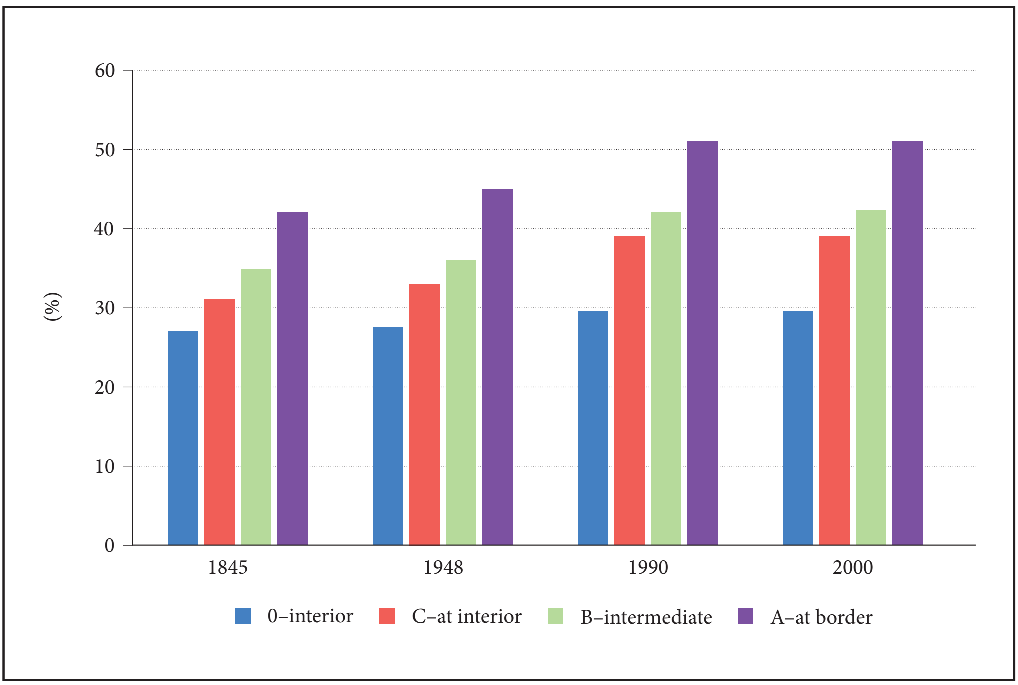


Figure 2: Percentage of forest areas in various Czech border zones (Bičík and Kabrda 2007).

The results are presented in Figure 3, capturing the extent of the changes in mapping units larger than 25 hectares. There is substantially higher transformation on the Czech side, especially in the first period after the fall of the Iron Curtain.

Table 1: Land cover in the Czech–Austrian borderland in 1990 and land-cover changes for 1990–2000 and 2000–2006 (15 km along both sides of the border; east = 15 km border section in Czechia; west = 15 km border section in Austria; Kupková, Bičík and Najman 2013).

Category	Share of category 1990 (%)		Decrease/increase in area of category, 1990–2000 (%)		Decrease/increase in area of category, 1990–2006 (%)	
	East	West	East	West	East	West
Urban fabric	2.65	3.28	0.90	0.42	1.33	0.61
Industrial, commercial, and transport units	0.36	0.01	3.11	0.00	3.75	9.51
Mine, dump, and construction sites	0.13	0.00	−39.52	0.00	−20.98	+
Artificial, non-agricultural vegetated areas	0.14	0.00	0.00	+	21.79	+
Arable land	43.06	31.96	−12.87	−0.01	−15.97	−0.06
Permanent crops	1.47	3.10	5.04	−0.06	36.06	−0.27
Pastures	4.18	3.47	127.43	−0.77	146.03	−1.15
Heterogeneous agricultural areas	6.88	25.16	1.98	−0.08	1.93	−0.20
Forests	34.41	32.86	5.83	−0.20	5.74	−0.36
Scrub and/or herbaceous vegetation	0.40	0.01	−2.60	69.67	−1.62	39.70
Transitional woodland/shrubs	2.85	0.04	−69.56	127.55	−67.63	217.82
Inland wetlands	0.48	0.05	3.17	0.00	2.19	0.00
Inland waters	2.98	0.05	−0.35	0.00	0.01	0.00

Note: The sign + means that the initial area in 1990 was 0 and the share of the category increased during the period (the share of the total area in the second year was lower than 0.1% of the total area).

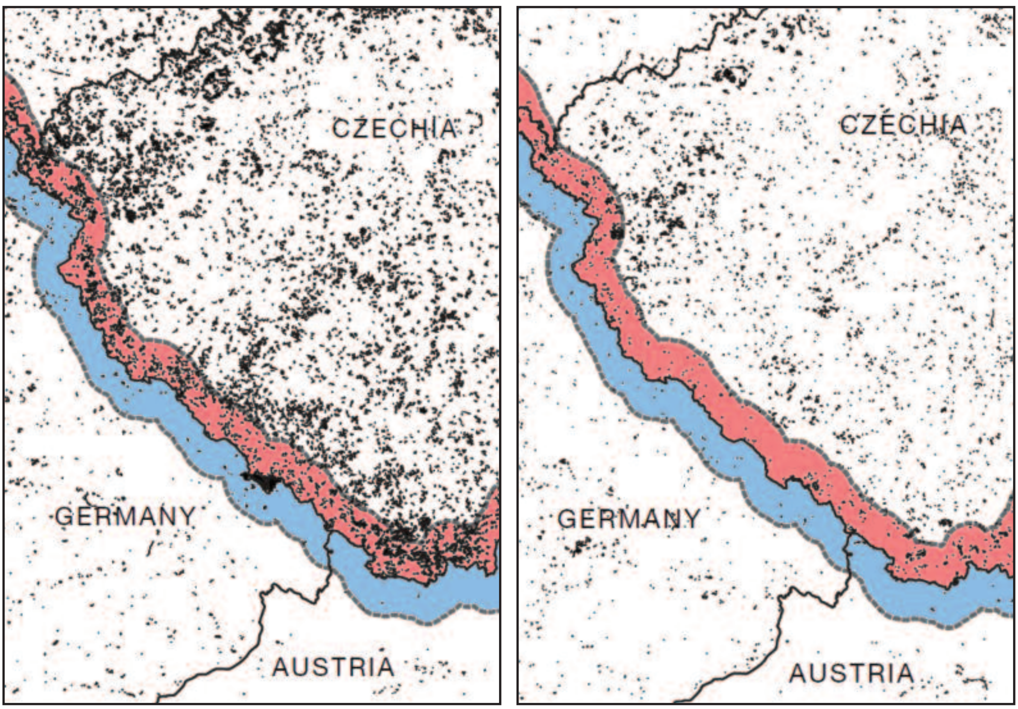


Figure 3: Land-cover changes between 1990 and 2000 (left), and 2000 and 2006 (right; adapted from Kupková, Bičík and Najman 2013).

3.3 A case study of Chvaleč and Petříkovice: a combination of land-registry data and a field survey

The area studied is in northeastern Bohemia in the Krkonoše foothills. The selection of this area was due to its position in the Czech–Polish borderland, which had not yet been analyzed for land-use / land-cover development.

Both the LUCC Czechia (2018) database and field survey (in 2015) were used to analyze this area. The data showed (Table 2) that the major changes in the Chvaleč region occurred after the Second World War and in the last thirty years, when its function changed from agricultural to recreational. Table 2 shows the differentiation of land use in six time horizons, with a visible trend of decreasing size in arable and agricultural land and an increase of forest from one-third to half. Similar processes were observed in Slovenian borderlands close to the Croatian border (Ribeiro, Burnet and Torkar 2013). The political and economic driving forces between 1845 and 1948 and the forced nationalization of local agriculture influenced changes in landscape functions after 1945 without the installation of the Iron Curtain there. The expulsion of ethnic Germans and the decline of coalmining in the vicinity (in the 1960s) were important factors responsible for transforming the landscape into an economic and settlement periphery (Boudný 2018).

Figures 4 and 5 show the conversion of arable land into permanent grassland and forest areas from 1845 to 2015. These changes primarily occurred after the Second World War as a result of the expulsion of the ethnic Germans, and again after 1990 due to the abandonment of agricultural land under less favorable conditions for agriculture and its subsequent grassing over.

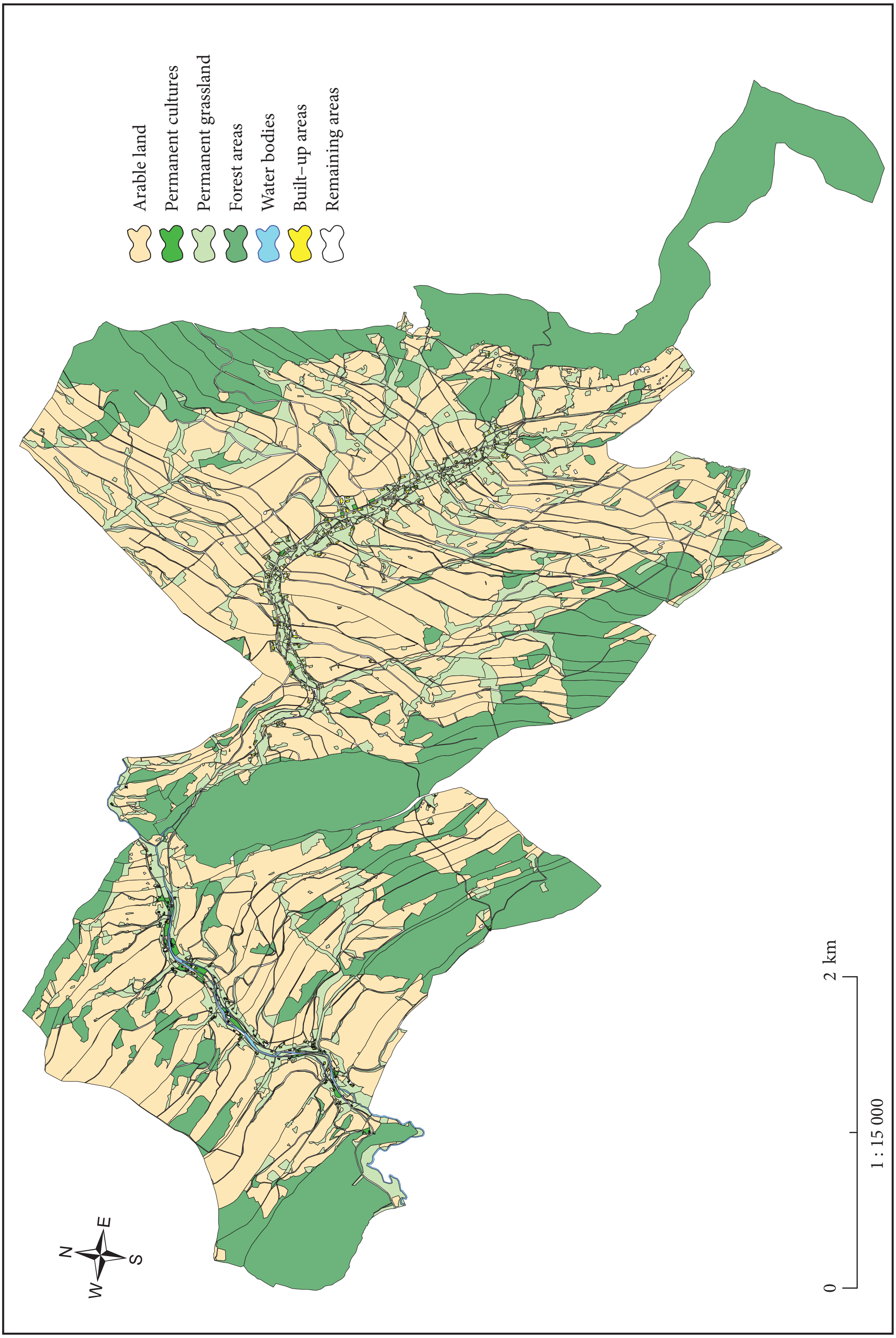
4 Discussion and conclusions

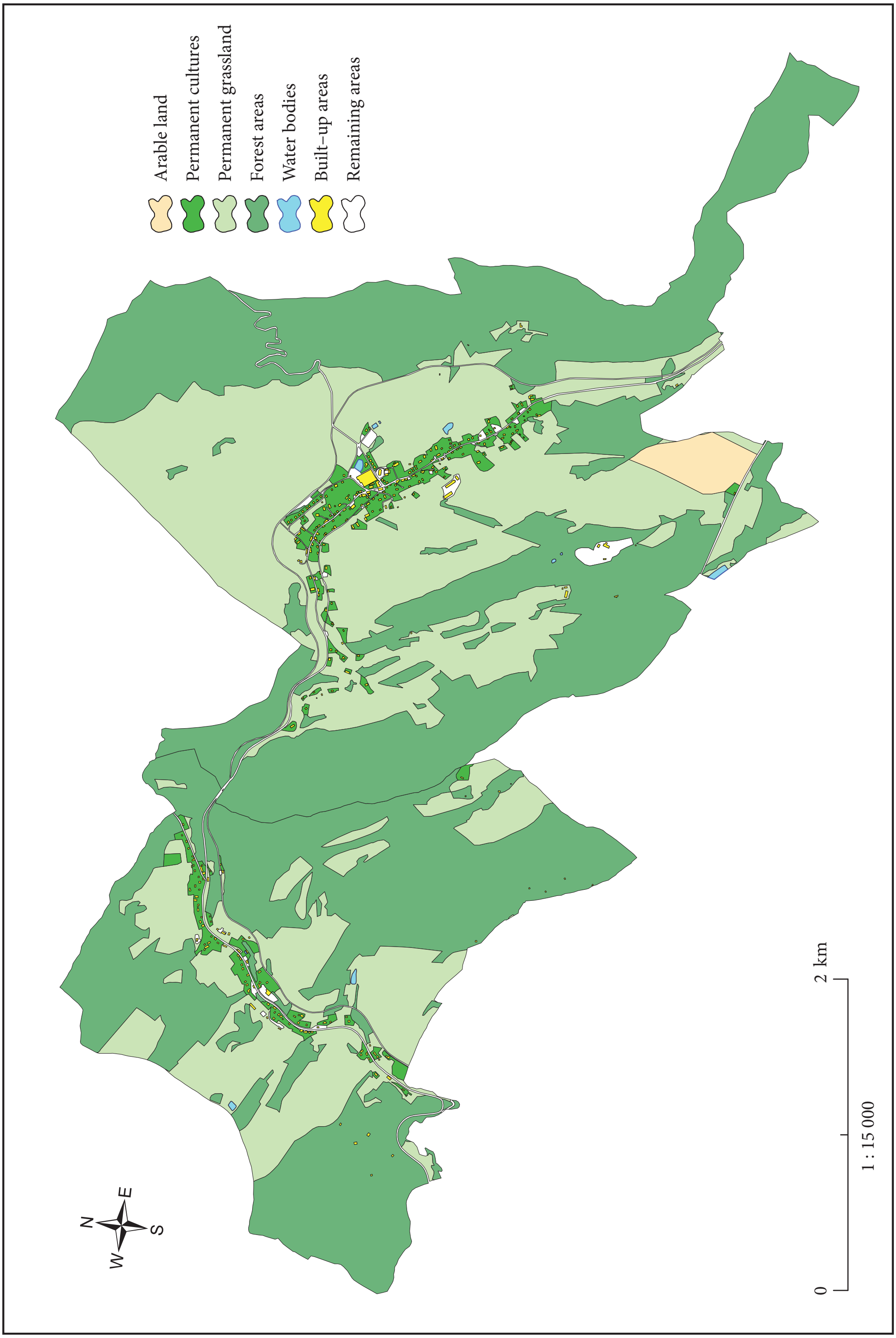
This selection of landscape change in the Czech borderland has demonstrated a clear result. Although they are variously delineated, the regions were influenced by a number of similar driving forces after 1990. Nevertheless, it is striking that the crucial driving forces were the political changes that occurred after the Second World War, as well as between 1989 and 1990. The landscape changes in Czechia were greater than those detected on the other side of the western border between 1990 and 2012 (Najman 2008; Kupková, Bičík and Najman 2013; Rašín and Chromý 2010).

Table 2: Overview of land use development in Chvaleč through six time horizons (Boudný 2018).

Category	1845		1896		1948		1990		2000		2010	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Arable land	833.8	48.6	885.0	51.6	834.3	48.7	363.2	21.09	358.5	20.8	358.1	20.8
Permanent cultures	3.1	0.18	2.9	0.17	7.2	0.42	26.1	1.52	23.7	1.38	23.4	1.36
Permanent grasslands	224.5	13.1	234.0	13.65	219.3	12.8	295.0	17.1	306.0	17.8	303.2	17.6
Agricultural land	1061.4	61.9	1121.9	65.5	1060.8	61.9	684.3	39.74	688.2	39.9	684.7	39.8
Forest areas	591.3	34.4	559.0	32.6	599.9	35.0	881.6	51.2	882.1	51.2	893.0	51.9
Water bodies	3.5	0.2	–	–	3.5	0.2	5.9	0.3	5.9	0.3	6.6	0.38
Built-up areas	5.3	0.3	–	–	12.6	0.7	13.7	0,8	13.8	0.8	13.3	0.8
Other areas	54.0	3.2	–	–	36.3	2.12	136.4	7.9	132.0	7.7	124.6	7.2
Remaining areas	62.8	3.7	33.1	1.93	52.4	3.1	156.0	9.1	151.7	8.8	144.5	8.4

Figure 4: Land use in Chvaleč and Petříkovice near Trutnov in 1845 (Boudný 2018). ➤ p. 114
Figure 5: Land use in Chvaleč and Petříkovice in 2015 (Boudný 2018). ➤ p. 115


Arable land
Permanent cultures
Permanent grassland
Forest areas
Water bodies
Built-up areas
Remaining areas
N
E
S
W
0
2 km
1 : 15 000


Arable land
Permanent cultures
Permanent grassland
Forest areas
Water bodies
Built-up areas
Remaining areas
0
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The second basic finding highlights a dramatic loss of arable land on the periphery and strong depopulation. The natural conditions that weaken or prevent economic activity in such localities are magnified by the significant shortage of manpower in the present day, primarily in manufacturing and services. Czechs and Slovaks from Czechoslovakia's interior, as well as people repatriated from abroad after 1945, often resettled the foothills and mountain areas and lacked the necessary experience for farming in this difficult terrain (Čapka, Slezák and Vaculík 2005; Vaishar 1992). Then, after the 1949 establishment of the Iron Curtain, many of them were forced to move further into the interior of the country. This resulted in a significant loss of agricultural land in these areas. Between 1948 and 1963, approximately 15% of agricultural land was lost (Bičík et al. 2010).

Hampl and Müller (2011) warned of the differing timing and also the duration of individual social processes. According to Hampl and Müller (2011), as a rule, political processes take place in days or weeks after a situation changes. Economic processes may last months or years, and demographic and social processes last several years. Complex geographical processes that include landscape changes start last and evolve over a longer period of time. This has been confirmed twice in the Czech lands. After the Second World War, the communist coup lasted a few weeks but transformed the political system for forty-two years. The second change followed in 1989, when the Velvet Revolution implemented a fundamental political change within a month, reintroducing Czechoslovakia to the western market economy (Bičík et al. 2015). An examination of the landscape transformation shows that these abrupt political changes initiated a perceptible impact on the entire Czech landscape. These changes took nearly fifteen years to realize, and their duration is substantially longer than their political triggers.

These results further prove the higher intensity of land-use changes in border areas compared to the intensity of landscape changes in core areas of the Czech lands and the countryside. In fact, most semi-peripheral areas and a large part of peripheral areas did not experience any major landscape changes after 1948.

The future development of border areas will be influenced by many drivers, especially by the EU and national subsidy programs, nature preservation, creation of new job opportunities, and so on; however, the land-use / land-cover changes will most likely be less intensive than in the majority of other Czech regions because border regions are usually marginal when there is no political change.

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LAND-USE CHANGES IN SLOVENIAN TERRACED LANDSCAPES

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MATEVŽ LENARČIČ

Overgrowth of former winegrowing terraces in the Haloze Hills.

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UDK: 911.53:631.613(497.4)
631.613:711.14(497.4)
COBISS: 1.01

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.

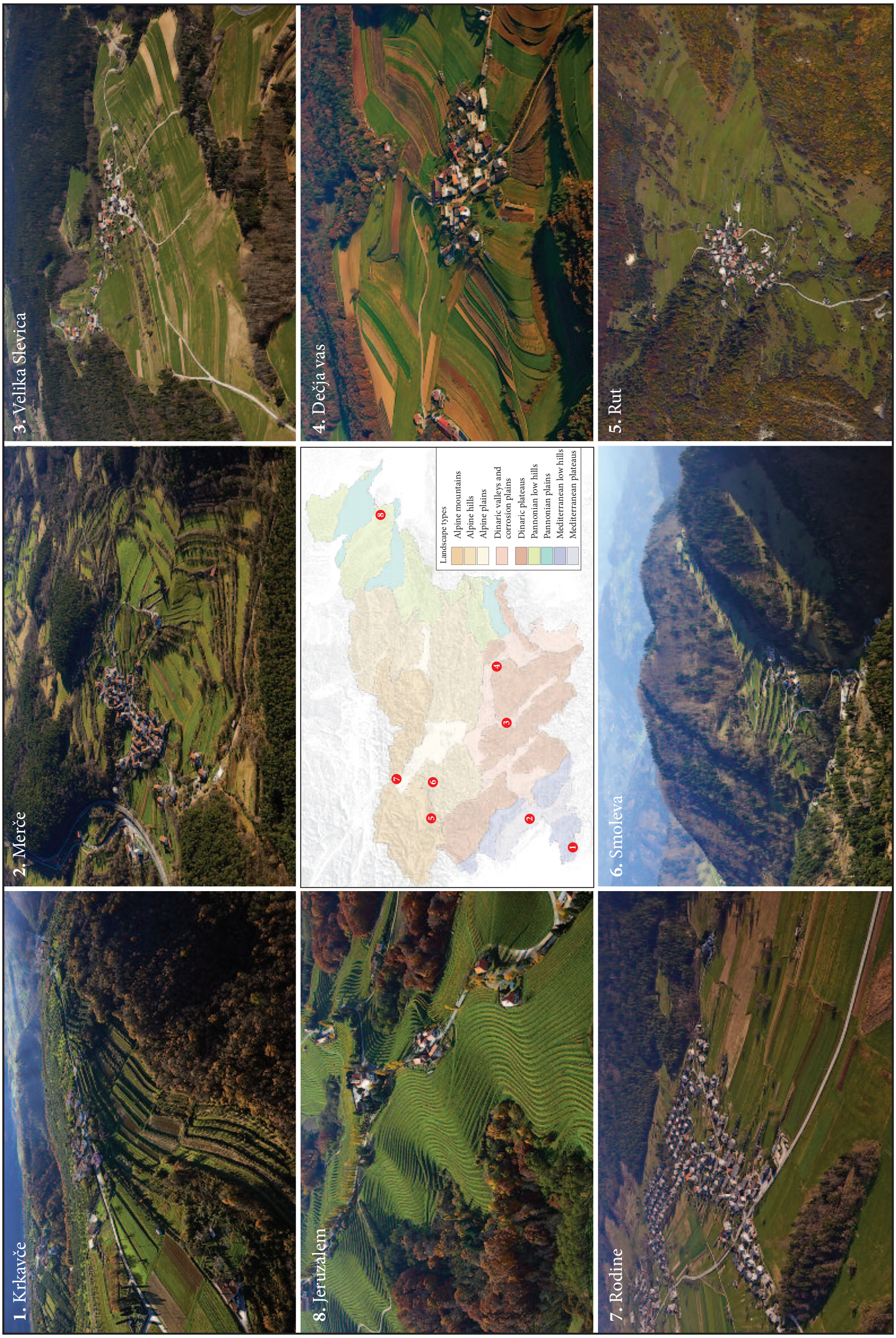
For contemporary cartographic representation of land use, we used Land Use data base for 2018 (Evidenca dejanske rabe … 2018). The following ten land categories were identified in the pilot areas: fields, vineyards, orchards, olive groves, grassland (meadows and pastures), uncultivated agricultural land,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

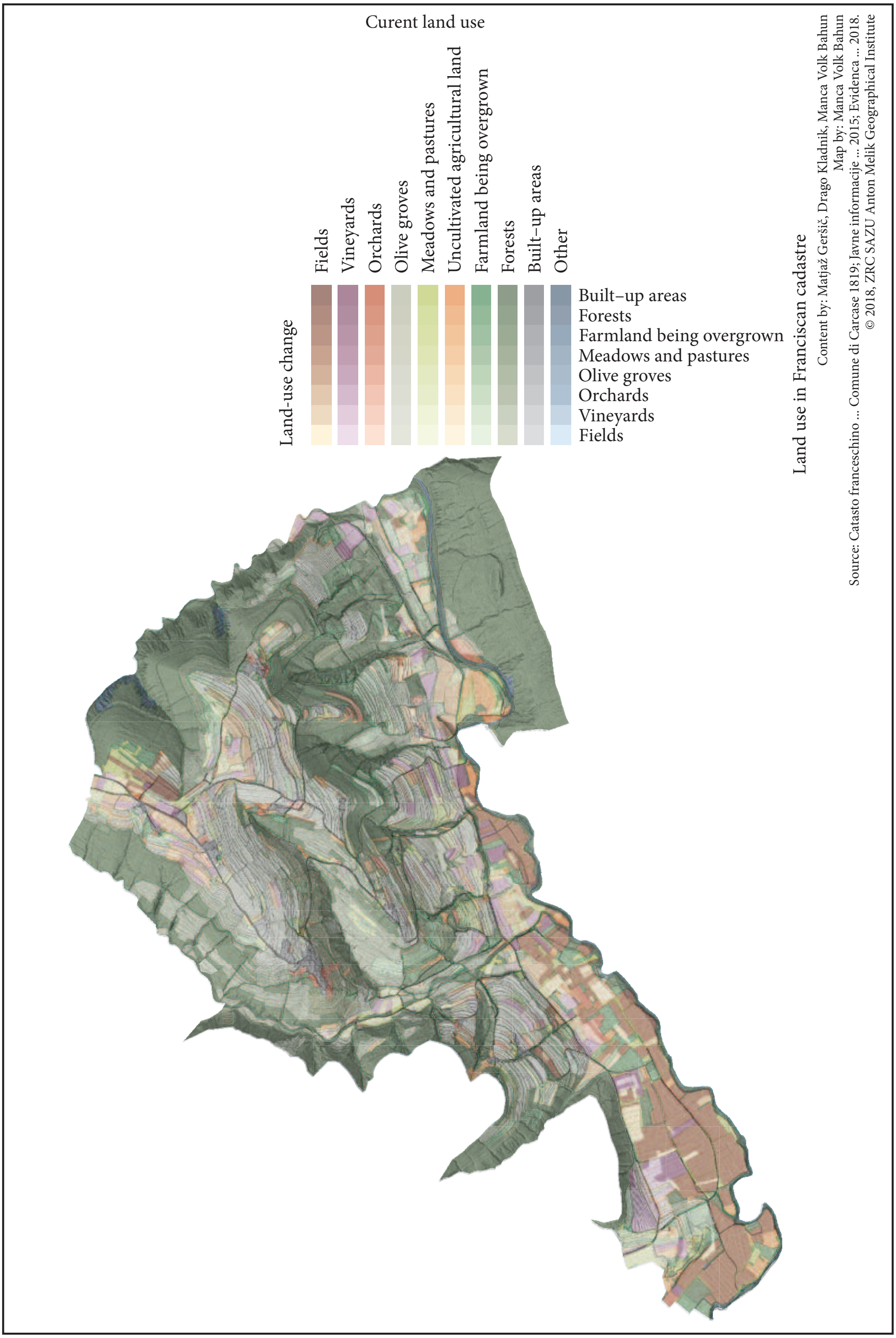
In the end, the present-day terraced and non-terraced areas were delimited, which made it possible to compare them. To determine the exact contemporary location of terraces, we employed color digital ortophoto maps, with an image resolution of 0.50 m, fieldwork, and data obtained from aerial laser scanning (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



MATEVŽ LENARČIČ


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
Land use in Franciscan cadastre
Built–up areas
Forests
Farmland being overgrown
Meadows and pastures
Olive groves
Orchards
Vineyards
Fields
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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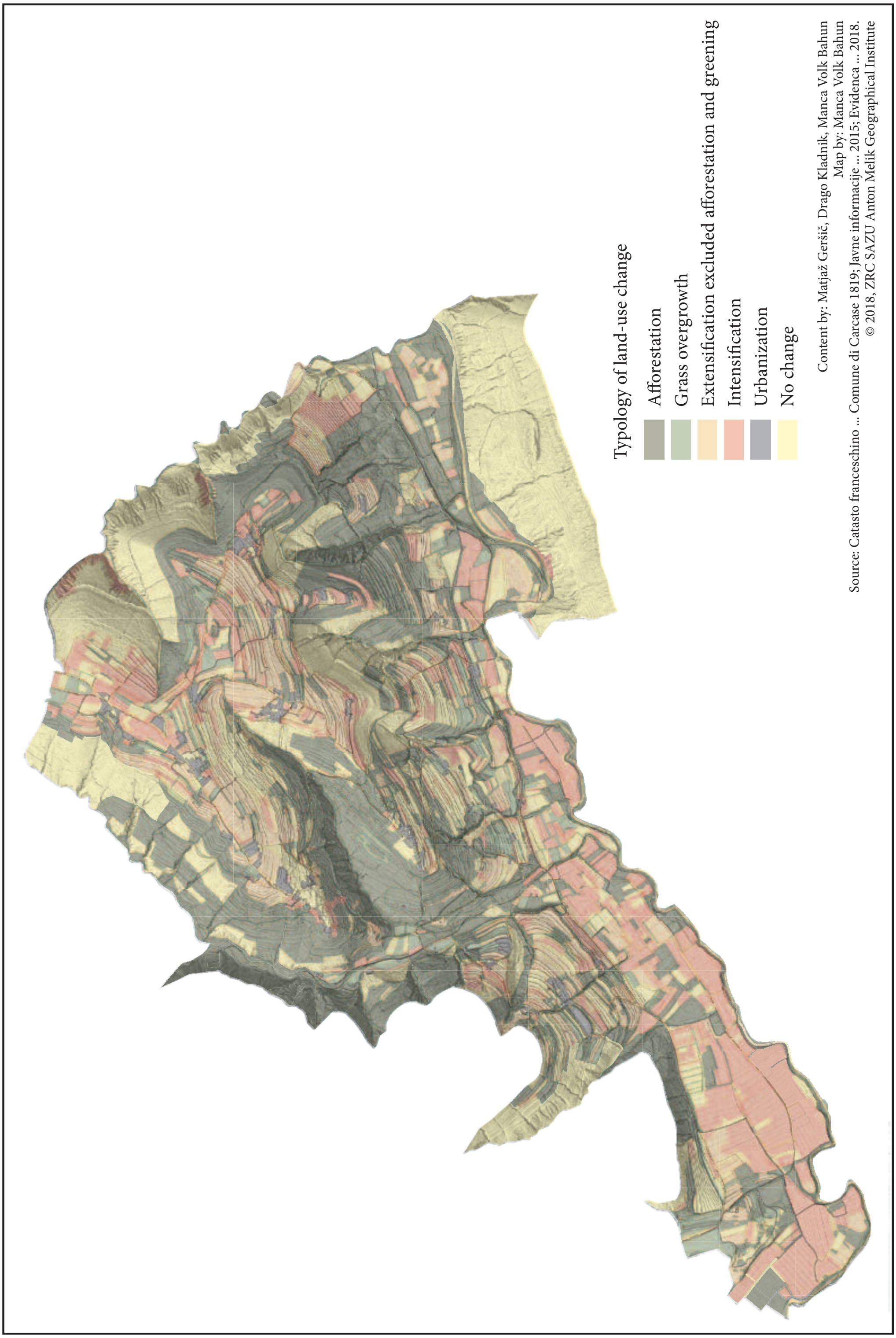
Typology of land-use change
Afforestation
Grass overgrowth
Extensification excluded afforestation and greening
Intensification
Urbanization
No change
Content by: Matjaž Geršič, Drago Kladnik, Manca Volk Bahun
Map by: Manca Volk Bahun
Source: Catasto franceschino ... Comune di Carcase 1819; Javne informacije ... 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%).

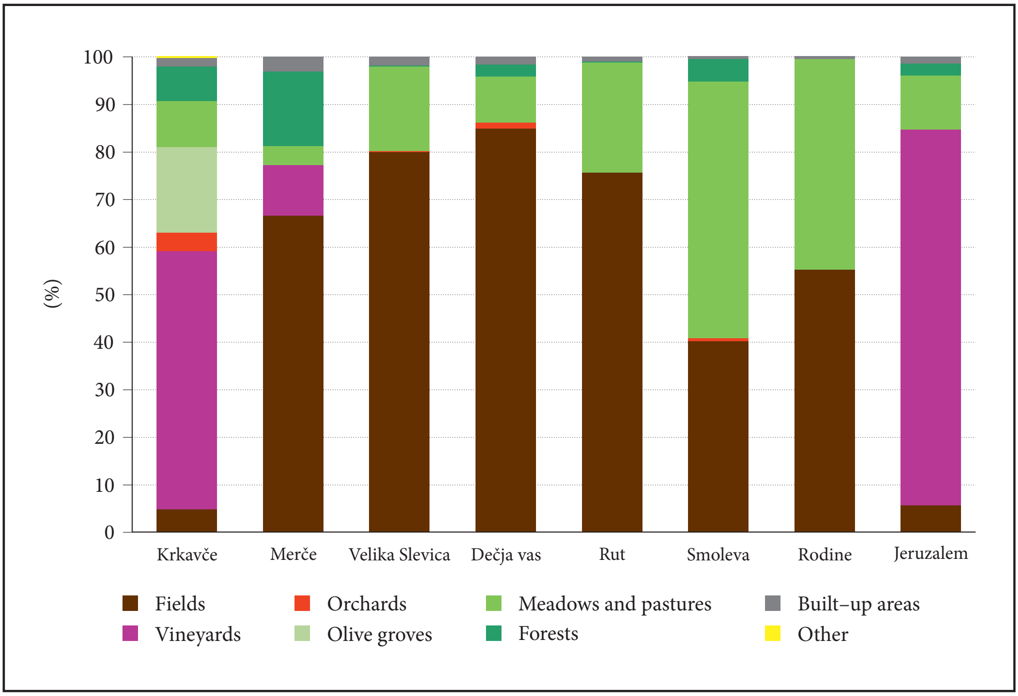

Figure 4: Land use on terraced land in pilot areas in the Franciscean cadaster (1820s).

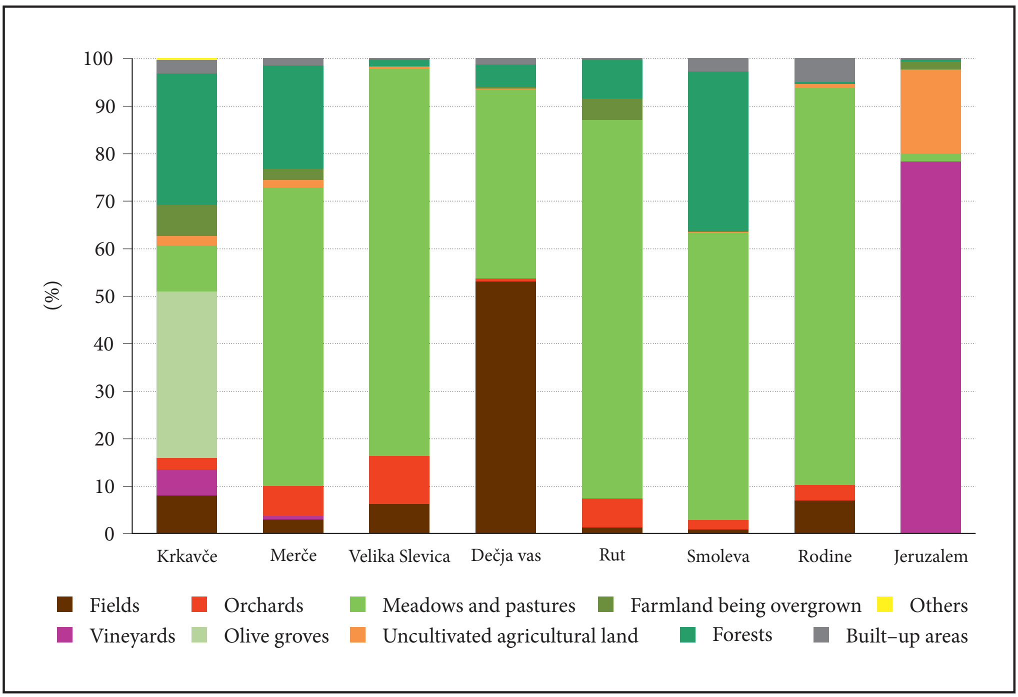

Figure 5: Land use on terraced land in pilot areas in 2018.

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


Land use
Fields
Vineyards
Orchards
Olive groves
Other permanent crops
Meadows and pastures
Uncultivated agricultural land
Farmland beeing overgrown
Forests
Built–up area
Other
Terraced area
0 250 500 750 1000 m
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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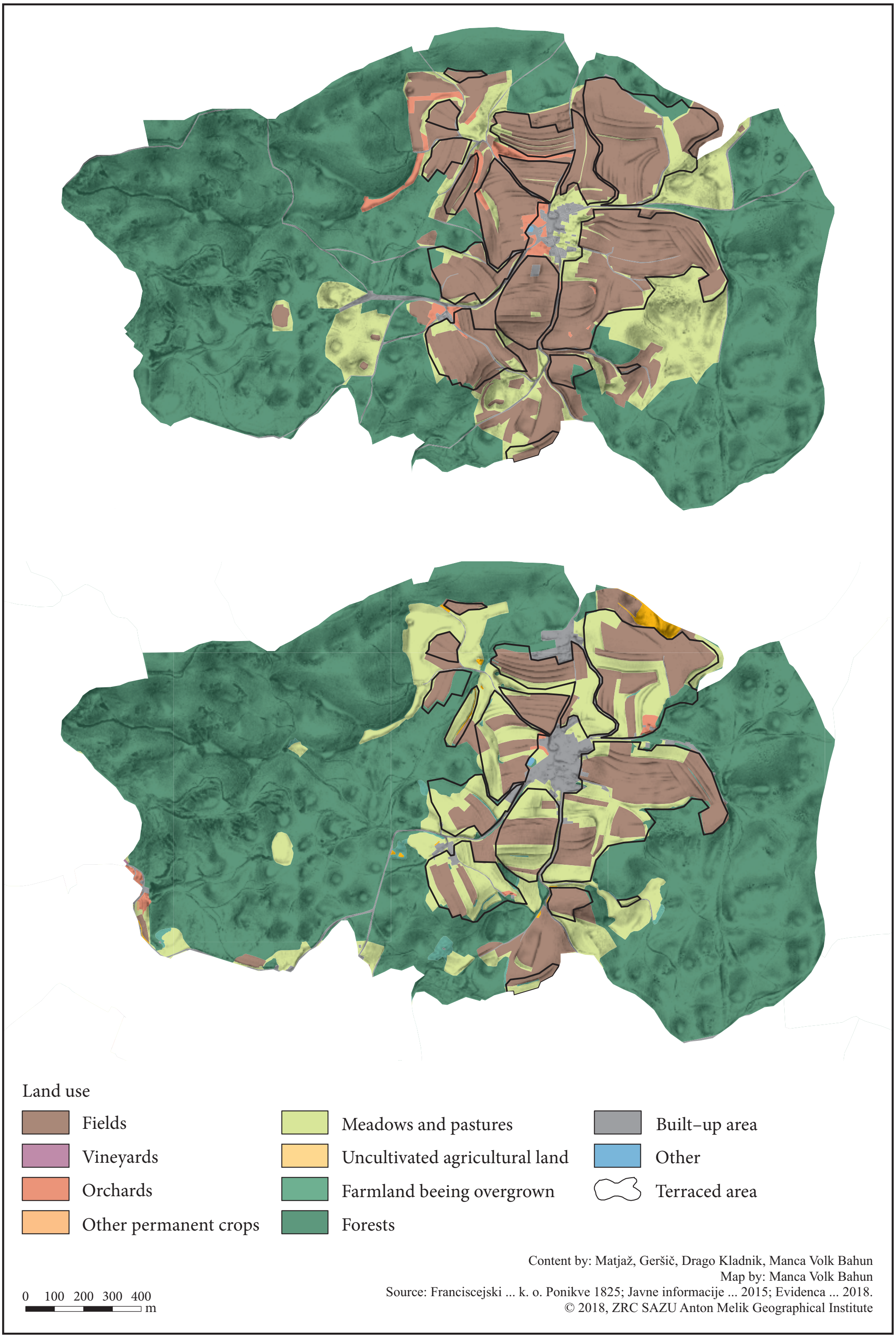
Land use
Fields
Vineyards
Orchards
Other permanent crops
Meadows and pastures
Uncultivated agricultural land
Farmland beeing overgrown
Forests
Built–up area
Other
Terraced area
0 100 200 300 400 m
Content by: Matjaž, Geršič, Drago Kladnik, Manca Volk Bahun
Map by: Manca Volk Bahun
Source: Franciscejski ... k. o. Ponikve 1825; Javne informacije ... 2015; Evidenca ... 2018.
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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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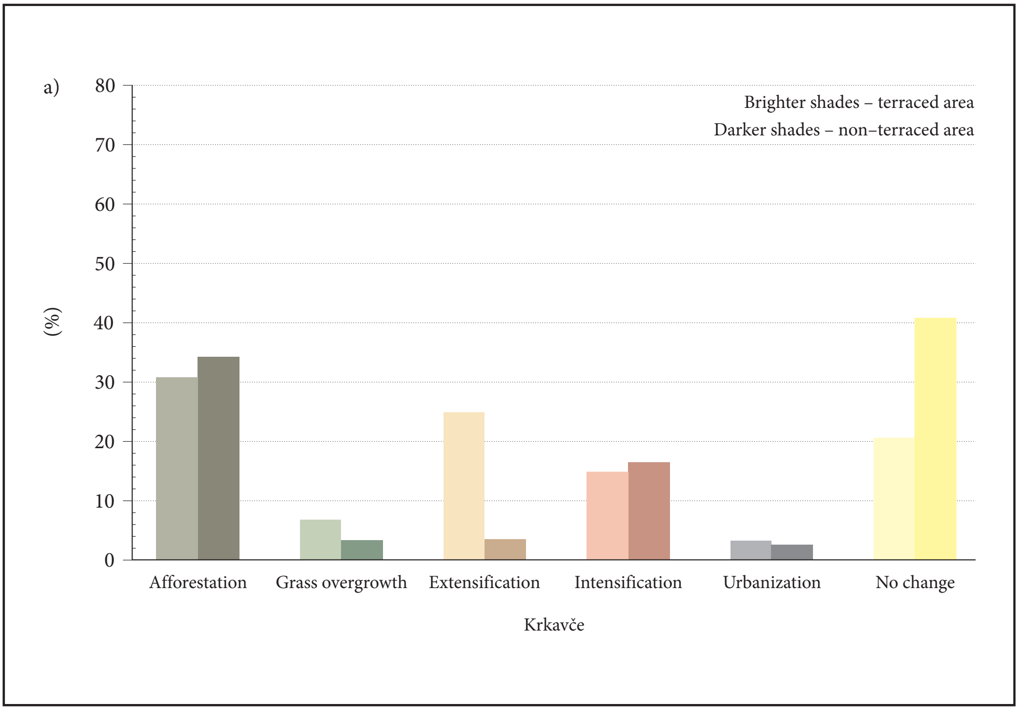
a)
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30
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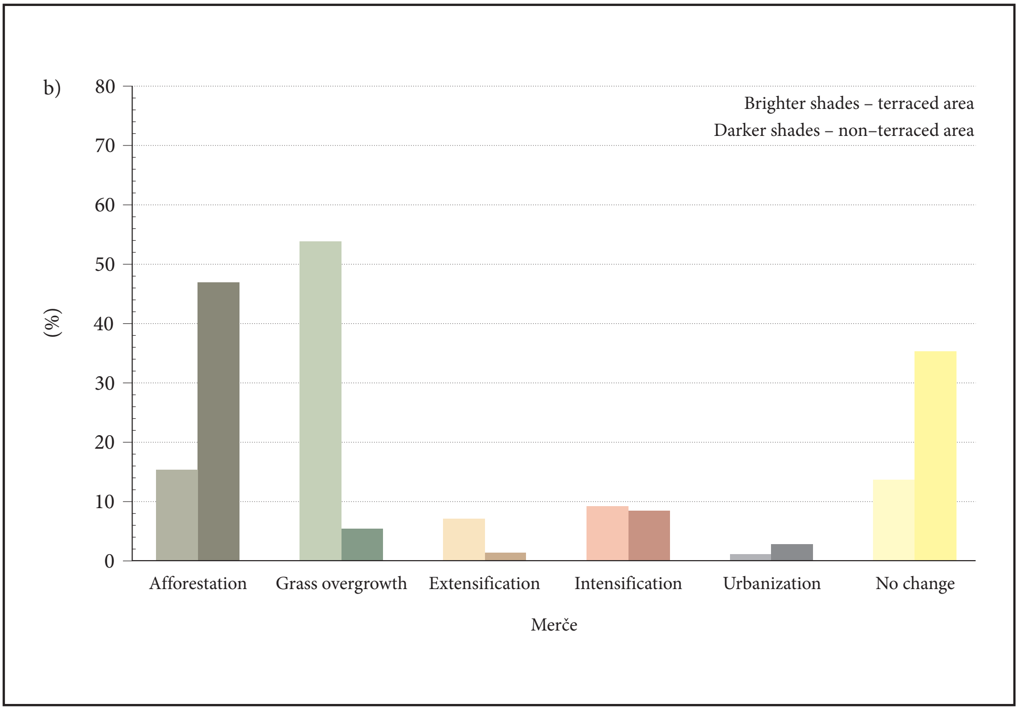
10
0
(%)
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Krkavče


b)
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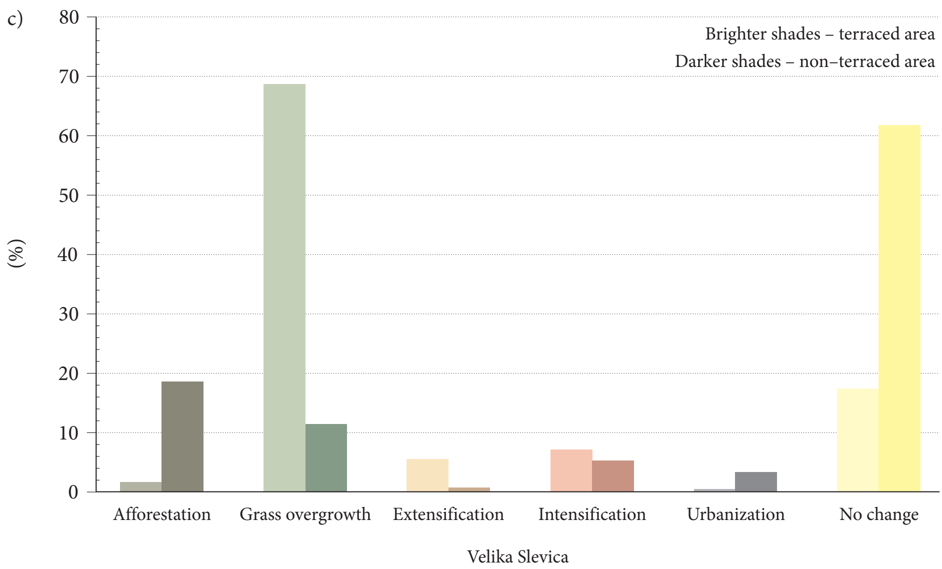
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Merče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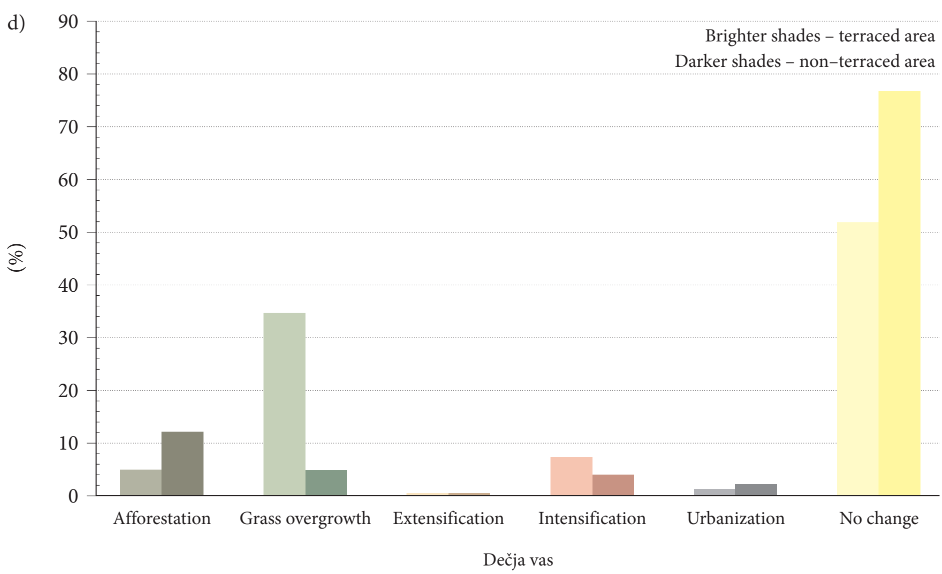
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Velika Slevica


d)
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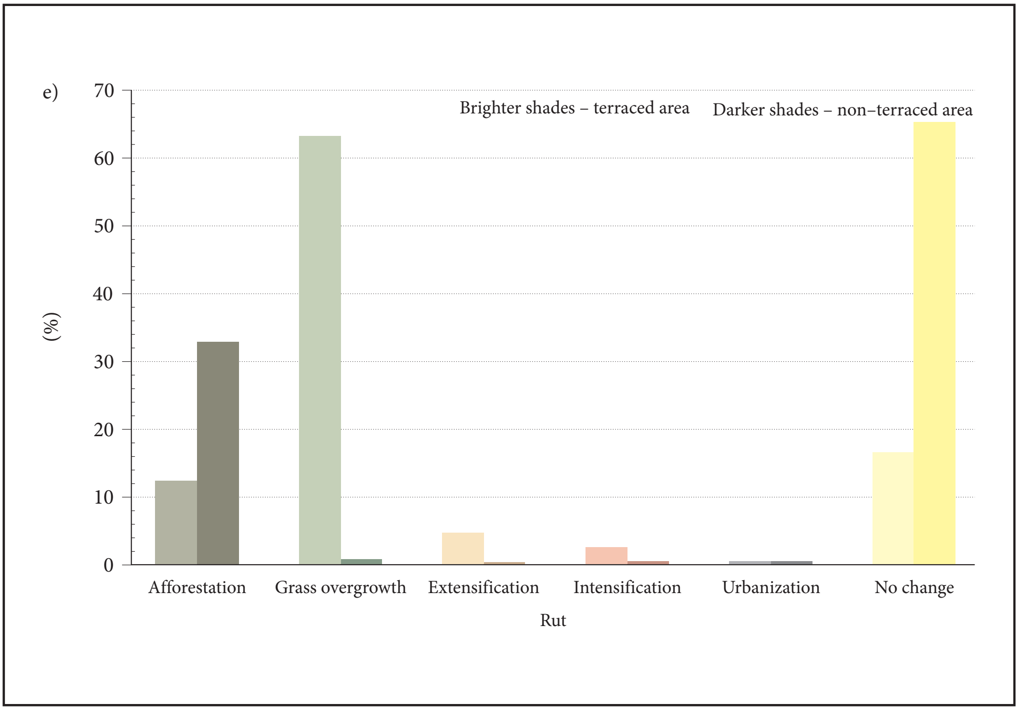
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Dečja vas


e)
(%)
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20
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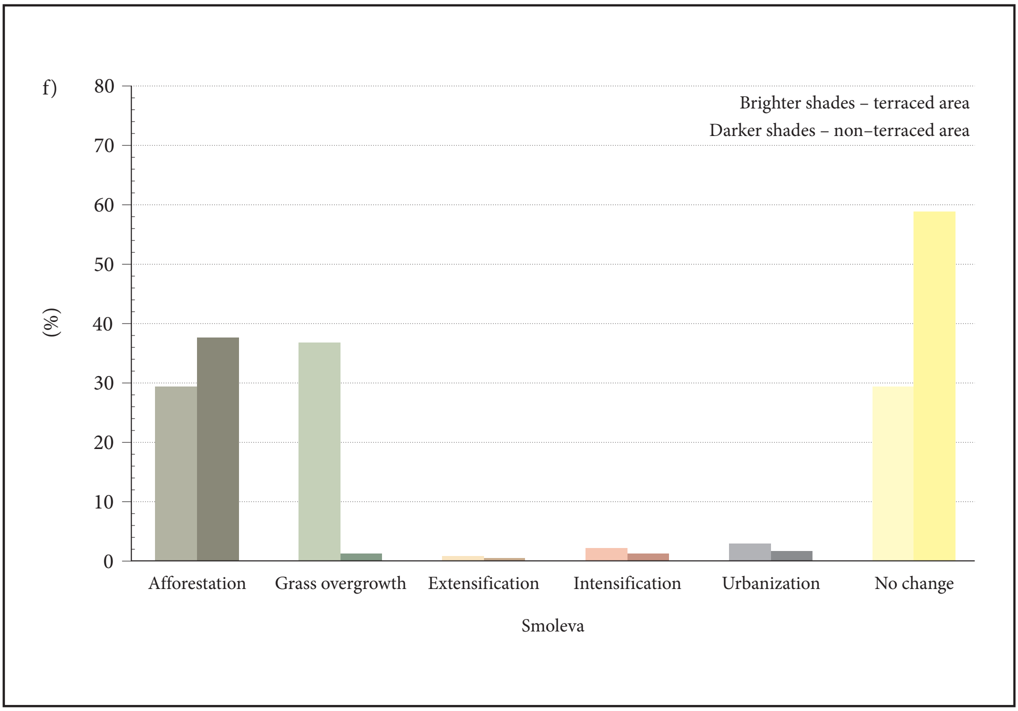
0
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Rut


f)
(%)
80
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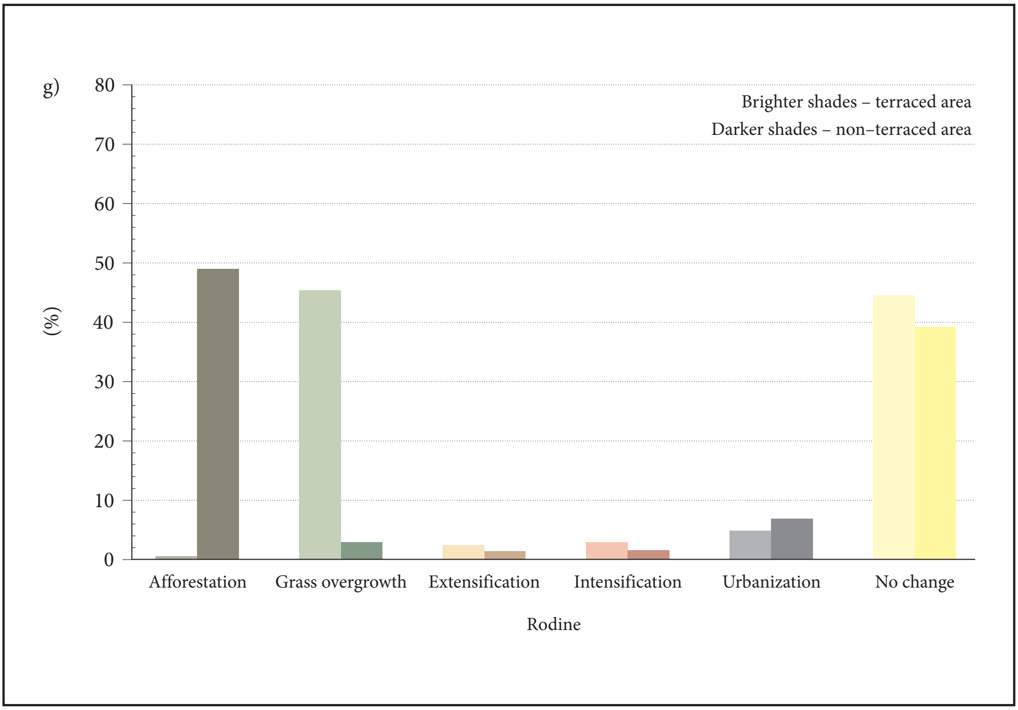
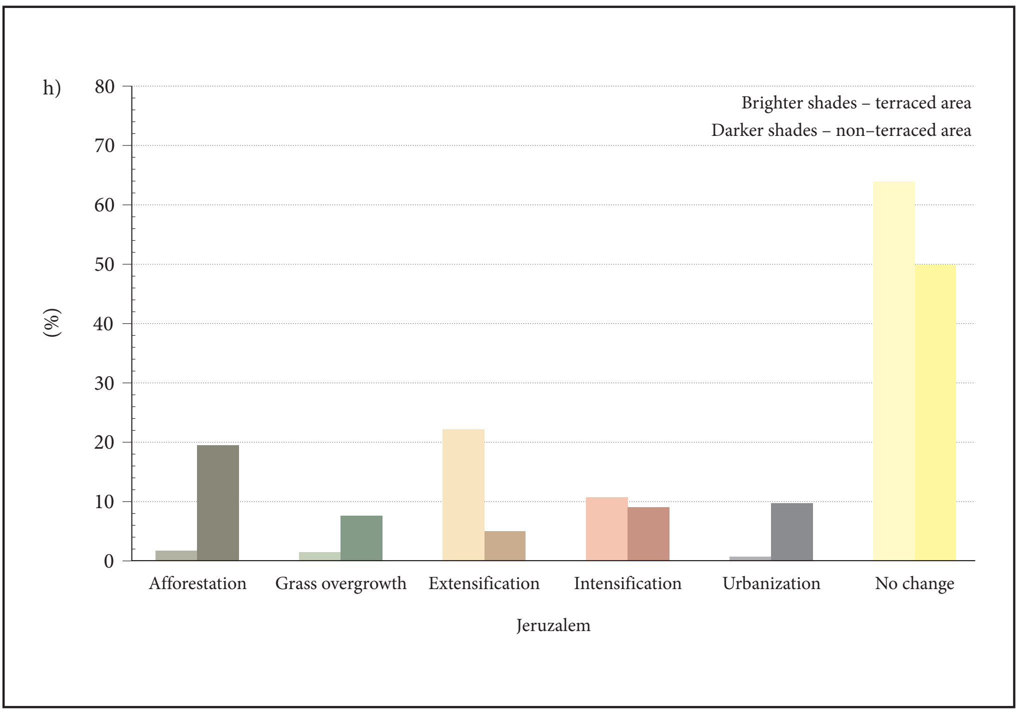
Brighter shades – terraced area
Darker shades – non–terraced area
Afforestation
Grass overgrowth
Extensification
Intensification
Urbanization
No change
Smoleva


g)
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
Rodine


h)
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
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

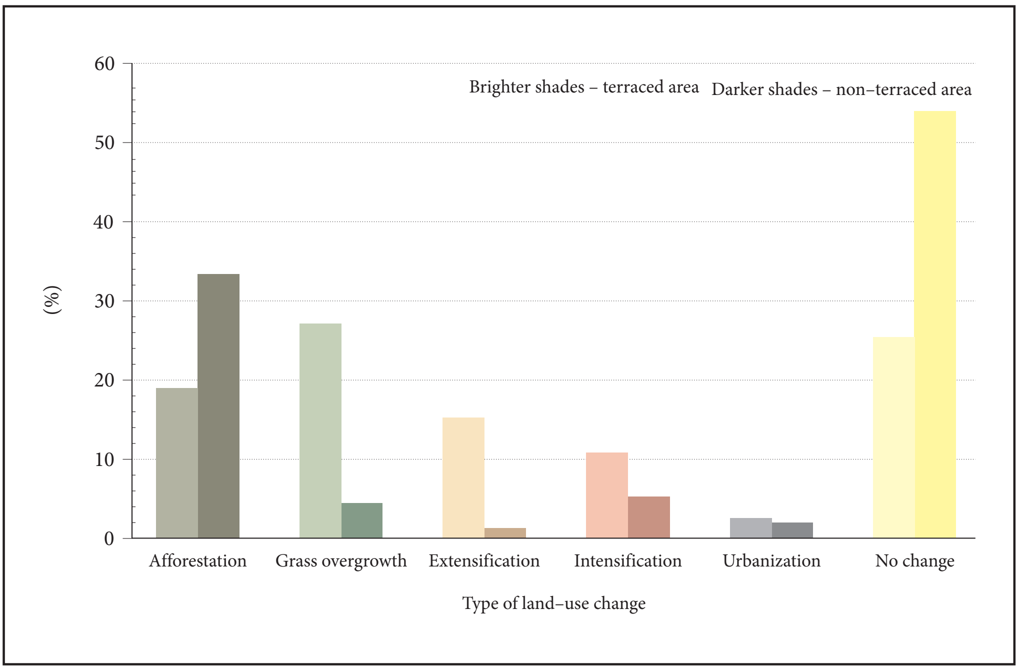


Figure 11: Types of land-use change from the time of the Franciscean cadaster to 2018 on terraced and non-terraced land for all pilot areas together.

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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Acta geographica Slovenica, 59-2, 2019, 143–159

ASSESSMENT OF LAND-USE CHANGES AND THEIR IMPACTS ON ECOSYSTEM SERVICES IN TWO SLOVENIAN RURAL LANDSCAPES

Daniela Ribeiro, Mateja Šmid Hribar

Due to the karst features human activities are limited and the landscape of Bela krajina is being overgrown (upper).
The landscape of the Ljubljana Marsh is largely composed of various meadows, fields, pastures, canals, hedges, tall herb communities, and shrubs (down).

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Assessment of land-use changes and their impacts on ecosystem services in two Slovenian rural landscapes

ABSTRACT: This study shows the link between land use, landscape changes, and ecosystem services. Two pilot areas were investigated for how land use changes from 1824 to 2013 affect the provision of ecosystem services. It was found that low-intensity managed traditional land use is disappearing due to the intensification of agricultural production on the one hand, and the retreat of agriculture from unfavorable areas on the other hand. However, such traditional land use contributes to more diverse and more numerous ecosystem services and helps preserve the cultural landscape. Therefore, intensification and overgrowth should be restricted, and less intensive agriculture should be encouraged. The approach presented can be used as a support tool for decision-making in managing and governing landscapes.

KEY WORDS: land use, ecosystem services, Franciscean Land Cadaster, Revised Land Cadaster, field mapping, Bela krajina, Ljubljana Marsh

Ocena sprememb rabe zemljišč in njihov vpliv na ekosistemske storitve v dveh podeželskih pokrajinah v Sloveniji

POVZETEK: Namen študije je pokazati povezavo med rabo zemljišč, pokrajinskimi spremembami in ekosistemskimi storitvami. Na dveh pilotnih območjih smo preučevali, kako je sprememba rabe zemljišč med leti 1824 in 2013 vplivala na zagotavljanje ekosistemskih storitev. Ugotovili smo, da tako zaradi intenziviranja kmetijske pridelave, kot tudi opuščanja kmetijstva na manj ugodnih območjih, izginja tradicionalna manj intenzivna raba zemljišč. Vendar pa prav tovrstna tradicionalna raba prispeva več bolj raznolikih ekosistemskih storitev ter pripomore k ohranjanju kulturne pokrajine. Zaradi tega bi bilo treba omejevati intenzifikacijo in zaraščanje, ter spodbujati obstoj manj intenzivnega kmetijstva. Predstavljeni pristop lahko služi kot podporno orodje pri odločanju za upravljanje in gospodarjenje s pokrajinami.

KLJUČNE BESEDE: raba zemljišč, ekosistemske storitve, franciscejski kataster, reambulančni kataster, terensko kartiranje, Bela krajina, Ljubljansko barje

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1 Introduction

The landscape, as a combination of abiotic, biotic, and cultural elements, provides ecological functions and ecosystem services essential for the existence of the human race (Millennium Ecosystem Assessment 2005). The landscape structure is influenced by human activities, particularly by land use that shapes socioeconomic development and modifies the structure and processes in the environment (Mander and Uuemaa 2010). Changes in the landscape's structure result in changes to its functions and consequently to ecosystem services as well. As a result of land-use changes, European landscapes have undergone rapid transformation (European Landscape Convention 2000). Two dominant trends in land-use changes are overgrowth due to agriculture marginalization and land abandonment, and land intensification due to more intensive agricultural production on a larger scale (Fry and Gustavsson 1996, Bender et al. 2005).

In Slovenia, various studies have examined land-use changes (e.g. Gabrovec and Kladnik 1997; Petek 2002; Petek and Urbanc 2004; Hladnik 2005; Paušič and Čarni 2012; Lisec, Pišek and Drobne 2013; Ribeiro, Ellis Burnet and Torkar 2013; Šmid Hribar 2016; Gabrovec and Kumer 2019). However, no one has tackled the effects of land-use changes on ecosystem services.

Ecosystem services are the direct and indirect contributions of ecosystems to human wellbeing (Kumar 2010). They have become an important tool for a wide range of decision-making contexts (Fisher, Turner and Morling 2009; de Groot et al. 2010). Transformation of natural ecosystems into other forms of land use alters the landscape's functioning and consequently the supply of ecosystem services. These changes often result in short-term economic benefits (Braat et al. 2008), but in the long run they may reduce and degrade regulating ecosystem services that are vitally important for people. Previous studies have shown that the provision of ecosystem services depends on biophysical conditions and landscape management practices (e.g., Ceschia et al. 2010; Otieno et al. 2011; Burkhard et al. 2012; Haines-Young, Potschin and Kienast 2012; Bürgi et al. 2015; Frélichová and Fanta 2015; Makovníková, Kanianska and Kizeková 2017). Frélichová and Fanta (2015) have proven that land-use intensification contributes to the decline of diversity and ecosystem services because landscapes are often converted to single-purpose land-use (Braat et al. 2008). On the other hand, underuse or no use also significantly impacts and threatens the multifunctionality of landscapes and consequently biocultural diversity and flows of ecosystem services (Mauerhofer et al. 2018). Hence, structural and functional landscape changes might result in a loss of diverse ecosystem services.

This study examines the link between landscapes, changes to them, and the ability to provide ecosystem services. It presents a novel approach to understanding the functioning of landscapes that can be used as an advanced decision-making tool for managing and governing landscapes. Based on two pilot areas, we investigated how land-use changes affect the provision of ecosystem services in Slovenia.

1.1 Pilot areas

We selected two pilot areas as examples of the two dominant trends in land-use changes. The first pilot area, Črna vas, is located in the Ljubljana Marsh Protected Landscape Area (IUCN Category V) near the capital city, Ljubljana. Črna vas is a Slovenian settlement where the landscape has changed significantly. The greatest changes occurred at the beginning of the nineteenth century, when extensive drainage was carried out in order to obtain new farmland. The drainage work was finished in 1829, and colonization of the area followed (Melik 1927). A major change to the landscape was also caused by intensive peat extraction, which lowered the surface by several meters in many areas and increased the risk of floods, and therefore floods are still common (Smrekar et al. 2016). The most important driving forces that shape today's landscape include intensive farming, nature protection, and urbanization due to the proximity of Ljubljana (Šmid Hribar 2016).

The second pilot area, Bojanci, is located in Bela krajina in southeastern Slovenia. In Bela krajina the use of the space, and its patterning and economic structure, are influenced by interlacing karst and Pannonian geographical characteristics (Plut 2008). Until the Second World War, people from Bela krajina mainly worked in and made a living from agriculture (Dražumerič 1987). However, due to the karst landscape features, cultivation is connected to great investments in land improvement, and the natural conditions do not allow the development of intensive agriculture in the region (Ciglič et al. 2012; Ribeiro 2017). For a variety of reasons, emigration from the area was common, and the population continued to decline, with a consequent increase in land abandonment. As a result, today the region is grappling with significant social and economic challenges (Ribeiro 2017).

2 Methods

2.1 Data

To determine long-term landscape changes, we applied data from the Franciscean Land Cadaster (Franciscejski kataster … 1824; 1825), the Revised Land Cadaster (Reambulančni kataster … 1869; 1877), and habitat mapping (Habitatni tipi … 2009, Čarni et al. 2011) combined with fieldwork (in 2013), which represented the current land use. The historical maps were first scanned and georeferenced, and then converted to vector format for further analysis.

To demonstrate the land use for 1824 and 1825, we used the Franciscean Land Cadaster for Carniola, which is a valuable data source for studying the cultural landscape of the nineteenth century (Ribnikar 1982; Petek and Urbanc 2004). Data for the next period (1869 and 1877) were obtained from the Revised Land Cadaster for Carniola. In determining land use, we used the descriptive part of the two cadasters, in which each land plot is defined by land use. In rare cases in which the use was not known or unreadable, we identified it as »unknown«.

For the current land use, habitat mapping data were used combined with our field mapping. Data for the Črna vas pilot area were acquired from the mapping of habitat types carried out in 2009 for the Ljubljana Marsh area (Erjavec et al. 2009). Data for the Bojanci pilot area were acquired from the mapping of habitat types carried out in 2011 for the Marindol area (Čarni et al. 2011). The habitat mapping data were converted into land use type data (Table 1, column 1). In the case of doubt, additional fieldwork was conducted for Črna vas in 2013. For instance, certain habitat types, such as alder swamp woods, were sometimes classified as hedgerows and sometimes groves according to land use and field observations. The same principle was used for rare land plots in which two or even three different habitat types were mapped.

2.2 Analysis of land use changes

In order to make comparisons over time, the datasets were thematically generalized (Ribeiro, Ellis Burnet and Torkar 2013). Table 1 shows how the land use categories were classified in the datasets used, as well as the corresponding CORINE Land Cover category (European Environmental Agency 1995), which allows an international comparison. Because the datasets used were prepared for different needs, the main challenge of categorization was to unify various detailed datasets, which is subjective to a certain degree. In ArcGIS 10, we examined the topology of all digital land use layers and eliminated the errors. For each of the two pilot areas, we produced land use maps (1825, 1869, 2013 for Črna vas, and 1824, 1877, 2011 for Bojanci). The land use change maps were produced by successively overlaying the three temporal spatial data layers (Figure 1).

2.3 Assessment of ecosystem services

The assessment of ecosystem services was based on the matrix for the assessment of various land use types' capacities to provide ecosystem services, as proposed by Burkhard et al. (2009; Table 2). The »recreational and aesthetic values« (see Table 2, cultural services column) were divided into two separate criteria, and

Table 1: Land-use categories in the pilot areas from 1824 until 2013 (sources: Franciscejski kataster . . . 1824; 1825, Reambulančni kataster . . . 1869; 1877, Habitatni tipi . . . 2009, Čarni et al. 2011, Šmid Hribar 2016).

Land-use type (2013)	Franciscean Land Cadaster (1824 and 1825)	Revised Land Cadaster (1869 and 1877)	Habitat mapping (2009 and 2011)	CORINE land cover
Cultivated field	Cultivated field	Cultivated field	82.11 Field crops	2.1.1 Non-irrigated arable land
Extensive orchard	Orchard	Orchard	83.151 Northern fruit orchards	2.2.2 Fruit trees and berry plantations
Garden	Garden with fruit trees Vegetable garden	Garden with fruit trees Vegetable garden	83.15 Fruit orchards 85.3 Gardens	2.2.2. Fruit trees and berry plantations

Intensive meadow	–	–	38.222 Hygromesophile medio-European lowland hay meadows	2.1.1 Non-irrigated arable land
Extensive to medium-intensive meadow	Meadow Wet meadow Meadow with trees Meadow with fruit trees and grapevines Meadow with fruit trees	Meadow Meadow with trees Meadow with fruit trees	37.311 Calcareus purple moorgrass meadow 37.2 Eutrophic humid grasslands 37.21 Atlantic and sub-Atlantic humid meadows 37.211 Cabbage thistle meadows 81 Improved grasslands	2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation 3.2.1 Natural grassland
Vineyard	Vineyard	Vineyard	83.21 Vineyards	2.2.1 Vineyards
Pasture	Pasture Pasture with trees Pasture with fruit trees	Pasture Pasture with trees	38.1 Mesophile pastures	2.3 Pastures
Wet pasture	Wet pasture	–	–	–
Tall-herb communities	–	–	37.11 Western nemoral tall-herb communities	3.2 Shrub and/or herbaceous vegetation associations
Wetland	Marshes	–	53.1 Reed beds 53.21 Large carex beds	4.1.1 Inland marshes
Peatland	–	Peatland	–	4.1.2 Peatbogs
Shrubland	Pasture with shrubs Pasture with shrubs and trees Meadow with shrubs Meadow with shrubs and trees	–	38.13 Ruderalized abandoned grasslands 87.1 Fallow fields 87.2 Ruderal communities 87.2 × 31.8D/44.9 Ruderal communities × Western Eurasian thickets / Alder, willow, oak, aspen swamp woods	3.2.4 Transitional woodland/shrub
Forest	Young forest Mature forest Forest with fruit trees	Young forest Mature forest	84.3 Small woodlots 83.311 Native conifer plantations	3.1 Forests
Grove	–	Bushes	44.91 Alder swamp woods 83.311 Native conifer plantations	3.2.4 Transitional woodland/shrub
Hedgerow	–	–	44.3 Middle European stream ash-alder woods 44.91 Alder swamp woods 84.2 Hedges	2.4.4 Agro-forestry areas
River	River	River Stream	24.1 River and streams	5.1.1 Watercourses
Channel	Channel	Channel	89.22 Ditches and small canals 89.22/22.4 Ditches and small canals/Euhydrophyte communities	5.1.2 Water bodies
Pond	Pond	Pond	–	5.1.2 Water bodies
Built-up area	Built-up Cemetery Path	Built-up Path Passage	86 Towns, villages, and industrial sites Paths and tracks Roads	1.1 Urban fabric 1.2 Industrial, commercial, and transport 1.3 Mine, dump, and construction sites

additional criteria were added for »cultural/natural heritage and identity« (Table 3). We scored the generalized land use types from 0 to 5 according to their relevant capacity to supply each ecosystem service as determined by Burkhard et al. (2009) in Table 2. Then we corrected certain values of ecosystem services and adjusted them according to the actual state of landscape elements in the pilot areas determined by expert assessment (Čarni 2013). The results are shown in Table 3. To explore landscape changes and the consequent changes in their functions, three ecosystem services were studied in detail: pollination, crops, and cultural/natural heritage and identity.

Table 2: Matrix for assessing various land cover types' capacities to provide selected ecosystem goods and services (Burkhard et al. 2009).

	Ecological Integrity ∑	Abiotic heterogenity	Biodiversity	Biotic waterflows	Metabolic efficiency	Exergy capture (radiation)	Reducation of nutrien loss	Storage capacity (SOM)	**Provisioning Services ∑**	Crops	Livestock	Fodder	Capture Fisheries	Acquaculture	Wild foods	Timber	Wood fuel	Energy (Biomass)	Biochemicals/ medicine	Freshwater	**Regulating Services ∑**	Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air quality regulation	Erosion regulation	Nutrient regulation	Water purification	Pollination	**Cultural Services ∑**	Recreational&Aesthetic Values	Intrinsic Value of Biodiversity
Continuous urban fabric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Discontinuos urban fabric	7	1	1	1	1	1	1	1	3	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial or commercial units	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road and rail netwroks	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Port areas	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	1	0
Airports	7	1	1	1	1	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mineral extraction sites	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dump sites	8	2	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction sites	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green urban areas	18	3	3	2	1	4	3	2	2	0	0	0	0	0	1	0	1	0	0	0	11	2	1	0	2	1	2	1	1	1	3	3	0
Sport and leisure facilities	16	2	2	2	1	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	9	1	1	0	2	1	1	1	1	1	5	5	0
Non-irrigated arable land	22	3	2	3	4	5	1	4	21	5	5	5	0	0	0	0	0	5	1	0	5	2	1	1	1	0	0	0	0	0	1	1	0
Permanently irrigated land	21	3	2	5	2	5	1	3	18	5	5	2	0	0	0	0	0	5	1	0	5	3	1	1	0	0	0	0	0	0	1	1	0
Ricefields	20	3	2	5	1	5	1	3	7	5	0	2	0	0	0	0	0	0	0	0	4	2	0	0	2	0	0	0	0	0	1	1	0
Vineyards	14	3	2	3	1	3	0	2	5	4	0	0	0	0	0	0	1	0	0	0	3	1	1	0	1	0	0	0	0	0	5	5	0
Fruit trees and berries	21	4	3	4	2	3	2	3	13	5	0	0	0	0	0	4	4	0	0	0	19	2	2	2	2	2	2	1	1	5	5	5	0
Olive groves	17	3	2	3	2	3	1	3	12	4	0	0	0	0	0	4	4	0	0	0	7	1	1	0	1	1	1	1	1	0	5	5	0
Pastures	24	2	2	4	5	5	2	4	10	0	5	5	0	0	0	0	0	0	0	0	8	1	1	1	1	0	4	0	0	0	3	3	0
Annual and permanent crops	18	2	2	3	2	4	2	3	20	5	5	5	0	0	0	0	0	5	1	0	7	2	1	1	1	1	1	0	0	0	1	1	0
Complex cultivation patterns	20	4	3	3	2	4	1	3	9	4	0	3	0	0	0	0	0	0	2	0	5	2	1	1	1	0	0	0	0	0	2	2	0
Agricultural& natural vegetation	19	3	3	3	2	3	2	3	21	3	3	2	0	0	3	3	3	3	1	0	13	3	2	1	2	1	3	0	1	0	5	2	3
Agro-forestry areas	27	4	4	4	3	4	4	4	14	3	3	2	0	0	0	3	3	0	0	0	13	2	1	1	1	1	2	1	1	3	3	3	0
Broad-leaved forest	31	3	4	5	4	5	5	5	21	0	0	1	0	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
Coniferous forest	30	3	4	4	4	5	5	5	21	0	0	1	0	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
Mixed forest	32	3	5	5	4	5	5	5	21	0	0	1	0	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
Natural grassland	30	3	5	4	4	4	5	5	5	0	3	0	0	0	2	0	0	0	0	0	22	2	3	1	1	0	5	5	5	0	6	3	3
Moors and heathland	30	3	4	4	5	4	5	5	10	0	2	0	0	0	1	0	2	5	0	0	20	4	3	2	2	0	0	3	4	2	10	5	5
Sclerophyllous vegetation	21	3	4	2	3	3	4	2	8	0	2	0	0	0	1	0	2	0	3	0	7	2	1	1	1	0	0	0	0	2	6	2	4
Transitional woodland shrub	21	3	4	2	3	3	4	2	5	0	2	0	0	0	1	0	2	0	0	0	3	1	0	0	0	0	0	0	0	2	4	2	2
Beaches, dunes and sand plains	10	3	3	1	1	1	0	1	2	0	0	0	0	0	0	0	0	2	0	0	6	0	0	5	1	0	0	0	0	0	7	5	2
Bare rock	6	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	0	0	0	1	0	4	4	0
Sparsely vegetated areas	9	2	3	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	1	1	0	0	0	0	0	0	0	0
Burnt areas	6	2	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Glaciers and perpetual snow	3	2	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	10	3	3	0	4	0	0	0	0	0	5	5	0
Inland waters	25	3	2	4	4	4	3	5	7	0	2	5	0	0	0	0	0	0	0	0	14	2	2	4	2	0	0	4	0	0	0	0	0
Peatbogs	29	3	4	4	4	4	5	5	5	0	0	0	0	0	0	0	0	5	0	0	24	4	5	3	3	0	0	3	4	2	8	4	4
Salt marshes	23	2	3	4	3	3	3	5	2	0	2	0	0	0	0	0	0	0	0	0	8	1	0	5	0	0	0	2	0	0	3	3	0
Salines	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2	0
Intertidal flats	13	2	3	0	2	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0	5	0	0	0	1	0	0	4	4	0
Water courses	18	4	4	0	3	3	3	1	12	0	0	0	3	0	4	0	0	0	0	5	10	1	0	2	1	0	0	3	3	0	10	5	5
Water bodies	23	4	4	0	4	4	3	4	12	0	0	0	3	0	4	0	0	0	0	5	7	2	1	1	2	0	0	1	0	0	9	5	4
Coastal lagoons	25	4	4	0	5	5	3	4	16	0	0	0	4	5	4	0	0	3	0	0	5	1	0	4	0	0	0	0	0	0	9	5	4
Estuaries	21	3	3	0	5	5	3	2	17	0	0	0	5	5	4	0	0	3	0	0	9	0	0	3	0	0	0	3	3	0	7	4	3
Sea and ocean	15	2	2	0	3	3	4	1	11	0	0	1	5	5	0	0	0	0	0	0	13	3	5	0	0	0	0	5	0	0	6	4	2

Furthermore, we prepared maps showing the capacity of land use types to supply ecosystem services (Figures 2 to 4). »Pollination,« representing the regulative group of ecosystem services, was chosen due to its importance for food production. Intensive agriculture using pesticides threatens bees and other pollinators (Klein et al. 2007). An additional threat to pollinators is the loss of their habitats. The ability to provide crops in the provisioning group of ecosystem services is the capacity of the landscape for food provision. From among the cultural ecosystem services, we selected the potential of providing »cultural/natural heritage and identity« because Slovenian cultural landscapes are recognized as valuable and are probably one of the main elements of national identity (Perko and Urbanc 2004, Golobič and Lestan 2016).

3 Results

3.1 land use changes in the pilot areas

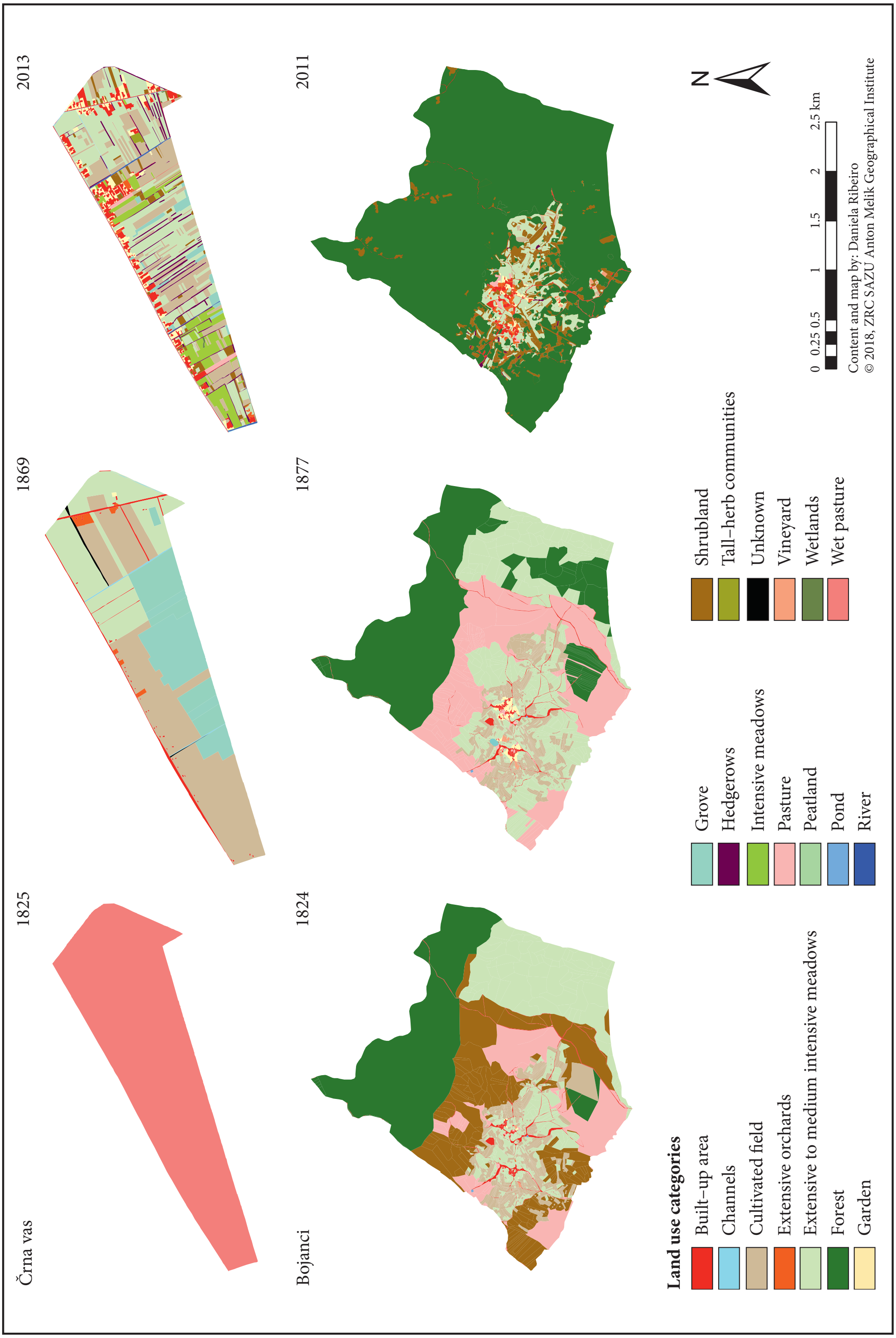
In 1825 in Črna vas there were wet pastures, which later disappeared. In the same year drainage work started, resulting in the colonization of the Ljubljana Marsh in 1829. Over the following decades, Črna vas changed completely (Figure 1). In 1869, cultivated fields and meadows, separated by channels, characterized the landscape. In addition, groves and peatland were mapped. Peatlands were subjected to the greatest changes due to peat cutting (Melik 1927). The built-up area was introduced due to colonization. Some houses had fruit trees and gardens. In the third period studied, 2009–2013, the area became even more heterogeneous. The inhabitants shifted their activities towards animal husbandry, cultivated fields decreased, and meadows were intensified. The share of built-up area increased as well. Near houses, the proportion of vegetable gardens and ornamental gardens with fruit trees increased, replacing the extensive orchards. Areas of groves, among which we included bushes, have decreased. Due to abandonment, some areas have been overgrown with shrubland and non-native tall-herb communities. The native tall-herb communities present a special landscape element that provides a habitat for endangered bird species. However, due to changes in farming modes, tall-herb communities are decreasing. Pastures have appeared again. Hedgerows that were planted along the parcel borders by new inhabitants during the colonization after 1829 (as described in Melik 1927), and were not mapped in cadasters, have nowadays become a recognizable element of the landscape. Fragments of wetland have been found in abandoned channels. Rivers and channels are also present.

In Bojanci, cultivated fields showed a dramatic decrease from 1824 to 2011, although this change was more evident after 1877 (Figure 1). The areas occupied by gardens experienced fluctuations for the timespan studied. The area of vineyards is almost negligible and, as with gardens, this land use category also experienced slight fluctuations in the period studied. In 1824, extensive meadows and pastures dominated. Both meadows and pastures increased between 1824 and 1877, and decreased between 1877 and 2011. Pastureland almost disappeared in 2011, presumably as a result of afforestation. Shrubland occupied an extensive area in 1824; in 1877 this land use category was not mapped, whereas in the third period shrubland was mapped, although it occupied a much smaller proportion than the initial area. Even though forest area was already quite extensive in 1824, the afforested land significantly expanded over time. Inland waters were negligible in 1824 and 1877, and these elements do not occur again after this period. The built-up area did not show major changes over more than 180 years; this could be understood as a sign of population stagnation. The major landscape changes in Bojanci took place after 1877. It was also reported by Ribeiro (2017) that the major peak of emigration was reached between 1912 and 1927, and so it was expected that the extent of land abandonment would increase as a result of emigration.

3.2 Link between land use and ecosystem services

Because landscape governance aims to be sustainable, it is important to know the functions and roles of ecosystems and individual landscape elements, and to manage landscapes accordingly. Therefore, based on the matrix from Table 2, values of ecosystem services were assigned for each landscape element. The result is presented in Table 3, in which landscape elements are sorted according to the total sum of all estimated values to supply ecosystem services.

Figure 1: Land-use changes in Črna vas (1825–2013) and Bojanci (1824–2011). ➤ p. 150
Table 3: Matrix for evaluating ecosystem services provided by various land-use types in both pilot areas. ➤ p. 151


Črna vas
1825
1869
2013
Bojanci
1824
1877
2011
Land use categories
Built-up area
Channels
Cultivated field
Extensive orchards
Extensive to medium intensive meadows
Forest
Garden
Grove
Hedgerows
Intensive meadows
Pasture
Peatland
Pond
River
Shrubland
Tall-herb communities
Unknown
Vineyard
Wetlands
Wet pasture
N
0 0.25 0.5 1 1.5 2 2.5 km
Content and map by: Daniela Ribeiro
© 2018, ZRC SAZU Anton Melik Geographical Institute

	Built-up area	Vineyard	Intensive meadow	Pond	Channel	Pasture	Cultivated field	Garden	Wetland	River/stream	Wet pasture	Shrubland	Tall-herb communities	Peatland	Hedgerow	Extensive orchard	Extensive to medium intensive meadow	Grove	Mixed forest
Total	**8**	**35**	**37**	**39**	**40**	**46**	**50**	**52**	**52**	**52**	**53**	**53**	**55**	**61**	**68**	**76**	**81**	**96**	**105**
Ecological integrity ∑	**1**	**15**	**20**	**17**	**23**	**24**	**22**	**20**	**25**	**18**	**27**	**22**	**23**	**27**	**19**	**21**	**27**	**30**	**32**
Abiotic heterogenity	1	3	2	3	4	2	3	3	3	4	3	3	2	3	3	4	3	3	3
Biodiversity	0	2	2	2	4	2	2	3	2	4	3	3	3	4	3	3	5	4	5
Biotic waterflows	0	3	3	0	0	4	3	3	4	0	4	3	3	4	3	4	4	4	5
Metabolic efficiency	0	1	4	3	4	5	4	2	4	3	5	3	3	4	2	2	3	4	4
Exergy capture (radiation)	0	3	5	3	4	5	5	4	4	3	4	3	4	4	3	3	3	5	5
Reducation of nutrien loss	0	1	1	3	3	2	1	2	3	3	3	4	4	4	2	2	4	5	5
Storage capacity (SOM)	0	2	3	3	4	4	4	3	5	1	5	3	4	4	3	3	5	5	5
Regulating Services ∑	**0**	**3**	**6**	**7**	**7**	**8**	**6**	**10**	**17**	**10**	**14**	**20**	**16**	**21**	**22**	**20**	**27**	**34**	**39**
Local climate regulation	0	1	2	2	2	1	2	2	2	1	1	3	2	4	3	3	3	4	5
Global climate regulation	0	1	1	1	1	1	1	1	2	0	1	2	1	3	3	2	3	3	4
Flood protection	0	0	1	1	1	1	1	1	4	2	3	2	2	3	2	1	2	2	3
Groundwater recharge	0	1	1	2	2	1	1	1	2	1	2	2	2	2	2	2	2	3	2
Air quality regulation	0	0	0	0	0	0	0	1	0	0	0	2	1	0	2	2	0	4	5
Erosion regulation	0	0	1	0	0	3	0	1	0	0	2	3	2	0	4	3	4	5	5
Nutrient regulation	0	0	0	1	1	0	0	1	3	3	3	1	2	3	1	1	4	4	5
Water purification	0	0	0	0	0	0	0	0	4	3	1	2	2	4	2	1	5	4	5
Pollination	0	0	0	0	0	1	1	2	0	0	1	3	2	2	3	5	4	5	5
Provisioning Services ∑	**0**	**6**	**9**	**10**	**4**	**8**	**16**	**11**	**2**	**9**	**7**	**8**	**8**	**6**	**17**	**22**	**13**	**18**	**22**
Crops	0	4	0	0	0	0	5	5	0	0	0	0	0	0	1	5	0	0	0
Livestock	0	0	0	0	0	5	0	0	2	0	3	0	0	0	2	5	3	0	0
Fodder	0	0	5	0	0	3	5	1	0	0	2	0	0	0	1	1	2	0	1
Capture Fisheries	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Acquaculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wild food	0	0	1	2	0	0	0	1	0	1	1	3	2	0	3	0	4	4	5
Timber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0	5	5
Wood fuel	0	1	0	0	0	0	0	1	0	0	1	2	0	1	4	4	0	5	5
Energy (Biomass)	0	1	3	3	0	0	5	1	0	0	0	0	2	5	1	2	1	0	1
Biochemicals/medicine	0	0	0	0	0	0	1	2	0	0	0	3	4	0	2	1	3	4	5
Freshwater	0	0	0	4	4	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Cultural Services ∑	**7**	**11**	**2**	**5**	**6**	**6**	**6**	**11**	**8**	**15**	**5**	**3**	**8**	**7**	**10**	**13**	**14**	**14**	**12**
Recreational values	2	4	1	0	0	0	0	3	0	5	0	0	0	0	0	3	4	5	4
Aesthetic values	2	3	1	2	2	3	3	4	4	5	3	3	5	4	5	5	5	5	4
C/N heritage and identity	3	4	0	3	4	3	3	4	4	5	2	0	3	3	5	5	5	4	4

3.3 Changes in the supply of selected ecosystem services as a result of landscape changes over 180 years

The capacity to provide pollination in Črna vas was the greatest in 1869 (Figure 2), when this landscape was not as fragmented and intensively used as in 2013. In contrary, in Bojanci the capacity to provide pollination was the greatest in 2011 (Figure 2), when the forest area reached its maximum.

The best period for supporting crop provision in Črna vas was in 1869 (Figure 3) due to the high proportion of cultivated fields. Many of them were later transformed into various types of meadows and built-up areas. In Bojanci as well, the best period for supporting crop provision was in 1877 (Figure 3). After this period, the area experienced an increase in land abandonment as a result of emigration and consequently depopulation.

In Črna vas, the capacity for supplying cultural/natural heritage and identity started with the first inhabitants after 1829. Colonization introduced elements (channels, hedgerows, meadows, and cultivated fields) that later significantly influenced the identity of this landscape. However, nowadays some of them are being replaced by intensive meadows and shrublands, which are not contributing to current heritage and identity. The capacity for supplying cultural/natural heritage and identity in Bojanci was quite high in 1877 due to the increase in areas of pastures, meadows, and forests. This result might be due to the fact that shrubland was not mapped in 1877; the areas previously mapped as shrubland in 1824 were mapped as pastures or meadows in 1877. According to the map, the greatest capacity to provide this cultural ecosystem service was achieved in 2011 (Figure 4), when the forested area was larger.

4 Discussion

We analyzed long-term land use changes in two pilot areas from 1824 to 2013 (Figure 1). Due to a lack of data from 1900 to 2000, the intervals between the datasets are unequal, but this did not affect the main goal of the study.

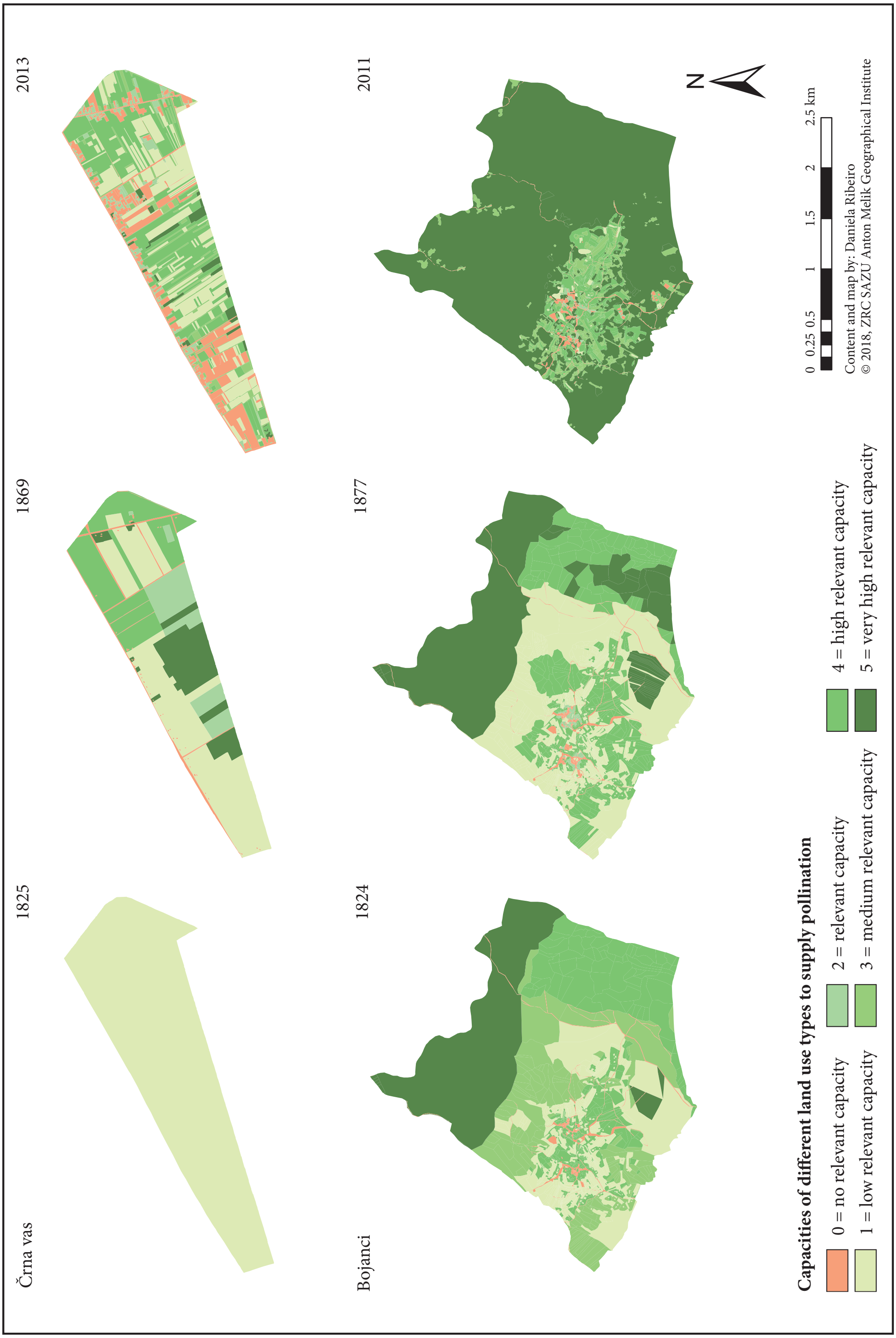
The study of land use changes in Črna vas has shown that since 1825 the main driving forces of the area were agriculture, settlement, and water management, which introduced a number of new landscape elements yielding various ecosystem services. In recent decades, nature protection became an important driving force, resulting in declaring the Ljubljana Marsh a protected landscape area in 2008. This protection has limited intensified agriculture and, in addition to regular agricultural subsidies, has also introduced specific ones. However, the system of subsidies has a voluntary basis, enabling farmers to make their own decisions. All of this has resulted in the simultaneous presence of two opposite trends: intensification and abandonment accompanied by the disappearance of managing the landscape in less intensive manners that are closer to nature. Elements such as wet pastures, peatland, and partly also groves and extensive orchards have almost disappeared in Črna vas as a result of ongoing agricultural intensification. Without sustainable governance, this trend will continue leading to fragmentation and the disappearance of low-intensity landscape usage elements, which are important for providing more diverse ecosystem services.

Land management is lacking in Bojanci, and landscape elements are being transformed into other elements. Land abandonment may contribute to the natural restoration of the landscape on the one hand, and it may threaten the functional diversity of cultural landscapes on the other hand.

Landscape elements such as cultivated fields or meadows have practically disappeared in Bojanci in recent times. This phenomenon can be explained primarily as the result of the retreat of agriculture from unfavorable areas and rural depopulation.

The method applied made it possible to assess ecosystem services based on land use (Table 3). The originality of this paper lies in its application of the method to land use at the parcel level from three time periods, making it possible to show the influence of land use changes on the capacity to provide ecosystem services (Figures 2–4).

Figure 2: Changes in the supply of pollination in Črna vas (1825–2013) and Bojanci (1824–2011). ➤ p. 153
Figure 3: Changes in the supply of crops in Črna vas (1825–2013) and Bojanci (1824–2011). ➤ p. 154
Figure 4: Changes in the supply of cultural/natural heritage and identity in Črna vas (1825–2013) and Bojanci (1824–2011). ➤ p. 155



Črna vas
1825
1869
2013
Bojanci
1824
1877
2011
N
Capacities of different land use types to supply pollination
0 = no relevant capacity
1 = low relevant capacity
2 = relevant capacity
3 = medium relevant capacity
4 = high relevant capacity
5 = very high relevant capacity
0 0.25 0.5 1 1.5 2 2.5 km
Content and map by: Daniela Ribeiro
© 2018, ZRC SAZU Anton Melik Geographical Institute


Črna vas
1825
1869
2013
Bojanci
1824
1877
2011
N
0 0.25 0.5 1 1.5 2 2.5 km
Content and map by: Daniela Ribeiro
© 2018, ZRC SAZU Anton Melik Geographical Institute
Capacities of different land use types to support crops
0 = no relevant capacity
1 = low relevant capacity
2 = relevant capacity
3 = medium relevant capacity
4 = high relevant capacity
5 = very high relevant capacity


Črna vas
1825
1869
2013
Bojanci
1824
1877
2011
N
0 0.25 0.5 1 1.5 2 2.5 km
Content and map by: Daniela Ribeiro
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Capacities of different land use types to provide cultural/natural heritage and identity
0 = no relevant capacity
1 = low relevant capacity
2 = relevant capacity
3 = medium relevant capacity
4 = high relevant capacity
5 = very high relevant capacity

In Črna vas, the provision of ecosystem services studied was higher in 1869. In this pilot area neither a lack of agriculture (mapped in 1825) nor intensive agricultural use (mapped in 2013) positively contributes to a balanced provision of regulating and provisioning ecosystem services. Cultural ecosystem services increased with colonization; however, they are now threatened by synchronous intensification and abandonment.

Land abandonment in Bojanci is leading to an increase in regulating ecosystem services and to a decrease in provisioning ecosystem services. Cultural ecosystem services increased in Bojanci recently following the expansion of forests. The high relevant capacity for provisioning heritage and identity attributed to Bojanci in 2011, shown in Figure 4, is arguable because this abandoned landscape has resulted in an expansion of forested land. This points to a critical aspect of the methodology used. We assigned forest a high value for cultural services because forests are much appreciated and highly important for Slovenians. However, the aesthetic value of mosaic landscapes with a diversity of land use patches is here not taken in account. We are aware that not all forested areas support the same level of these ecosystem services. Therefore, on the one hand, for some cultural ecosystem services it would be more accurate to assign values for specific points (e.g., monuments and viewpoints) and not for the landscape element as a whole. On the other hand, a landscape itself can sometimes be recognized as heritage and national identity (Lowenthal 2007).

We suggest that cultural ecosystem services should be further studied and elaborated using systematic field walk based analysis as proposed by Bieling and Plieninger (2013) and interviews as mentioned by Bieling et al. (2014).

Based on the landscape changes studied, we argue that preservation of traditional and low-intensity agriculture should be promoted to protect against the overgrowth of agricultural land and that intensive use of agricultural land should be restricted due to the importance of preserving cultural landscapes and providing diverse ecosystem services (e.g., food provisioning and preservation of cultural heritage/identity, which consequently attracts tourism). In addition, the findings of this study should influence incentive-based policies (e.g., the future Common Agricultural Policy), which should be better adapted to local contexts and characteristics.

5 Conclusions

With this study we linked land use with ecosystem services. We are aware that the ecosystem service values used in this study are only an approximation, and detailed studies should be carried out for a more accurate assessment.

A comparison of selected ecosystem services provided over 180 years for the pilot areas revealed that provisioning and cultural services were significantly reduced in Bojanci due to land abandonment and depopulation, whereas these ecosystem services increased due to colonization and the proliferation of arable land in Črna vas. On the other hand, for exactly the same reasons, regulating ecosystem services increased in Bojanci in recent decades, but they decreased in Črna vas during the same time period.

It also turned out that land use data are not always relevant for mapping the supply of cultural ecosystem services. Nevertheless, from the estimated values shown in Table 3 it is already evident that less intensively used landscape elements contribute to more numerous and diverse ecosystem services than landscape elements with more intense use or abandoned ones. This finding should be taken into account in landscape management, which should consider natural characteristics and try to maintain those landscape elements that require little input while still offering various ecosystem services.

The approach presented can be used as a support tool for decision-making in managing and governing landscapes. Furthermore, the study opens an arena for theoretical discussion between various disciplines (e.g., geography, ecology, forestry, and sociology) that should contribute to understanding the landscape as a complex integrated whole.

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MONITORING LAND-USE CHANGE USING SELECTED INDICES

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Vineyards as the prevailing land use in the Lendavske gorice Hills.

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Monitoring land-use change using selected indices

ABSTRACT: This article presents various indices for describing the characteristics of land use and monitoring land-use change in various periods. These indices were either developed by the authors or were derived from landscape metrics. They were calculated for five selected sites of agricultural land (sites) for the time when the Franciscean Cadaster was introduced and for 2015. A comparison of the values of the indices revealed the changes in the selected sites, and the conclusions present an opinion on their suitability. It was found that the numerical values of the indices reflect visually detected changes in the graphic representation of land use, and they could therefore be introduced into the system for monitoring land-use changes.

KEY WORDS: land use, index, landscape metrics, Franciscean Cadaster, Slovenia

Spremljanje sprememb rabe zemljišč z izbranimi indeksi

POVZETEK: V prispevku predstavljamo indekse za opisovanje značilnosti rabe zemljišč in spremljanje sprememb rabe v različnih časovnih obdobjih. Indekse smo oblikovali samostojno ali jih prevzeli iz krajinske metrike. Izračunali smo jih za pet izbranih območij kmetijskih zemljišč (polja) v času nastanka franciscejskega katastra in v letu 2015. S primerjavo vrednosti indeksov smo na izbranih poljih ugotavljali spremembe, v zaključku pa podali mnenje o njihovi ustreznosti. Ugotovili smo, da številčne vrednosti indeksov odražajo spremembe, ki jih vizualno zaznavamo tudi pri grafični upodobitve rabe, zato menimo, da bi jih lahko vpeljali v sistem spremljanja sprememb rabe zemljišč.

KLJUČNE BESEDE: raba zemljišč, indeks, krajinska metrika, franciscejski kataster, Slovenija

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1 Introduction

Land use and land-use changes are a reflection of economic, political, and social conditions (Bičík, Jeleček and Štěpánek 2001; Antrop 2005). Land use is identified using various methods: fieldwork, identification based on available data, and, in recent decades, automated classification of remote sensing images (Kokalj and Oštir 2005). Determination of land-use changes requires data on land use over time. The first records on land use in Slovenia date back to the Theresian Cadaster (1774–1754), whereas the Franciscean Cadaster (established between 1818 and 1827) and the Revised Cadaster (1869) are most frequently used for studying land-use changes. They also depict land uses in a graphic section, offering better representation of their spatial distribution (Petek and Urbanc 2004). Tax assessment prompted rather detailed consideration of agricultural land use; specifically, at the plot level (Ribnikar 1982). The Franciscean Cadaster as a source for studying land-use changes has been used by Petek (2005; 2007), Kladnik and Petek (2007), Verderber (2013), Golob (2014), Harvey, Kaim and Gajda (2014), Bičík et al. (2015), Gabrovec and Kumer (2019), and many others.

The Franciscean Cadaster was also used as a source to study land-use changes in this study. Land-use changes in selected sites were checked using indices, which were developed either on our own or were derived from landscape metrics. Index development depends on the study purpose, scale of observation, size of the study area, and type of data (raster or vector). This article shows how the indicators developed are suitable for describing land-use changes, and that the numerical values obtained reflect changes detected by visually comparing mapped land uses in two time periods (at the time the Franciscean Cadaster was introduced and in 2015 using Land Use data base (Evidenca dejanske … 2015).

Landscape metrics (LSM) began to take root after 1995 for analyzing the situation and changes in the landscape and ecological spatial characteristics. This is a successful method for determining the heterogeneity of land cover (Turner et al. 2003) as well as for identifying changes. Landscape metrics indices for quantifying landscape elements and landscape compositions were developed by McGarigal and Marks (1995), McGarigal (2002) and further improved until the most recent version of the software program FRAGSTATS 4.4 (McGarigal 2015). As software, Patch Analyst (an extension to the ArcGIS software; Sushant and Yuan 2012; Rempel, Kaukinen and Carr 2012) is commonly used, whereas Polenšek and Pirnat (2018) used Graphab 1.1 for spatial analysis of forest patches.

The landscape metrics method is most commonly used in ecology, where the diversity, spatial distribution, size, and shape of patches are relevant (Alberti 2005), but other sciences also benefit from its use. Irwin and Bockstael (2007), Clark et al. (2009), Shrestha et al. (2012), and Zhang et al. (2013) used this method to study interactions between urbanization and changes in parcel shape and size. Sivrikaya et al. (2007), Pijanowski and Robinson (2011), and Shoyama and Braimoh (2011) used it to analyze land-use changes across various periods.

The basic observation unit in landscape metrics is a »patch« (Polenšek and Pirnat 2018; Foški 2017). For the purpose of this study, a patch is understood in the same way as it was defined by Irwin and Bockstael (2007, 20673) and Shrestha et al. (2012); namely, as a contiguous area of the same land use. This method is most commonly used with raster data, particularly when study areas are large (Wu et al. 2002). When comparing areas, one must first allow for equal quality of input data or raster-to-vector conversion under the same conditions and at the same scale (Wu et al. 2002). The use of indices at different levels and at different scales is reasonable using vector data.

McGarigal (2015) identified six groups of indices and, within each group, indices may be defined at the patch level (defined for individual patches), class level (all the patches of a given type), and landscape level (all patches in the study area), as shown in Table 1. Based on their meaning, one can distinguish between a group of indices that express land-use composition (e.g., the number of different land uses, land-use proportions, or the number of patches) and a group of indices expressing the characteristics of a spatial pattern (Ramezani et al. 2013).

At the level of the study area, land-use diversity indices are particularly interesting (Table 1, gray field), which can be divided into three groups: 1) indices of patch number and density, three indices, 2) land-use diversity indices, three indices, and 3) indices of land-use distribution in the area, three indices (McGarigal 2015, 164-171; Foški 2017). The indices can be used for monitoring land-use changes across time. Shannon's diversity index and Simpson's diversity index are most commonly used (Robič 2004; Pijanowski and Robinson

Table 1: Number of indices of landscape metrics based on McGarigal (2015) for individual characteristics at the patch, class, or landscape level (authors' own classification).

Index groups	Patch (number of indices)	Class (number of indices)	Landscape (number of indices)
Area and edges	3	7	6
Shape	5	7	7
Compactness	3	7	6
Contrast	1	3	3
Aggregation	3	16	15
Diversity	0	0	9

2011; Ramezani and Holm 2011; Comer and Greene 2015). A comparison of indices (Lo Papa, Palermo and Dazzi 2011, 340) showed that for describing land-use diversity it is enough to choose a single index, either from the second group or from the third.

For the purpose of this study we also used some landscape metrics indices; the patch richness index (PR), the number of patches (N_z), the relative land-use diversity index (RPR), and Simpson's diversity index (SIDI), as developed by McGarigal and Marks (1995) and McGarigal (2015). We developed the Use Proportion Index (IDr) and the Index of Shape and Size of Patches (IOV_z) ourselves (Foški 2017). A combination of indices was used to analyze land use in selected sites (enclosed arable land) at the time the Franciscean Cadaster was introduced and in 2015. Our thesis was that numerical values (indices) can describe the characteristics of land use in two time periods and that the changes in index values are also reflected visually; that is, on graphic representations of land use in two time cross-sections. To that end, this article graphically presents land use in two time cross-sections, whereas values and changes in indices are expressed numerically and with graphs.

2 Working method and data

The working method consists of three steps: 1) development and selection of indices, 2) calculation of indices for selected test areas in two time cross-sections, and 3) evaluation of results.

The indices were determined based on the literature and land-use characteristics in Slovenia. For this, the following data are required:

- Land-use diversity in the study area (patch richness and the number of all patches);
- Distribution of land-use proportions in the study area (the ratio between the proportions of land uses);
- Characteristics of patches (shape and size) in the study area (contiguity and the size of individual patches); and
- Relationships between all land uses.

The indices were selected and developed (Table 2) so that they are computable using vector data. The patch richness index (PR) and the number of all patches are greater than 1, and all other indices range from 0 to 1. The extension FK was added to the indices calculated from the Franciscean Cadaster data (e.g., $PR_{\_FK}$).

Five sites were selected as areas of observation: Zatolmin, Vinjole, Predoslje, Kleče and Podgora, and Pernice (Figure 1). These differ in terms of arable land division (Ilešič 1950), land-use diversity, size of contiguous areas of one land use, land-use fragmentation, and different landscape types (Perko, Hrvatin and Ciglič 2015). Vinjole (arable land division into irregular blocks) is not an independent settlement but instead a hamlet of Lucija; it was selected because of its mix of olive and grape patches, significant overgrowth, and small-size patches. In Zatolmin (arable land division into irregular blocks), fields and grassland intermix; the fields are as a rule small and inside meadows, and there is little overgrowth. In Predoslje (arable land division into furlongs) and Kleče and Podgora (arable land division into continuous strips), open fields in large patches prevail, and land-use diversity is small. Agricultural land was consolidated in Predoslje. At Pernice (arable land division into enclosures) there is a mix of various uses in large and small patches, the area is undulating, and agricultural land is surrounded by forests.

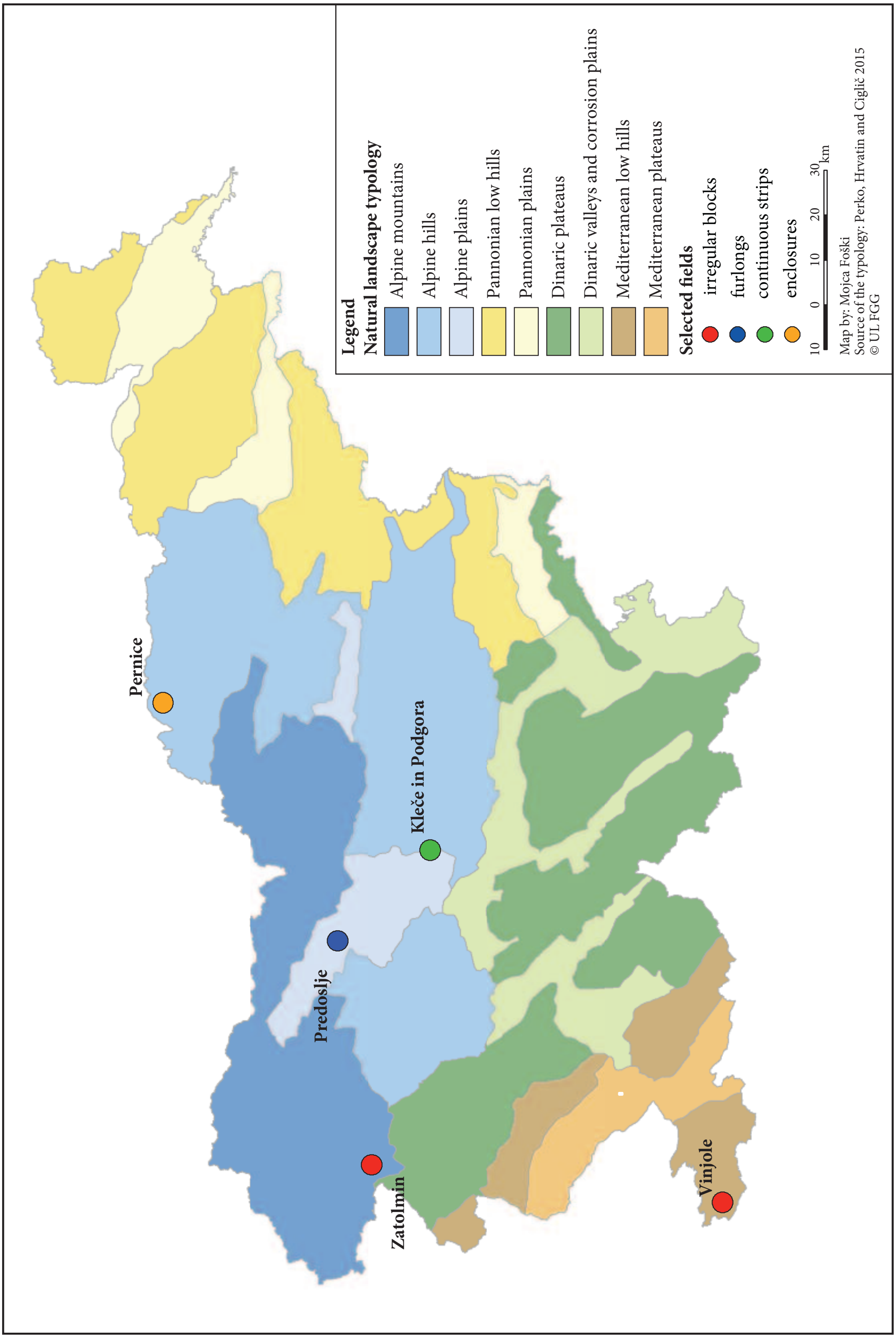
Table 2: Selected indices for land-use characteristics.

	Index type name	Equation; Range	Brief description
Diversity of land use	Patch richness index	$PR = m$ $PR \geq 1$	m = number of different land uses Nz = number of all patches.
	Number of all Patches	Nz $Nz \geq 1$	m_{max} = maximum number of possible land uses. $m_{max} = 25$
	Index of the Relative Number of Land Uses	$RPR = \frac{m}{m_{max}}$ $0 < RPR \leq 1$	$m_{max\,PR} = 25$
Land-use proportion distribution	Land-use proportion index	$IDr_i = \frac{R_i}{A_0}; R_i = \sum_{i=1}^{n} r_i$ $0 < IDr_i \leq 1$ $\sum_{i}^{m} IDr_i = 1$	R_i = area of a single land use; this is the sum of areas of all patches of land use r. A_0 = area of the site. The sum of proportions of all land uses in a site is 1. If a single land use exists, the index value is 1. The value of 0 is unattainable.
Characteristics of patches of a single land use	Index of shape and size of patches	$IOV_Z = \frac{I'_{kom} + 2 \times I'_{vel}}{3}$ $0 < IOV_Z \leq 1$	This describes the shape and size of a patch $I'_{kom} = \frac{4\pi A}{P^2}$; A = area and P = perimeter I_{vel} was obtained with linear standardization of patch areas using the following equation: $I'_{vel_i} = 0.05\ ha \rightarrow I_{vel} = 0$ $0.05\ ha < I'_{vel_i} < 4ha \rightarrow I_{vel_{ij}} = \frac{I'_{vel_{ij}}}{I'^{\,max}_{vel_{ij}}}$ $4\ ha \leq I'_{vel_i} \rightarrow I_{vel} = 1$
Land use ratios	Simpson's diversity index	$SIDI = 1 - \sum_{i=i}^{m} Ad_i^2$ $0 \leq SIDI \leq 1$	Ad_i = proportional part of land use in the study area, where there are m different land uses. $\sum_{1}^{m} Ad_i = 1$ $SIDI = 0$, when there is a single land use, approaching 1 by increasing the number and evenness of distribution of land-use proportions.

The land divisions were based on geographical dividing lines (to a stream, road, forest, or village) or the cadastral municipality boundary. We selected a contiguous area of land showing the characteristics of arable land division (Ilešič 1950; Foški 2017). For Zatolmin and Predoslje, all of the agricultural land is considered within a cadastral municipality. For Kleče and Podgora, the agricultural land between Podgora and Kleče that is still divided into strips is considered; furthermore, nine contact enclosures within the cadastral municipality of Pernice are considered. In Vinjole we address the geographically coherent areas of a hamlet based on geographical divisions (i.e., stream, ridge, forest, or road). The sites were named after the closest settlement or hamlet. The analysis of land use in 2015 was carried out using data from the Land Use data base (Evidenca dejanske rabe … 2015). Using graphic cross-sections, the Land Use data base data were trimmed to the area of the sites. All patches smaller than 20 m², which are a consequence of the graphic cross-section of the Land Use data base with the area of a site and which are at the edges of an area, were aggregated with contiguous land use.

For all selected sites we obtained cadastral maps of the Franciscean Cadaster from the Archives of the Republic of Slovenia (Franciscejski kataster za Kranjsko 1825; 1826; Franciscejski kataster za Primorsko 1822; Franciscejski kataster za Štajersko 1825) or the State Archives in Trieste (Catasto franceschino 1818) and georeferenced them using affine transformation in ArcGIS 10.3 based on the tie points from the land

Figure 1: Distribution of test sites by various landscape types of Slovenia. ➤ p. 166


Legend
Natural landscape typology
Alpine mountains
Alpine hills
Alpine plains
Pannonian low hills
Pannonian plains
Dinaric plateaus
Dinaric valleys and corrosion plains
Mediterranean low hills
Mediterranean plateaus
Selected fields
irregular blocks
furlongs
continuous strips
enclosures
10 0 10 20 30 km
Map by: Mojca Foški
Source of the typology: Perko, Hrvatin and Ciglič 2015
© UL FGG
Pernice
Kleče in Podgora
Predoslje
Zatolmin
Vinjole

cadaster depiction (Zemljiški kataster 2015). Vectorization was carried out and the data were topologically sorted. Based on the records and the associated key of the Franciscean Cadaster (Franciscejski kataster za Štajersko 1823–1869; Čuček 1979; Čuček-Kumelj 1983), the land use at the time the Franciscean Cadaster was introduced was classified into twenty-five classes: field, vegetable garden, fruit garden, hop plantation, field with fruit trees, field with olive trees (olive grove), vineyard, vineyard with olive trees, dry meadow, wet meadow, meadow with scrubland, meadow with fruit trees, pasture, pasture with trees, wetland, wetland with rushes, deciduous forest, coniferous forests, mixed forest, grove, shrubs, built-up land (occupied by structures and tracks), water, quarry, clay pit or rock and other. Some categories, such as saffron, chestnut plantations, paddy fields, and so on, were not included in the total sum of land uses because we assumed that they are not found in Slovenian territory. Altogether, the Land Use data base contains twenty-five land uses (Interpretacijski ključ 6. 2. 2014).

The analysis (calculations of indices and graphic representations) was performed in ArcGIS 10.3 (Esri); Microsoft Excel 2010 and IBM SPSS 23 software were used for calculations and statistical processing.

3 Results

Figure 2 shows land uses in selected sites for 2015 and for the time when the Franciscean Cadaster was introduced. Table 3 shows the calculated values of indices (PR, Nz, RPR, IDr_{max}, SIDI) and the IDr distribution. The Use Proportion Index (IDr) is shown in the last column of Table 3 as a graph. For each land use its proportion is shown, and the graphic representation shows the relationships between land-use proportions in two time periods. For example, in Pernice there are ten different land uses identified today (PR = 10), but only two land uses stand out in terms of proportion (Table 3, the last column). There were five land uses (PR = 5) there at the time the Franciscean Cadaster was introduced, but they were more evenly distributed (Table 3, last column).

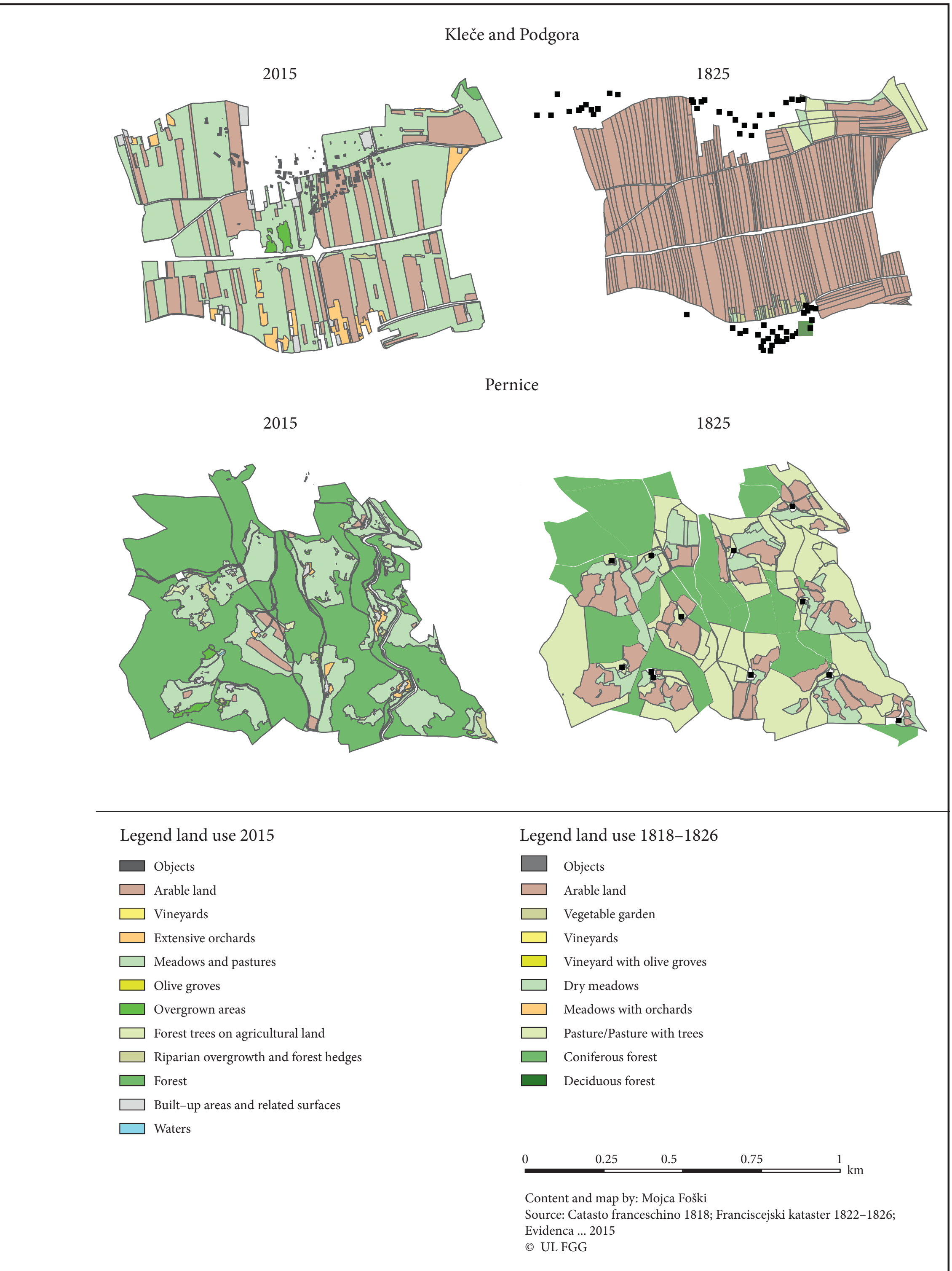
Figure 3 shows the case of Vinjole with a graphic depiction of the IOVz and IOVz_FK values, and Figure 4 shows the distribution of values IOVz and IOVz_FK in the histogram with ten equally sized classes. The same methodology was used to analyze all other selected sites; the analysis results are available in Foški (2017, 187–202).

The number of various land uses (i.e., richness; Table 3, column 1) increased in all sites, the most at Vinjole (i.e., from three during the establishment of the Franciscean Cadaster to twelve land uses in the Land Use data base). In Vinjole, the number of patches (Nz) increased significantly as well, from eighteen to 464. The number of patches remained almost the same in Predoslje, whereas the prevailing land-use proportion changed (IDr_{max}). Interestingly, during the establishment of the Franciscean Cadaster, fields prevailed ($IDr_{max\_}FK = 0.93$) with much larger areas than those today ($IDr_{max} = 0.49$), even though agricultural land consolidation was undertaken in the area. A similar trend of a decreasing proportion of arable land is observed in Kleče and Podgora ($IDr_{max\_}FK = 0.93$; $IDr_{max} = 0.62$). In Zatolmin, meadows with trees prevailed at the time the Franciscean Cadaster was introduced, whereas today meadows prevail (land-use code 1300 from the Land Use data base). In Vinjole, olive groves still prevail, but their proportion decreased substantially ($IDr_{max\_}FK = 0.97$, $IDr_{max} = 0.26$); at present, olive groves are identified only when they are the prevailing land use in an area larger than 500 m² (Interpretacijski ključ 6.2 2014). Forest land prevails in Pernice, whereas pastures with trees prevailed when the Franciscean Cadaster was introduced.

Land-use changes can be identified using Simpson's Diversity Index. At Vinjole, Simpson's diversity index changed from 0.07 during the introduction of the Franciscean Cadaster to 0.99 in 2015. An index close to 0 suggests the prevalence of a single land use, as is evident in Figure 2 (Vinjole in 1818), whereas an index value close to 1 suggests an equal distribution of a larger number of land uses, as is evident in Figure 2 (Vinjole in 2015). Importantly, when the Franciscean Cadaster was established, the land use »vineyard with olive trees« was registered for almost all of Vinjole, whereas today mixed uses are no longer in place and the land uses »vineyard« or »olive grove« are registered separately if they cover an area greater than 500 m² (Interpretacijski ključ 6.2 2014). Land-use diversity inside individual parcels during the establishment of the Franciscean Cadaster was greater, whereas today land-use diversity in the entire study area of Vinjole is greater (PR = 12). The same values of SIDI and SIDI_FK for Predoslje and for Kleče and Podgora

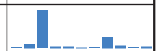
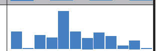
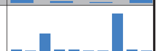
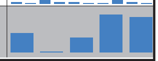
Figure 2: Land use in 2015 and at the time the Franciscean Cadaster was introduced. ➤ p. 168–169


Zatolmin
2015
1822
Vinjole
2015
1818
Predoslje
2015
1826


Kleče and Podgora
2015
1825
Pernice
2015
1825
Legend land use 2015
Objects
Arable land
Vineyards
Extensive orchards
Meadows and pastures
Olive groves
Overgrown areas
Forest trees on agricultural land
Riparian overgrowth and forest hedges
Forest
Built-up areas and related surfaces
Waters
Legend land use 1818–1826
Objects
Arable land
Vegetable garden
Vineyards
Vineyard with olive groves
Dry meadows
Meadows with orchards
Pasture/Pasture with trees
Coniferous forest
Deciduous forest
0
0.25
0.5
0.75
1
km
Content and map by: Mojca Foški
Source: Catasto franceschino 1818; Franciscejski kataster 1822–1826; Evidenca ... 2015
© UL FGG

show a similar trend of changes. A similar value of SIDI (close to 0.55) is found in Zatolmin, Predoslje, Kleče and Podgora, and Pernice; two land uses prevail, as illustrated in the graphs (Table 3, last column). The proportion of prevailing land use (IDr_{max}) at the time the Franciscean Cadaster was established and that of today suggests that prevailing land use has changed.

Table 3: Land-use fragmentation for selected sites in 2015 and at the time the Franciscean Cadaster was introduced.

Field	PR	Nz	RPR	IDr_{max}	LAND USE (IDr_{max})	SIDI	distribution chart IDr
Zatolmin	11	190	0.44	0.65	meadows	0.53	
Zatolmin FK	4	128	0.16	0.51	pasture	0.62	
Vinjole	12	464	0.48	0.26	olive groves	0.99	
Vinjole FK	3	18	0.12	0.97	vineyard with olive groves	0.07	
Predoslje	8	113	0.32	0.49	arable land	0.54	
Predoslje FK	4	106	0.16	0.93	arable land	0.13	
Kleče and Podgora	9	137	0.36	0.62	meadows	0.54	
Kleče and Podgora FK	4	49	0.16	0.93	arable land	0.13	
Pernice	10	271	0.4	0.63	forest	0.51	
Pernice FK	5	124	0.2	0.36	pasture with trees	0.71	

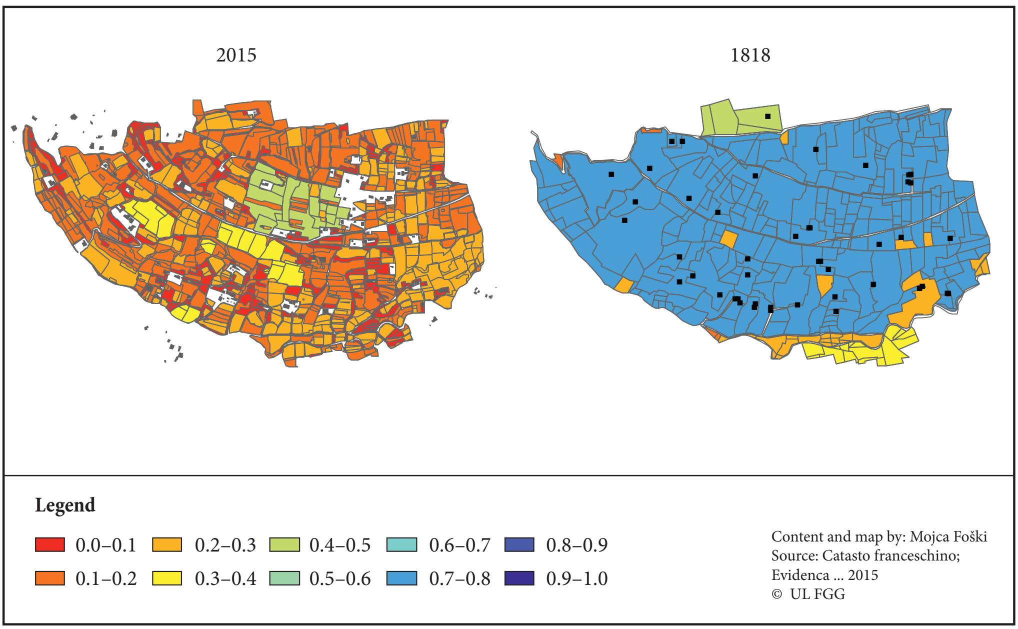
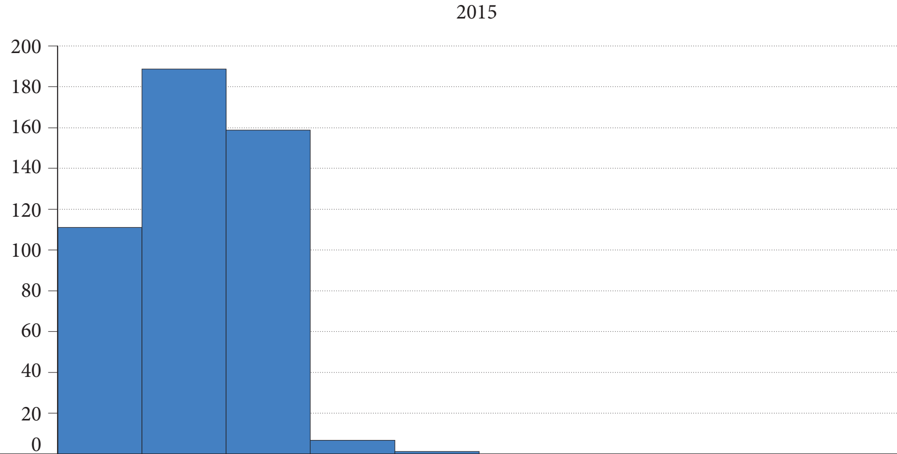
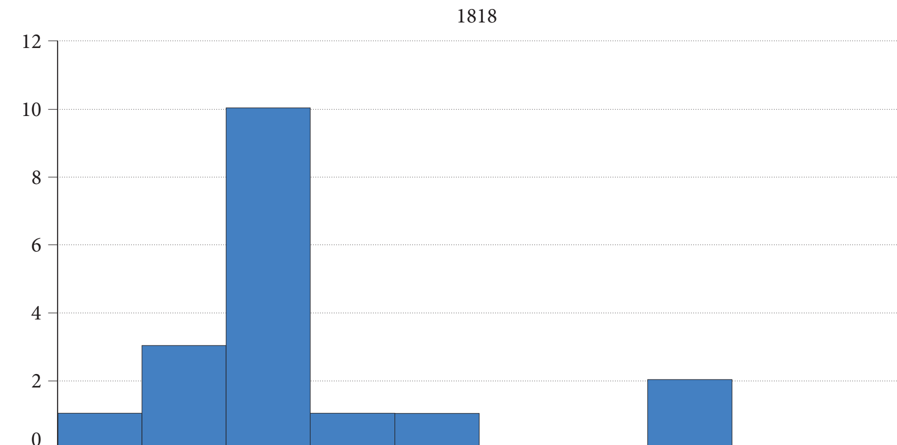


Figure 3: Index of Shape and Size of Patches (IOVz) for Vinjole.

The changes in indices are also evident in visual depictions of land use in two time cross-sections (Figure 2). As a rule, the graphic representation fails to show the entire extent of land-use diversity because the proportions of land uses are rather small. The changes in prevailing land uses (Table 3, IDr_{max}, graph) and the distribution of land uses in a site are clearly evident (Table 3, SIDI, graph).



IOVz	0.0–0.1		0.2–0.3		0.4–0.5		0.6–0.7		0.8–0.9	
Number of patches	111	188	158	6	1	0	0	0	0	0
Share of patches [%]	13.11	42.71	33.11	5.47	5.59	0.00	0.00	0.00	0.00	0.00



IOVz	0.0–0.1		0.2–0.3		0.4–0.5		0.6–0.7		0.8–0.9	
Number of patches	1	3	10	1	1	0	0	2	0	0
Share of patches [%]	0.01	0.30	5.09	2.62	2.71	0.00	0.00	89.27	0.00	0.00

Figure 4: Distribution of values IOVz for Vinjole.

The Index of Shape and Size of Patches (IOVz) shows the relationship between small and large patches. The index is calculated for each patch separately, whereas the situation for the area of a site (all patches) is best illustrated using a histogram in ten equal classes (Figure 4, the case of Vinjole). The large number of patches in lower classes (0.0–0.1; 0.1–0.2; 0.2–0.3) suggests large land-use fragmentation, particularly if the proportion of the land use in question in the site is large. The histogram for the case of Vinjole (Figure 4) shows that many patches are in the first three classes, which together make up 88.93% of the study area, whereas a detailed land-use structure is also visible in Figure 2 (the case of Vinjole). The large number of patches in higher classes (0.7–0.8; 0.8–0.9; 0.9–1.0) suggests large contiguous areas of land use, particularly when the proportion of these land uses is large. The two patches in the 0.7–0.8 class shown on the histogram (Figure 4) correspond to a full 89.27% of the area, and land-use contiguity is also evident in Figure 2 (the case of Vinjole). Because of mixed land use at the time the Franciscean Cadaster was introduced, in the area there was an even mix of vineyards and olive trees, whereas today the large number of patches in the area (Nz = 464) and their land-use diversity suggest a much higher landscape diversity of the area. The working methodology for capturing land use in the Land Use data base should be emphasized, where the number of polygons increases with each new revision of data, despite the fact that the spatial situation has not changed (Foški 2018).

4 Discussion

Generally, a single index can describe one land-use characteristic; the illustration of various land-use characteristics requires a larger set of indices, for which it is important that they be independent and that their number not be too large. The selection of indices for describing land use in a site was recognized as being sufficient. Because there were a maximum of twenty-five land uses both during the introduction of the Franciscean Cadaster as well as in 2015, the index of the relative number of land uses was found to be less useful. Nevertheless, this correspondence in the number of various land uses is purely accidental. The number of land uses in the Franciscean Cadaster is, in fact, larger, but we only took into account the land uses found in Slovenian territory. Its applicability would increase if the number of land uses in two time cross-sections varied. In any case, the number of different land uses in two time periods does not say anything about the comparability of individual categories. We are also unable to precisely determine the relationship between the individual categories in the past and today due to the various criteria and the purpose of determining land uses. At the time the Franciscean Cadaster was established, a distinction was made between a meadow with scrubland, a meadow with fruit trees, a pasture, and a pasture with trees. Today, on the basis of Interpretation Key (Interpretacijski ključ 6.2 2014), we register extensive orchards, permanent meadows, and marshy meadows. Pastures with trees prevailed in Pernice at the time the Franciscean Cadaster was introduced, whereas today this category is often divided into permanent grassland and overgrown areas. Even at the level of a meadow one cannot equate the land use at the time the Franciscean Cadaster was introduced with the categories used today. Today the land use in Vinjole (mixed land use at the time the Franciscean Cadaster was introduced) is classified into vineyards and olive groves separately.

Some authors (Petek 2005; Verderber 2013; Gabrovec and Kumer 2019) made a comparative table of land uses at the time the Franciscean Cadaster was introduced and in the Land Use data base, respectively, but they combined some of the categories (e.g. field, meadow, forest, and vineyard), which was suitable for the purpose of their work, whereas the information on land-use diversity in various time periods was lost. Due to the incomparability of the categories, the information on land-use richness can be somewhat misleading. This can be avoided if one is familiar with all the characteristics of identifying land use across different time periods.

A comparison of data from two time periods is possible if the data used are of equal quality (Wu et al. 2002) – which, however, cannot be said for the data on land use at the time the Franciscean Cadaster was introduced and the Land Use data base in 2015. The minimum mapping unit, working methodology, precision and accuracy of data, and data maintenance vary. We believe that such differences in data fail to impact the key findings and the checking of indices' usefulness, and that the data from the Franciscean Cadaster, particularly with vectorization in place, are highly useful for identifying land-use changes, which is in agreement with the findings by Petek and Urbanc (2005), Harvey, Kaim, and Gajda (2014), Bičík et al.

(2015), and Gabrovec and Kumer (2019). The time interval (approximately 180 years) is large enough to make the changes obvious so that they are reflected in the indices.

The number of land-use types present, or patch richness (PR), increased in all sites compared to the time when the Franciscean Cadaster was introduced. The increased number of patches, the decreased number of large enclosed patches (IOVz), and the decreased prevailing land-use proportion (IDr_{max}) suggest land-use fragmentation and larger diversity of vegetation cover. This finding contradicts some studies, which suggest a decrease in land-use diversity and particularly an increase in contiguous areas of a single land use, usually forests (Munroe, Croissant and York 2008; Hansen and Adhikari 2018). Such findings are often the result of analyses of raster data (pixel size) and in large territorial areas (data generalization; Wu et al. 2002). By studying land use in small spatial units, using vector data, one can see the changes that can be lost because of the type of data and the scale (Wu 2004). The cases of studying characteristics of land use at the micro level are essential for understanding landscape ecology (Fischer, Hanspach and Hartel 2011) and can contribute to the understanding of global problems. Some authors (Plieninger et al. 2016) also emphasize that researchers all too frequently focus on studying land-use changes rather than land-use stability. In fact, in 30.1% of the EU-27 member states' area there is no indication of an increase in fragmentation (Meiner and Pedroli 2017).

The large number of land uses is often visually not detected, particularly if the study area is not large or when the land-use structure is very fine. This is why using indices is more appropriate than visual comparisons of land-use maps. The index can be calculated for the data in various time cross-sections, and the interpretation of the values in a time series allows continuous monitoring of the land-use situation and its changes. Therefore indices could be introduced into systematic land-use monitoring in all spatial units.

The SIDI index is easy to calculate, and its value is a good indication of land-use distribution and fragmentation. It depends on the prevailing land-use proportion (IDr_{max}) and the patch richness (PR). Values up to 0.5 show low fragmentation (the case of Predoslje, and Kleče and Podgora at the time the Franciscean Cadaster was established), whereas above 0.7 the land use is fragmented (e.g., Vinjole) because the share of prevailing land use is below 40%. This index is the basic indicator of land-use fragmentation. Based on the available, regularly updated vector land-use data (the Land Use data base), we see great applicability of the SIDI index in systematic monitoring of the situation and land-use changes.

5 Conclusions

Land-use changes are among the indicators of social processes, and knowledge of these changes is crucial for many fields of research. This article proposed a method for analyzing and monitoring land-use changes using indices. Using the indices, we pointed out changes that are overlooked at smaller scales and we drew attention to land-use fragmentation and the increasing number of patches. The indices increase the objectivity of research work and facilitate systematic monitoring of the land-use situation. Indices have commonly been used for identifying land-use characteristics abroad, and we recommend their use in Slovenia as well.

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We accept original research papers and review papers.

Papers presenting new developments and innovative methods in geography are welcome. Submissions should address current research gaps and explore state-of-the-art issues. Research based on case studies should have the added value of transnational comparison and should be integrated into established or new theoretical and conceptual frameworks.

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- **Discussion:** interpret the results, generalize from them, and present related broader principles and relationships between the study and previous research. Critically assess the methods and their limitations, and discuss important implications of the results. Clarify unexpected results or lacking correlations.
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Do not use contractions or excessive abbreviations. Use plain text, with sparing use of **bold** and *italics*. Do not use auto-formatting, such as section or list numbering and bullets.

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2.2 Language

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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
- Fridl, J., Urbanc, M., Pipan, P. 2009: The importance of teachers' perception of space in education. Acta geographica Slovenica 49-2. DOI: https://doi.org/10.3986/AGS49205

- Gams, I. 1994a: Types of contact karst. Geografia fisica e dinamica quaternaria 17.
- Gams, I. 1994b: Changes of the Triglav glacier in the 1955-94 period in the light of climatic indicators. Geografski zbornik 34.
- Perko, D. 1998: The regionalization of Slovenia. Geografski zbornik 38.
- 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.
- Fridl, J., Kladnik, D., Perko, D., Orožen Adamič, M. (eds.) 1998: Geografski atlas Slovenije. Ljubljana.
- 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
- Nared, J., Razpotnik Visković, N. (eds.) 2014: Managing cultural heritage sites in Southeastern Europe. Ljubljana.

3.3 Citing parts of books or proceedings

- Gams, I. 1987: A contribution to the knowledge of the pattern of walls in the Mediterranean karst: a case study on the N. island Hvar, Yugoslavia. Karst and man, Proceedings of the International Symposium on Human Influence in Karst. Ljubljana.
- 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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- Zorn, M., Komac, B. 2013: Land degradation. Encyclopedia of Natural Hazards. Dordrecht. DOI: https://doi.org/10.1007/978-1-4020-4399-4_207

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- 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.
- Holmes, R. L., Adams, R. K., Fritts, H. C. 1986: Tree-ring chronologies of North America: California, Eastern Oregon and Northern Great Basin with procedures used in the chronology development work including user manual for computer program COFECHA and ARSTAN. Chronology Series 6. University of Arizona, Laboratory of tree-ring research. Tucson.
- Hrvatin, M. 2016: Morfometrične značilnosti površja na različnih kamninah v Sloveniji. Ph.D. thesis, Univerza na Primorskem. Koper.
- Šifrer, M. 1997: Površje v Sloveniji. Elaborat, Geografski inštitut Antona Melika ZRC SAZU. Ljubljana.

3.5 Citing online material with authors and titles

- 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).
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3.7 Citing sources without authors

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

3.8 Citing cartographic sources

- Buser, S. 1986: Osnovna geološka karta SFRJ 1 : 100.000, list Tolmin in Videm (Udine). Savezni geološki zavod. Beograd.
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- Franciscejski kataster za Kranjsko, k. o. Sv. Agata, list A02. Arhiv Republike Slovenije. Ljubljana, 1823–1869.
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3.9 Citing official gazettes

- 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.
- 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.

3.10 In-text citations

Please ensure that every reference cited in the text is also in the reference list (and vice versa). In-text citations should state the last name of the author(s) and the year, separate individual citations with semicolons, order the quotes according to year, and separate the page information from the name of the author(s) and year information with a comma; for example: (Melik 1955), (Melik, Ilešič and Vrišer 1963; Kokole 1974, 7–8; Gams 1982a; Gams 1982b).

For sources with more than three authors, list only the first followed by *et al.*: (Melik et al. 1956). Cite page numbers only for direct citations: Perko (2016, 25) states: »Hotspots are …« To cite online material with authors, cite the name: (Zorn 2010). To cite online material without authors, cite only Internet followed by a number: (Internet 2).

3.11 Works cited list

Arrange references alphabetically and then chronologically if necessary. Identify more than one reference by the same author(s) in the same year with the letters *a*, *b*, *c*, etc., after the year of publication: (1999a, 1999b). Use this format for indirect citations: (Gunn 2002, cited in Matei et al. 2014).

Include the Digital Object Identifier (DOI) in the reference if available. Format the DOI as follows: https://doi.org/… (for example: https://doi.org/10.3986/AGS.1812).

4 Tables and figures

Number all tables in the paper uniformly with their own titles. The number and the text are separated by a colon, and the caption ends with a period. Example:

Table 1: Number of inhabitants of Ljubljana.
Table 2: Changes in average air temperature in Ljubljana (Velkavrh 2009).

Tables should contain no formatting and should not be too large; it is recommended that tables not exceed one page.

Upload figures to the OJS as separate supplementary files in digital form. If the graphic supplements prepared cannot be uploaded using these programs, consult the editorial board in advance.

Number all figures (maps, graphs, photographs) in the paper uniformly with their own titles. Example:

Figure 1: Location of measurement points along the glacier.

All graphic materials must be adapted to the journal's format. Illustrations should be exactly 134 mm wide (one page) or 64 mm wide (half page, one column), and the height limit is 200 mm.

To make anonymous peer review possible, include the name of the author(s) with the title of the illustration in the supplementary file metadata, but not in the paper text.

Maps should be made in digital vector form with *Corel Draw, Adobe Illustrator*, or a similar program, especially if they contain text. They can exceptionally be produced in digital raster form with at least 300 dpi resolution, preferably in TIFF or JPG format. For maps made with *CorelDraw* or *Adobe Illustrator*, two separate files should be prepared; the original file (.cdr or .ai format) and an image file (.jpg format).

For maps made with *ArcGIS* with raster layers used next to vector layers (e.g., .tif of relief, airborne or satellite image), three files should be submitted: the first with a vector image without transparency together with a legend and colophon (export in .ai format), the second with a raster background (export in .tif format), and the third with all of the content (vector and raster elements) together showing the final version of the map (export in .jpg format).

Do not print titles on maps; they should appear in a caption.

Save colors in CMYK, not in RGB or other formats.

Use Times New Roman for the legend (size 8) and colophon (size 6). List the author(s), scale, source, and copyright in the colophon. Write the colophon in English (and Slovenian, if applicable). Example:

Scale: 1 : 1,000,000
Content by: Drago Perko
Map by: Jerneja Fridl
Source: Statistical Office of the Republic of Slovenia, 2002
© 2005, ZRC SAZU Anton Melik Geographical Institute

Graphs should be made in digital form using *Excel* on separate sheets and accompanied by data.

Photos must be in raster format with a resolution of 240 dots per cm or 600 dpi, preferably in .tif or .jpg formats; that is, about 3,200 dots per page width of the journal.

Figures containing a screenshot should be prepared at the highest possible screen resolution (Control Panel\All Control Panel Items\Display\Screen Resolution). The figure is made using Print Screen, and the captured screen is pasted to the selected graphic program (e.g., *Paint*) and saved as .tif. The size of the image or its resolution must not be changed.

Examples of appropriate graphic data forms: see the templates of maps in cdr and mxd files for a whole-page map in landscape view and an example of correct file structure for submitting a map made with *ESRI ArcGIS*.

SUBMISSION PREPARATION CHECKLIST

As part of the submission process, check your submission's compliance with the following items. Submissions may be returned to author(s) that do not follow these guidelines.

1. The journal policies have been reviewed.
2. The submission has not been previously published and is not being considered for publication elsewhere (or an explanation has been provided in comments to the editor).
3. The metadata (title, abstract, key words, full address, etc.) are provided in English and Slovenian, when applicable.
4. The submission is in Microsoft Word format and the document template was used (single-spaced text, 12-point font, no formatting except italics and bold).

5. The manuscript has been checked for spelling and grammar.
6. All figure locations in the text are marked. Figures are not in the text and are provided as supplementary files: cdr, .ai for maps and illustrations; .tif for photographs; xlsx for graphs.
7. Tables are placed in the text at the appropriate place.
8. The reference list was prepared following the guidelines.
9. All references in the reference list are cited in the text, and vice versa.
10. Where available, URLs and DOI numbers for references are provided.
11. Supplementary files are in one .zip file not exceeding 50 MB.
12. I agree for this article to be translated or copyedited at my expense AFTER the article is accepted for publication (see guidelines for details).
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14. The instructions for ensuring a double-blind review have been followed.

ACTA GEOGRAPHICA SLOVENICA EDITORIAL REVIEW FORM

Acta geographica Slovenica editorial review form

1 The paper is an original scientific one – the paper follows the standard IMRAD scheme and is original and the first presentation of research results with the focus on methods, theoretical aspects or case study.)

Yes No

2 The paper's content is suitable for publishing in the AGS journal – the paper is from the field of geography or related fields of interest, the presented topic is interesting and well presented. In case of negative answer add comments below.)

Yes No

3 Editorial notes regarding the paper's content.

4 Length of the paper is acceptable for further processing (25.000 characters including space). If longer, the paper has to be shortened by the author and resubmitted.
- The paper has less than 25.000 characters.
- The paper has more than 25.000 characters, but less than 30.000.
- The paper has more than 30.000 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

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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).
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- It is more suitable for a specialized journal.
- Does not fit the aims and scopes of the AGS journal.
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1a) Are the findings original and the paper is therefore a significant one?

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2 SIGNIFICANCE

2a Does the paper discuss an important problem in geography or related fields?

Yes No Partly

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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

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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?

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5f Which tables are not necessary?

5g Which figures are not necessary?

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Comments of the reviewer on the contents of the paper:
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7 RECOMMENDATION OF THE REVIEWER TO THE EDITOR-IN-CHIEF

My recommendation is:
Please rate the paper from 1 [low] to 100 [high]:
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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* in volume 50-1.«

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Contents

Special issue – Franciscean cadaster as a source of studying landscape changes

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