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Fotografija na naslovnici: Kamniti most čez reko Rak na obrobju kraškega polja Rakov Škocjan, ki je sicer bolj znano po čudovitih naravnih mostovih (fotografija: Matej Lipar).

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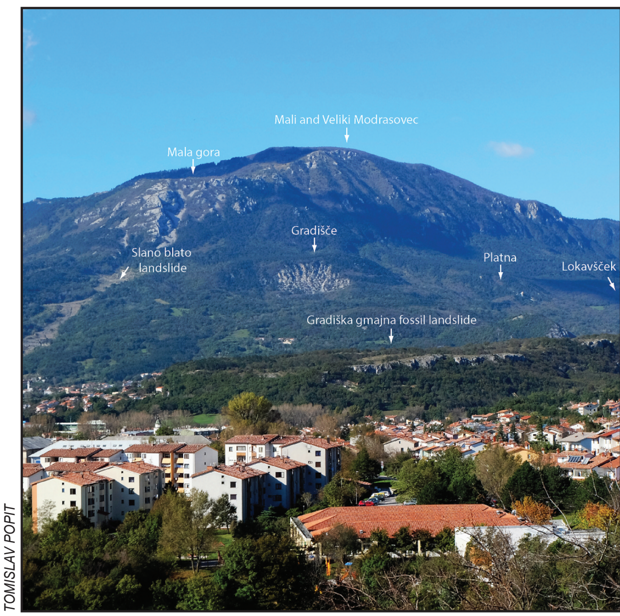
GRAVITATIONAL SLIDING OF THE CARBONATE MEGABLOCKS IN THE VIPAVA VALLEY, SW SLOVENIA

Maja Kocjančič, Tomislav Popit, Timotej Verbovšek



Photograph of carbonate gravitational blocks, Slano blato landslide and Gradiška gmajna fossil landslide on the southern slopes of the Trnovo Plateau from Ajdovščina, Vipava Valley (view towards NW).

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Gravitational sliding of the carbonate megablocks in the Vipava Valley, SW Slovenia

ABSTRACT: The area of Lokavec in the Vipava Valley, SW Slovenia, consists of Mesozoic carbonates thrust over Paleogene siliciclastic flysch. Overthrusting and tectonic damage of carbonates accelerated their mechanical disintegration. As a result, accumulations of slope gravel and large carbonate gravitational blocks are deposited on the slopes. Based on previous research, basic geological mapping and analysis of the DEM, ten carbonate blocks were identified. The aim of our research was to map lithology, measure and analyse the dip of carbonate strata and to determine transport mechanisms for individual blocks. The displacement of blocks from the source area ranged from 80 m to 1950 m. With the displacement of gravitational blocks, changes in dip direction and dip angle were also observed. The differences between the strata dip of carbonate source area and gravitational megablocks are from 4° to 59°.

KEY WORDS: mass movement, slope deposits, gravitational carbonate blocks, lidar, Vipava Valley, Slovenia

Gravitacijski karbonatni megabloki v Vipavski dolini

POVZETEK: Širše območje naselja Lokavec v Vipavski dolini gradijo mezozojski karbonati narinjeni preko paleogenskega siliciklastičnega fliša. Zaradi narivne zgradbe in tektonske pretrtosti, ki pospešuje mehansko razpadanje karbonatov, se na pobočjih med Trnovskim gozdom in Vipavsko dolino odlagajo večje količine pobočnih gruščev med katerimi izstopajo tudi veliki karbonatni bloki. Na podlagi predhodnih raziskav, osnovnega geološkega kartiranja in analize digitalnega modela višin, ki je bil pridobljen z lidarsko tehnologijo, je bilo identificiranih 10 blokov. Namen raziskovalnega dela je bil določitev litologije blokov, meritve in analize vpada karbonatnih plasti ter določitev mehanizmov transporta posameznega karbonatnega bloka. Rezultati meritev so pokazali, da so razdalje premikov blokov po pobočju znašali od 80 m do 1950 m. Vpadi plastnatih karbonatnih blokov so pri premiku, glede na karbonatne plasti izvornega območja, spremenili smer in naklon. Razlike pri vpadu karbonatnih plasti izvornega območja in karbonatnih blokov so od 4° do 59°.

KLJUČNE BESEDE: masni transport, pobočni sediment, gravitacijski karbonatni blok, lidar, Vipavska dolina, Slovenija

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1 Introduction

The Vipava Valley is a SE-NW oriented valley in SW Slovenia, bordering Italy, and named after the 49 km long river Vipava. The valley is geomorphologically very diverse, with elevations from 60 m to almost 1500 m. a. s. l. Large differences in elevation occur due to overthrusting of Mesozoic carbonates over flysch. Fractured carbonates easily disintegrate and, in addition to the large amount of sediment (scree deposits), form huge detached translational or rotational carbonate slide blocks. Such large carbonate blocks are mostly known in submarine mass movements (Alves 2015; Alves and Lourenço 2010; Jo, Eberli and Grasmueck 2015; Reijmer, Mulder and Borgomano 2015) and less in terrestrial settings (Benac et al. 2005; Davis and Friedmann 2005; Huntley, Duk-Rodnik and Sidwell 2006; Di Maggio, Madonia and Vattano 2014). Movement of large individual blocks is a known phenomenon and has been documented early for the Alps region (Moser 2002). The purpose of our research was to investigate the position and spatial distribution of these gravitational blocks, their outline and lithology, to investigate their mass transport mechanisms.

1.1 Geological and geomorphological setting

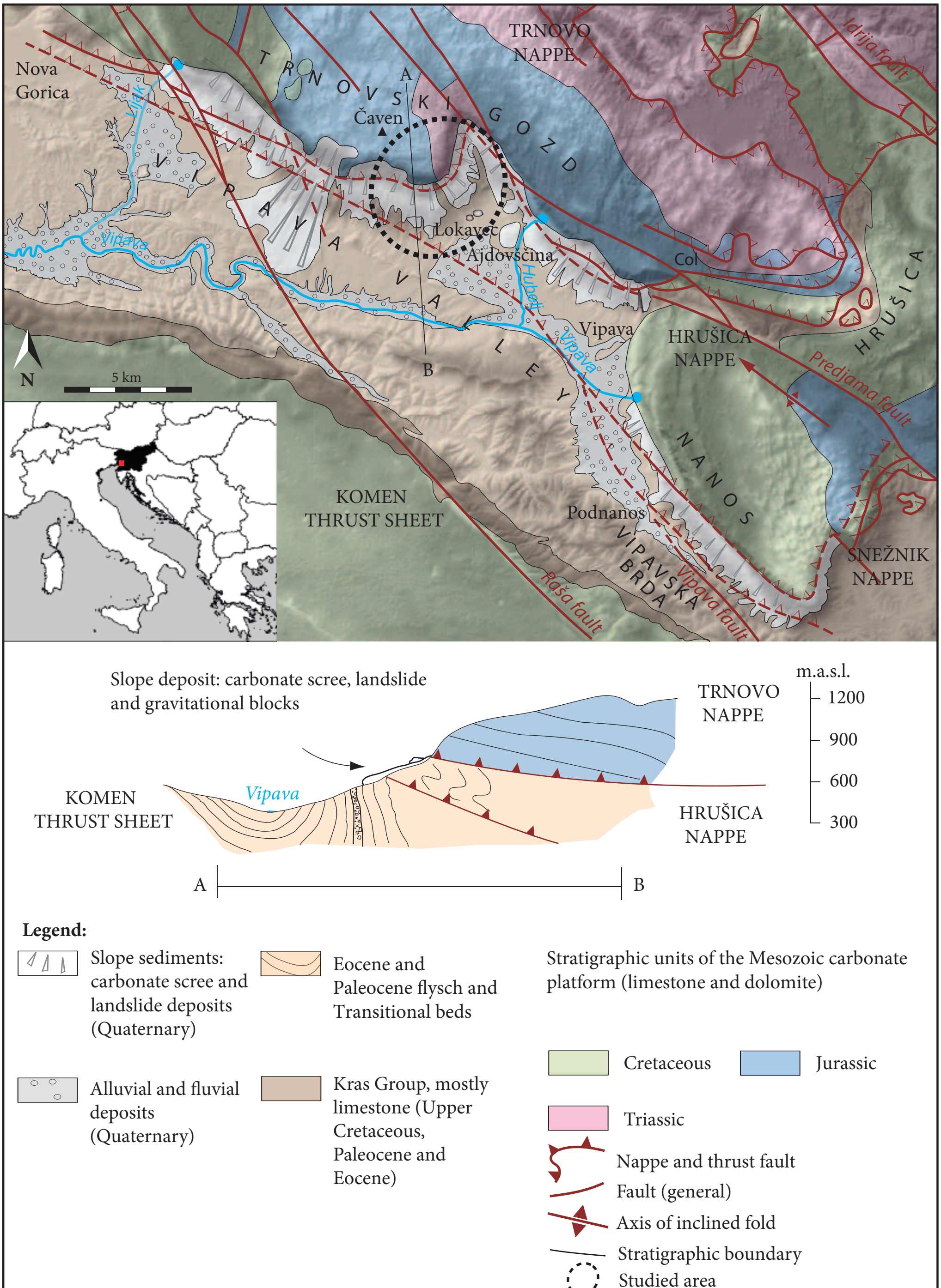
The study area covers approximately 18 km^2 (4.0 × 4.5 km) on the southern slopes of the high Trnovo plateau (*Trnovski gozd*; with elevations of major peaks: Kucelj – 1237 m, Mala gora – 1032 m and Mali Modrasovec – 1306 m), overlooking the Vipava Valley. High relief differences in the northeastern part of the Vipava Valley occur due to overthrusting of the Trnovo Nappe composed mostly of stratified Mesozoic carbonate platform limestone and dolomite, over Paleogene flysch composed of an alternation of sandstone, shale, and marl of the Hrušica Nappe (Figure 1). Both nappes belong structurally to the External Dinarides (Placer 1981; Placer 2008), with carbonates belonging to former Adriatic Carbonate Platform (Vlahović et al. 2005).

The Trnovo plateau is in this region composed of Upper Triassic (Norian-Rhetian) Main Dolomite (appearing on the eastern side of the study area) and Lower and Upper Jurassic limestones (on the western side). Besides the tectonic thrust contact, the major SE-NW oriented Predjama fault passes through the eastern part of the area (Figure 1), also responsible for mechanical disintegration of carbonates (Buser 1968).

Overthrusting and consequent erosion of carbonates has produced very steep slopes in carbonates compared to low-lying flysch with more gentle slopes. As a result, large deposits of limestone and dolomite scree have accumulated on the slopes in the transition zone between steep carbonates and low-relief flysch, and they cover the carbonate-flysch thrust contact. In some places, unconsolidated carbonate scree has consolidated into a slope breccia (Leban 1950; Melik 1960; Habič 1968; Jež 2007; Popit and Košir 2010). Such mechanical weathering of carbonates was probably more pronounced during Pleistocene, but the process is still active now (Melik 1959; Habič 1968; Komac and Ribičič 2006; Zorn and Komac 2008; Komac 2009; Kodelja, Žebre and Stepišnik 2013; Žebre, Stepišnik and Kodelja 2013; Ribičič 2014).

Average yearly precipitation is very high in the broader area of the Vipava Valley, from 1500 mm/year in the valley to more than 3000 mm/year on the higher Trnovo plateau (Janež et al. 1997; Agencija Republike Slovenije … 2016). Extremes can reach over 300 mm/day. Although the movement of the carbonate blocks cannot be regarded as classical landsliding, the movements are usually related not only to the total amount of precipitation, but to the intensity of precipitation during some time period (Komac 2005; Zorn and Komac 2009). Such a large amount of rainfall in combination with earthquakes and the geological and geomorphological setting has also triggered several active and fossil mass movements in the valley. These movements are of different types and have already been recorded (Habič 1968; Buser 1968; Zorn and Komac 2009; Popit and Košir 2010; Popit and Jež 2015; Popit 2016). Among the most studied is the large Slano blato landslide on the northern edge of the Vipava Valley (Kočevar and Ribičič 2002; Logar et al. 2005; Placer, Jež and Atanackov 2008; Fifer Bizjak and Zupančič 2009; Mikoš et al. 2014), and nearby the landslide Stogovce (Petkovšek et al. 2011). Other fossil complex landslides (Popit and Košir 2003; Popit et al. 2014b) and other mass movements (rockfall, creep, rotational landslide, debris flow and avalanche) also occur in the broader area, but are still not well studied (Jež 2007; Ribičič 2014). Several of these landslides have caused major damage in the Nova Gorica statistical region (Zorn and Komac 2011), comprising the Vipava Valley and studied area, and still pose a problem to the infrastructure and residential objects.

Figure 1: Geological map of broader area of the Vipava Valley, location of study area and cross-section through Trnovo plateau and the Vipava Valley (Buser 1968; Janež et al. 1997; Placer 1981; Placer 2008; Popit et al. 2014a). ➤ p. 10



Map by: Tomislav Popit
Source: Buser 1973 in 1968; Placer 1981 and 2008; Janež et al. 1997; Popit et al. 2014a

Among these, huge carbonate gravitational blocks appear on the gentle flysch slopes. They are observed above the village of Lokavec, near the Slano blato landslide, and clearly visible as positive relief structures on a Lidar-derived 1 m digital elevation model (DEM) map (Figure 2). It has already been interpreted by Placer, Jež and Atanackov (2008) that these carbonate blocks have been transported by gravitational movement. They identified 12 carbonate blocks. Five carbonate blocks (Mala gora, Gola gorica, Visoko, Križec and Gradišče) were named by the nearest topographical name in their vicinity, while other blocks were named by consecutive alphabetic letters from A to F (the Slovenian alphabet, including the letter Č between C and D). However, we use different names than proposed (topographical instead of consecutive), as (described in the Results section) their proposed blocks A and C are not carbonate blocks at all, but only local accumulations of carbonate scree. Therefore, these two blocks were excluded from further analysis and results, and other carbonate blocks were named according to topographic names (with the former names of Placer, Jež and Atanackov (2008) in parentheses): Kovači (B), Platna (Č), Lokavšček (D), Skuk (E) and Lozica (F). Placer, Jež and Atanackov (2008) noted that the major carbonate block of Mala gora was detached from the source area, due to its structural setting in a south-trending wedge-shaped carbonate plateau, which combined with a nearby E-W fault caused the Mala gora carbonate block to rotate slightly and settle compared to the Čaven source area. This geological setting was later used mostly for the explanation of groundwater related to the Slano blato landslide; however, no further discussion was provided for the individual blocks (i.e. no measurements of the block movement or mapping of the individual blocks were performed).

2 Methods

Our methods can be briefly divided into field mapping and in relief analysis as follows. Field mapping formed the basis for the identification of the carbonate gravitational blocks. It was performed at a scale of 1:10,000, on topographic maps (layers with settlements and infrastructure) of Slovenia, produced by The Surveying and Mapping Authority of the Republic of Slovenia (Internet 1). In addition, a shaded digital elevation model (DEM) was used in combination with these maps. The DEM (Figure 2) was produced from Airborne Lidar Scanning (ALS) data, widely used for the analysis of landslide movements (Baldo et al. 2009; Geist et al. 2009; Jaboyedoff et al. 2012; Popit and Verbovšek 2013; Popit et al. 2014b) and used as a topographic base map for the field mapping. It turned out to be very helpful in the determination of carbonate block locations, as the bare-earth DEM at a 1×1 m grid resolution was used to eliminate the vegetation cover. Also, a Lidar-derived DEM map was useful for delineation of some problematic parts of the carbonate blocks on several inaccessible points, as the slopes of some carbonate blocks were too steep and dangerous to measure directly.

The main objective of field mapping was to outline the carbonate blocks, to determine their lithological composition, and to measure the dip direction and dip angle of the carbonate strata. The results were then compared to a source area in the hinterland, which we assume to be the reference carbonate mass with no movement. The type of movement was therefore determined on the DEM layer by a horizontal distance of the carbonate block from this stable source area (Figure 1) and by the difference between the dip direction and dip angle of the strata of the carbonate block and source area. In this way, both changes in dip direction and dip angle could be defined. Change in dip direction (azimuth) was defined with rotation of a carbonate block around its vertical axis. A positive value was assigned to clockwise rotation (greater value of azimuth) and negative value to anticlockwise rotation (lower value of azimuth). Similarly, change in dip angle was defined with rotation of a carbonate block around its horizontal axis, with a positive value for a downward rotation from the horizontal plane with increase in dip angle and vice versa. With measured dip direction and dip angle, we were able to calculated the differences between the angles of carbonates of the source area and of individual blocks. In such way, we were able to determine the individual block movement.

The lithological composition of individual carbonate blocks was also compared to the source area, to check for changes in measured angles. The accurance of Triassic dolomite and Jurassic limestone in the source area and of individual block was mapped. Research points were taken on carbonate blocks and the source area. Points were assigned a unique ID, block name/source area, WGS84 point coordinates (latitude, longitude) and lithological and directional measurements. To determine the position, a handheld GPS receiver with horizontal precision of about ±5 meters was used.

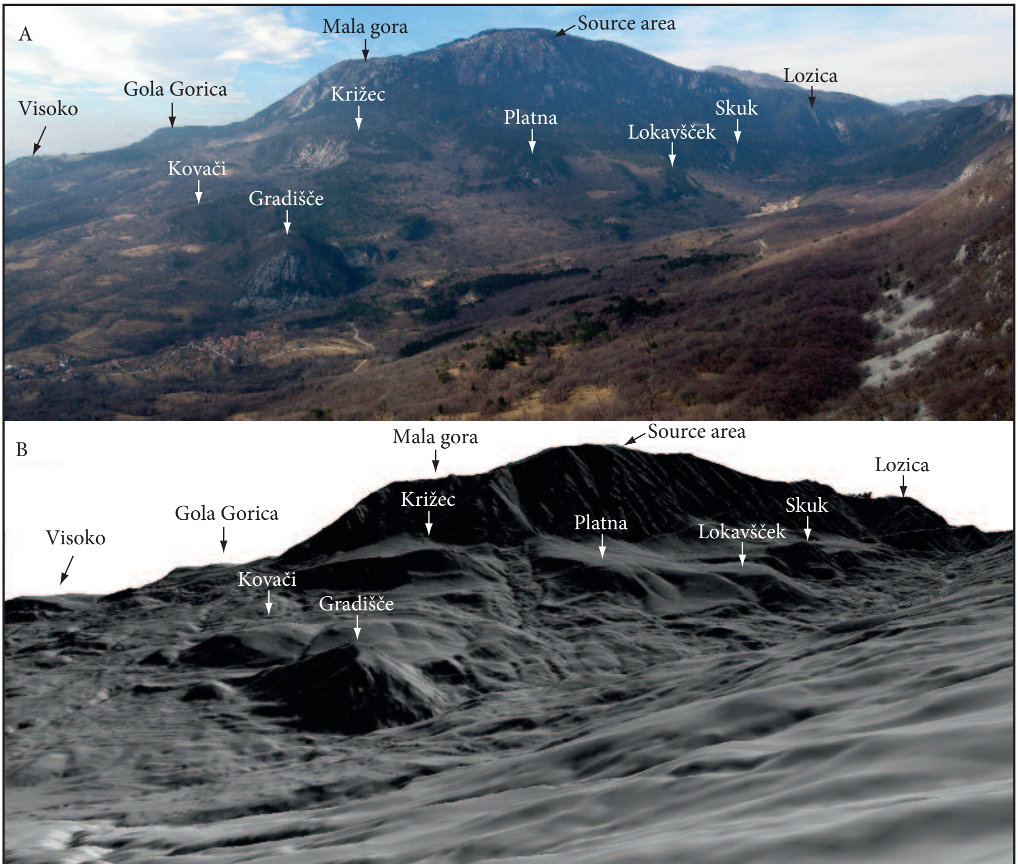


Figure A by: Tomislav Popit
Figure B by: Maja Kocjančič, Timotej Vrbovšek

Figure 2: A: Photograph of carbonate gravitational blocks from Navrše hill (view towards W). B: DEM of studied area (same viewpoint).

These field data were transferred to *ESRI ArcGIS v. 10.0* (ESRI 2012). The GIS environment served to produce a map, to measure the transport distance from the source area, to produce the longitudinal profiles for each carbonate block and to visualize the blocks in 3D on the Lidar DEM surface. The distance of transport was defined from the upper margin of each carbonate block to the supposed scarp of the carbonate source area.

Finally, the mean value of dip direction and dip angle for individual carbonate blocks and the source area were obtained in the stereographic program *Stereo32* (Röller and Trepmann 2013) by directional (circular) statistics. Consequently, differences of mean dip direction and mean dip angle between a gravitational carbonate block and the source area could be obtained in stereological program *Stereonet 9* (Allmendinger 2014). Values have been rounded to 5° for dip directions and dip angles, distances to 10 m, and areas to 100 m^2.

3 Results

The calculated dip angles of carbonate strata are presented for the source area, followed by results for each carbonate block. The blocks are clearly visible in the field from the valley and on the DEM (Figure 2), as they stand out as positive topographic anomalies of carbonate mass on the flysch slope. At the source area, 15 measurements were performed along the carbonate escarpment in the stable, undisturbed area (Table 1). The eastern part of the source area belongs to Upper Triassic dolomite (measurement points T02–T08), and western part to Jurassic limestones (points T01, T09–T15).

Table 1: Results for source area. Average dip direction and dip angle are 225/25.

Point	Latitude (°, WGS84)	Longitude (°, WGS84)	Dip direction (°)	Dip angle (°)	Lithology
T01	45.92703	13.85022	235	25	limestone
T02	45.92858	13.85583	220	20	dolomite
T03	45.93103	13.85858	220	20	dolomite
T04	45.92994	13.85878	220	20	dolomite
T05	45.93767	13.86292	220	20	dolomite
T06	45.93828	13.86064	230	30	dolomite
T07	45.94111	13.86250	230	25	dolomite
T08	45.94225	13.86683	230	25	dolomite
T09	45.92853	13.85178	220	30	limestone
T10	45.92467	13.83242	220	15	limestone
T11	45.92828	13.83236	240	35	limestone
T12	45.92839	13.82897	230	35	limestone
T13	45.92881	13.82689	230	30	limestone
T14	45.92878	13.82608	230	20	limestone
T15	45.92869	13.82503	220	20	limestone

Carbonate blocks are briefly described below, as Table 2 summarizes most of the results that are discussed in the next section. The largest carbonate block of Mala gora (Figure 3), lying between 650–1040 m a. s. l., has been transported about 100 m southwards from the source area. It covers an area of about 174.7 ha (Table 2). The eastern part of the block is composed of Triassic dolomite and the western part of Jurassic limestone, similar to the composition of the source area. In the most western part of the block, strata are not visible, and block is mostly disintegrated into carbonate gravel. The average dip direction and dip angle are 215/25, giving the angular difference from the source area of only 4°.

The carbonate block Gola gorica is composed of Jurassic limestone and has been displaced much more than the Mala gora block from the source area, about 850 m. Due to inaccessible steep parts of the block, six measurements were performed, but their variation is minimal. Apart from limestone, some breccia appears on the western side of the carbonate block Visoko. Carbonate strata are visible only in the south-eastern side, where the measurements were made. Weathered flysch was observed at the base of the block. Carbonate blocks Križec, Kovači, Platna, Lokavšček and Skuk are composed of dolomite and some carbonate breccia; weathered flysch also appears at the base of these blocks. On the carbonate block Gradišče, measurements were performed only on the accessible southwestern part. This block is composed only of dolomite. Dolomite layers and the contact of dolomitic block Lozica with the underlying flysch are well exposed in two road cuts; otherwise the block is mostly difficult to access.

The smallest difference between the strata dip was obtained for the carbonate block Mala gora (4°), which lies very close to the source area and has been among those with the smallest displacement. In contrast, the largest change between source area dip angle and block dip angle was observed for carbonate block Visoko, about 59°. This block has also one of the largest displacements, so it rotated greatly during the transport (Figure 4). This can be straightforwardly explained by the fact that blocks can change their rotation from clockwise to counter-clockwise during the transport and vice versa.

4 Discussion

Our observations confirm that block lithology corresponds to the lithology of the source area. Blocks lying below the eastern dolomitic part (blocks Mala gora, Križec, Gradišče, Kovači, Platna, Lokavšček, Skuk and Lozica) are also composed of dolomite, and those on the southern limestone side (blocks Mala gora, Gola gorica in Visoko) are composed of limestone. Some breccia was also mapped on blocks Visoko, Križec, Kovači, Platna, Lokavšček and Skuk (see Figure 3). This indicates a former scree that was consolidated behind the blocks (Figure 5), and was in some cases moved with the blocks to be present now in different positions. Flysch and carbonate scree appear in all areas around the blocks. The length of the transport was quite different: the minimum travel distance was about 80 m for carbonate block Lozica, with high elevations and close to source area, and maximum about 2050 m for carbonate block Gradišče, with the lowest elevation near the levelled bottom of the valley. Such a runout distance is quite long, but not unusual,

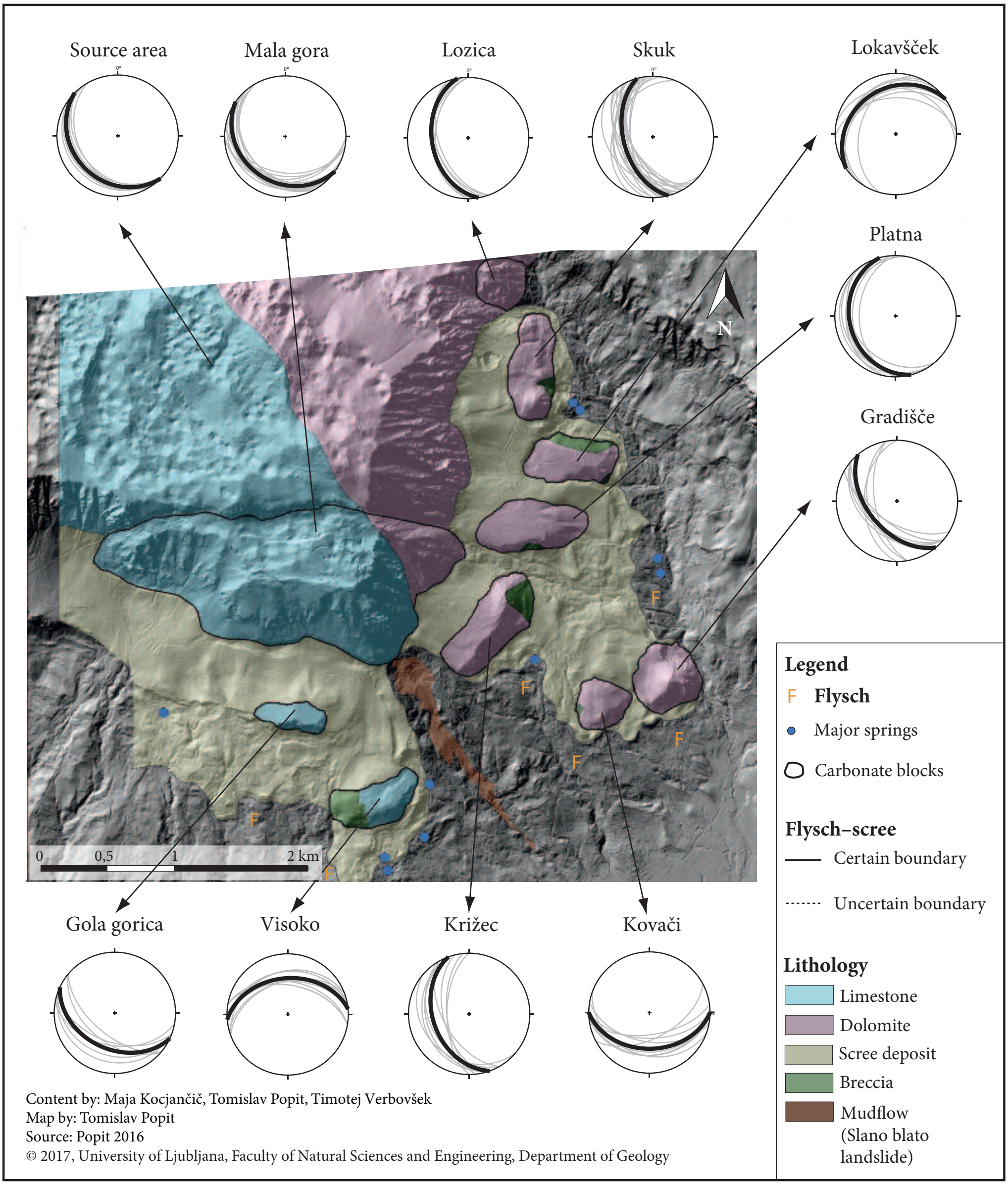


Figure 3: Lithology of the wider source area and studied carbonate blocks, locations of dip directions and dip angle measurements, springs on DEM Lidar surface stereographic plots of strata in individual carbonate blocks and in source area. Area without symbology (colours) belongs to flysch.

Table 2: Results of measurements for individual carbonate blocks and source area.

Block	Elevation [m a. s. l.]	Lithology	Area [ha]	Horizontal travel distance [m]	Number of measurements [–]	Average dip direction and dip angle [°/°]	Change of dip direction [°]	Change of dip angle [°]	Difference between source area dip and block dip [°]
Source area	/	dolomite & limestone	/	/	15	225/25	/	/	/
Mala gora	650–1040	dolomite & limestone	174.7	100	23	215/25	–10	0	4
Gola gorica	580–650	limestone	7.5	950	6	205/40	–20	+15	18
Visoko	440–510	limestone	15.2	1460	10	355/40	+130	+15	59
Križec	540–660	dolomite	23.5	850	10	250/40	+25	+15	20
Gradišče	260–380	dolomite	16.8	2050	10	230/50	+5	+25	25
Kovači	330–400	dolomite	9.9	1720	10	180/40	–45	+15	28
Platna	480–660	dolomite	20.9	750	10	255/25	+30	0	13
Lokavšček	470–620	dolomite	16.7	1000	10	325/25	+100	0	38
Skuk	580–700	dolomite	18.7	800	27	255/50	+30	+25	30
Lozica	700–930	dolomite	10.0	80	10	260/40	+35	+15	24

as the transport distances have been observed from some km to more than 15 km elsewhere in similar geomorphological and geological settings

(Davis and Friedmann 2005). In the nearby geologically similar area in Croatia (Dugonjić Jovančević and Arbanas 2012), several mass movements occur on the contact between steeper Paleogene and Cretaceous carbonates and flysch (Đomlija et al. 2014; Jovančević, Vivoda and Arbanas 2015), but such carbonate blocks have not been documented.

We assume that the transport mechanism is a combination of translational and rotational block-type slope movements, driven only by gravity, so the transport direction is downslope (mostly towards the south or southeast) with rotation of blocks around the horizontal and vertical axes. Some possible deviations from this direction could appear due to irregularities of the flysch slopes, which served as sliding surfaces

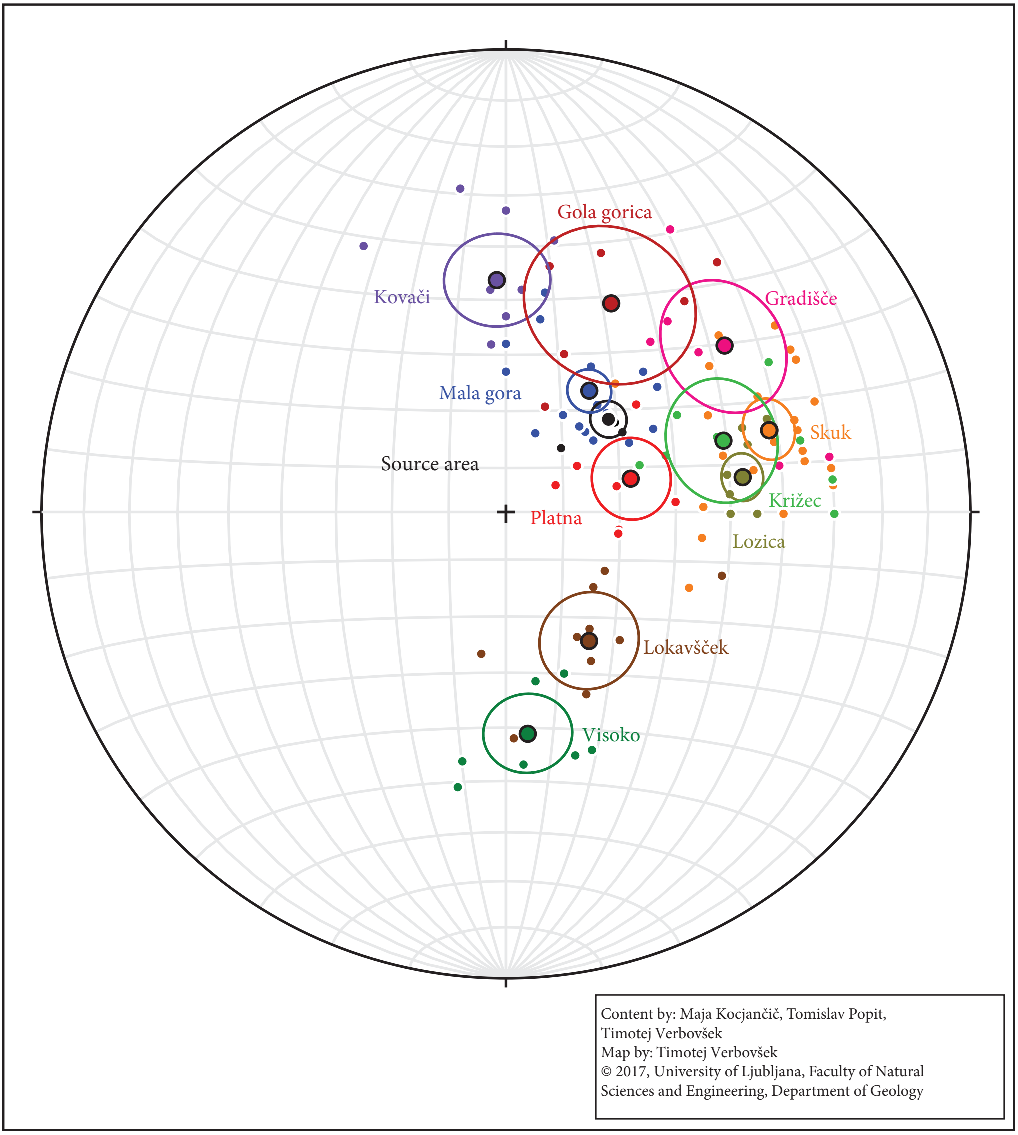


Figure 4: Plots of all strata poles on stereographic projection plot (small dots), with Fisher mean vectors (larger dots) and one circular standard deviation (ellipses).

for the blocks. The slope of the flysch terrain, measured below the blocks Visoko, Gola gorica and Mala gora, is on average 10° (9.5–12.6°). The movement of blocks can be related to tectonic and structural parameters in bedrock formation and some major triggering events (e.g. earthquakes). The wider region is seismically still active, as earthquakes with magnitudes above 5.5 have been recorded in 10s km radius around the studied area (obtained from the earthquake catalogue of Slovenian Environment Agency (Internet 2 and 3) and comprising earthquakes younger than 1348). Such large events are known to be a major cause for major landsliding (Benac et al. 2005; Shroder et al. 2011; Esper Angillieri and Perucca 2013). The study area lies in an active seismic zone (Poljak, Živičič and Zupančič 2000; Placer, Vrabec and Celarc 2010), very close to the Predjama fault, between the Raša and Idrija faults (Vrabec and Fodor 2006). These are active faults, as it was recently found that the Raša fault has slip-rates of about 1.3–2.8 mm/year and the Predjama fault has a mean slip-rate of about 1.4±0.1 mm/year (Moulin 2014). The Idrija fault has been active since Miocene (reactivated from oblique-normal to dextral strike slip from Miocene to Pliocene time) (Bavec et al. 2012; Moulin et al. 2014), with a major earthquake in 1511 (magnitude 6.8; (Bavec et al. 2013). Before this event, several earthquakes of similar magnitude most probably occurred (one of the major landslide events in the Vipava Valley probably related to earthquakes (Popit and Košir 2003) was dated to at least 40,000 years BP). Also, tectonic uplift of the Trnovo Nappe area is believed to be still active and is estimated to be about 2.0 mm/year (Rižnar, Koler and Bavec 2007). Maps for the seismic acceleration with a 1000-year return period (Internet 4) show about 0.225 g for the study area, and for the 10,000-year return period about 0.45 g. The latter acceleration is very close to the value of 0.5 g, being the lower limit for the sliding of large blocks (Davis and Friedmann 2005). Therefore, in such a time span, it is possible that the block movements were triggered due to ground shaking and consequent movement(s) due to seismic activity. The minimal earthquake magnitude to cause the movement is estimated as $M_L \approx 4.0$ (Keefer 1984) and magnitudes of this order and larger have been documented historically in broader area (Poljak, Živičič and Zupančič 2000). Another important factor is the river incision of the flysch bedrock (Huntley, Duk-Rodnik and Sidwell 2006), which could have easily been eroded by the Vipava River). Even apart from the river incision, erosion in flysch of the SW Slovenia is high and exceeds the European average for the Mediterranean part of Europe (Zorn 2009). On a micro level, erosion depends also on the steepness of the flysch slopes, with steeper relief allowing better drainage due to water-retaining clay minerals washed into lower parts (Jamšek Rupnik, Čuš and Šmuc 2016). Also, water can accumulate as groundwater in the carbonate blocks, as they are strongly fractured, karstified and permeable (Verbovšek 2008; Verbovšek and Veselič 2008), and some water can also be accumulated in carbonate scree, depositing above the blocks. In both cases, the presence of water can intensify the weathering of flysch below the blocks and deteriorate its mechanical properties. The presence of water accumulation is documented as the existence of several springs below the blocks (Figure 3) on the less permeable flysch. Only major springs are listed in the table: those that do not dry up during the year, with an average outflow of each spring around 3–5 l/s (Janež et al. 1997). Some unknown quantity of groundwater also flows to the more permeable flysch underground and does not emerge in springs, as was documented for the Slano blato landslide (Placer, Jež and Atanackov 2008). The infiltrated surface water and groundwater contributes to the weathering of the flysch, acting as a sliding base layer for the carbonate blocks. During the Pleistocene, especially in climatic conditions prevailing in the last glacial maximum (Monegato et al. 2015), climatic and hydrologic setting was very different from the present, and mechanical weathering, sediment accumulation and also carbonate block movements may have been greatly accelerated compared to recent mass movement processes. However, there is no proof for such influence in the research area. Finally, the weight of accumulated scree can act as an additional force on the blocks.

During some extreme rainfall and earthquake events, transport of gravitational carbonate blocks is possible, so they would require monitoring. By observing the movement of a block, the velocity could be determined. Velocities of blocks are presently unknown, as no measurements have been performed, but can lie over a very large value range (Davis and Friedman 2005). Most importantly, it would be possible to assess whether the movement is more or less slow and constant during the year, or only occasional and related to extreme catastrophic events (tectonically or climatically conditioned). Regardless if the movements are mostly controlled by climatic factors and/or the seismic events, transport of carbonate blocks could continue in the future, as neither of these factors can be neglected in the future. The region is seismically active with earthquakes of magnitudes above 6, and due to probable vertical uplift of the Trnovo Nappe (Rižnar, Koler and Bavec 2007).

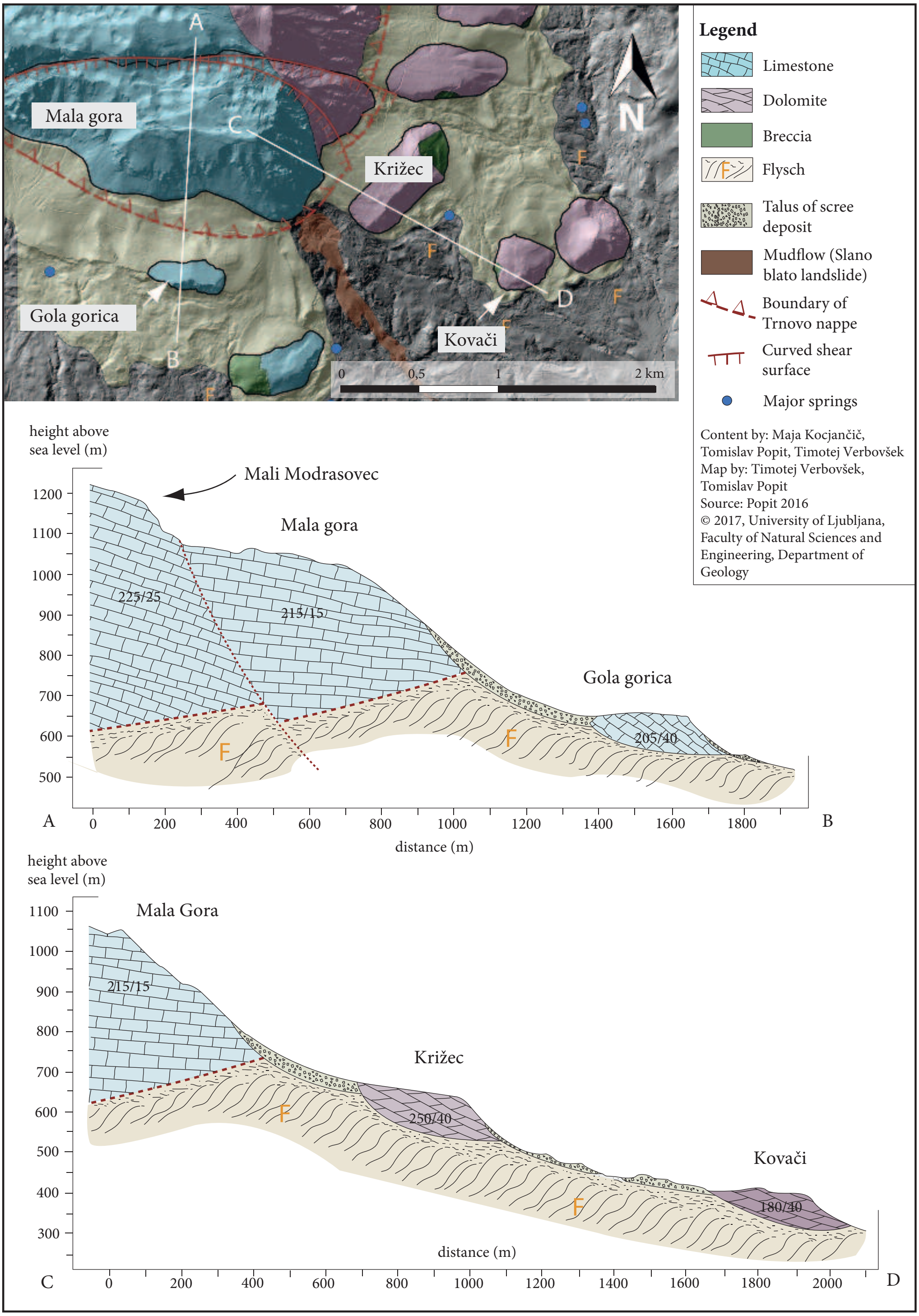


Figure 5: Two selected longitudinal profiles through the source area and Mala gora, Gola gorica, Križec and Kovači carbonate blocks.

5 Conclusion

The main conclusions can be summarized in the following statements:

- In the study area, ten separate carbonate gravitational blocks have been detached from the steep carbonate edge of the Trnovo plateau. Movement was both translational and rotational, proved by correlating lithology between the blocks and the source area and significant change in elevation of the blocks compared to flysch in the longitudinal profiles.
- The distance of the transport ranges from 80 m to about 2 km, and block areas range from 7.5–175 ha. The smallest difference between the strata dip was obtained for carbonate block Mala gora, 4° and the largest change in strata dip was for carbonate block Visoko, about 59°. There is no direct correlation of travel distance with the rotation/tilt angles.
- As seen from the earthquake magnitudes records and seismic acceleration maps the area is seismically still active, with the active nearby Predjama, Raša and Idrija faults, and the blocks can be transported at the major earthquakes events.
- The blocks and carbonate scree, accumulating behind the blocks, act as (ground) water accumulations, and several small springs appear below the blocks and on the contact between the permeable carbonate scree and the less permeable flysch.
- The velocity of the movement is unknown and it should be monitored, as several buildings lie below some of the blocks. Transport of blocks could continue in the future, due to vertical uplift and increasing potential energy of the blocks, and in the scenario of changed climatic conditions, which will change the quantity and intensity of precipitation.

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FLOOD TYPES IN A MOUNTAIN CATCHMENT: THE OCHOTNICA RIVER, POLAND

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The Ochotnica River during the May 2014 flood.

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Flood types in a mountain catchment: The Ochotnica River, Poland

ABSTRACT: This paper presents the results of a study on floods in the Ochotnica River catchment during forty years of hydrological observations (1972–2011). The Ochotnica River is located in the Gorce Mountains, in the Polish Western Carpathians. The characteristics of floods in the Ochotnica River channel were analyzed using limnigraphic records of water levels at the Tylmanowa gauging station and of precipitation based on data from the Polish Institute of Meteorology and the Water Management Station at Ochotnica Górna. Flood types were determined. The predominant type of floods in the Ochotnica River are normal floods with a discharge of 3.80 to 11.94 m^3/s in winter and 4.74 to 16.40 m^3/s in summer. The dominant recent process is incision, at an average speed of 3.2 cm/year. Similar results have been observed in other mountain rivers in Europe.

KEY WORDS: floods, water level, channel bed, Ochotnica River, Carpathians

Vrste poplav v gorskem porečju: reka Ochotnica na Poljskem

POVZETEK: V članku avtorici predstavljata izsledke štiridesetletnih hidroloških opazovanj poplav v porečju reke Ochotnice (1972–2011). Reka Ochotnica teče v pogorju Gorce v poljskem delu Zahodnih Karpatov. Avtorici sta značilnosti poplav v strugi reke analizirali na podlagi limnigrafskih podatkov o vodni gladini, izmerjenih na merilni postaji v kraju Tilmanova, in podatkov o količini padavin, ki sta jih pridobili od Poljskega meteorološkega inštituta in vodomerne postaje v kraju Ochotnica Górna. Na podlagi tega sta določili vrste poplav. Na reki Ochotnica prevladujejo normalne poplave z zimskim pretokom 3,80–11,9 m^3/s in poletnim pretokom 4,74–16,40 m^3/s. Prevladujoči proces v zadnjem času je vrezovanje, in sicer s povprečno hitrostjo 3,2 cm/leto. Podobni rezultati so bili ugotovljeni tudi pri drugih evropskih gorskih rekah.

KLJUČNE BESEDE: poplave, vodna gladina, rečna struga, reka Ochotnica, Karpati

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1 Introduction

The Ochotnica catchment is located in the Carpathian Mountains, the second-largest mountain range in central Europe (Pociask-Karteczka 2011). Floods in mountain catchments occur more quickly than in lowland rivers because of steep slopes and narrow valleys (Ruiz-Villanueva et al. 2010). In this article, a flood is understood as an event with a discharge greater than critical values, and not as water spreading over the surface near the river channel (Ozga-Zielińska and Brzezinski 1994). The course of flood events, types, volumes, and durations are important factors for several practical hydrological applications, such as hydropower plant operation (Bezak, Horvat and Šraj 2015).

Flood magnitude depends on precipitation intensity and duration as well as on characteristics of the catchment area, such as the length of the preceding dry period, soil moisture (water retention), vegetation cover, thickness of snow cover, snow water content, and intensity of melting and ground freezing depth (Christen and Christen 2003; Malarz 2005; Ogden and Dawdy 2003; Parajka et al. 2010; Gaal et al. 2012).

The course of floods is also dependent on land-use changes. Urbanization, deforestation (Bork et al. 1998), and agricultural intensification (van der Ploeg and Schweigert 2001) reduce the water-retention capacity of the soil (Mudelsee et al. 2004). These changes cause an increase in flood risk (Yin and Li 2001) and play a key role among the natural factors shaping river channel morphology (Bronstert 2003; Barredo 2007; Frandofer and Lehotský 2011; Kijowska-Strugała 2012; Gorczyca et al. 2014). During the flood in June 1957 in the Guil Valley (Queyras, southern French Alps), the entire valley bottom was affected, and the lower slopes were undermined by lateral cutting, which triggered landslides and transported enormous quantities of material to the valley bottom (Arnaud-Fassetta, Cossart and Fort 2005). During extreme rainfalls in September 2007 in the upper Selška Sora River in Slovenia, a flash flood caused bank erosion, channel-bed widening, and overbank deposition. Several debris flows and shallow landslides were triggered on the slopes, destroying the main road (Marchi et al. 2009). Changing the position of the level of river channel bottoms is one of the more visible morphological processes in mountain areas. In the Carpathians, incision of 1.3 to 3.8 m can be observed in rivers in recent decades (Bucała, Budek and Kozak 2015; Wyżga, Zawiejska and Radecki-Pawlik 2015; Wiejaczka and Kijowska-Strugała 2015). Similar studies have been conducted in other mountain rivers of Europe; for example, between 1928 and 1989/1995 incision (locally up to 5 m) was evident along the 100 km length of the Drôme River (Brookes 1987; Kondolf, Piégay and Landon 2002; Liébault and Piégay 2002; Rinaldi 2003).

The study area (the Ochotnica catchment) of 107.6 km² is located in the Gorce Mountains in the Western Carpathians (Figures 1, 2) characterized by deep valleys (Starkel 1972). The Ochotnica River is 22.7 km long and it is a left tributary of the Dunajec River. The average slope for the entire watercourse is 36.1‰ (ranging from 56.8‰ in the upper course to 15.5‰ in the lower course). The Ochotnica River channel is carved into solid rock with numerous shelves and rock outcrops upstream, and it is cut into sediments

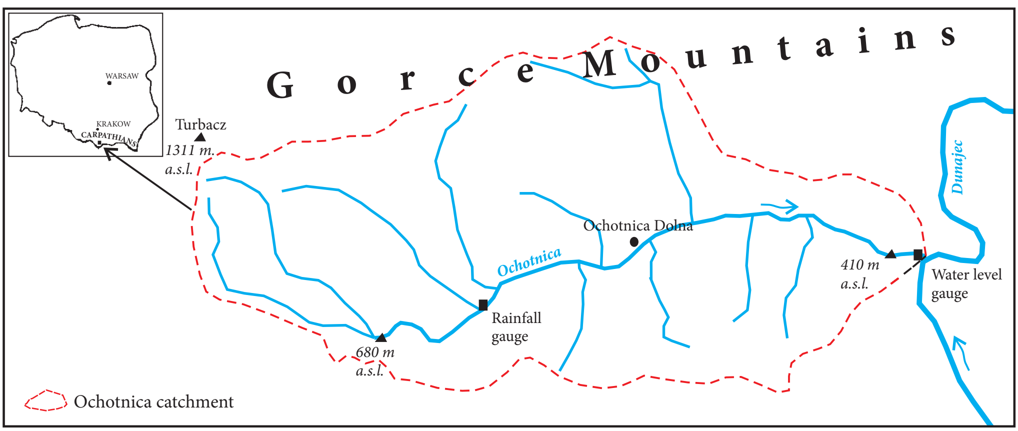

Figure 1: Location of the study area in the Polish Carpathians (Gorce Mountains).

in the middle and lower parts, where it is also braided (Krzemień 1984). Along the entire course, the Ochotnica River is fed by twelve left tributaries of and twenty-three right tributaries. The tributaries play an important role during flooding because they distort the natural wave of the flood, leading to delays or accelerations in the culmination of the main river below the mouth (Kijowska-Strugała 2015).

River floods in the Gorce Mountains frequently occur in spring and summer. Snowmelt floods are the result of thawing snow, and summer floods are the result of torrential and extreme rainfall, whereby the amount in three to five days can exceed 100 to 250 mm (Starkel 1976). Such high rainfall leads to catastrophic floods, as exemplified by the catchments of Konina, Jaszcze, Jamne, and Kamienica stream (Niemirowski 1974; Krzemień 1984). During the flood in July 1970, maximum daily precipitation was 154.9 mm, and discharges reached 15.5 m^3/s and 16.5 m^3/s in Jaszcze and Jamne streams, respectively. Bank erosion dominated in both streams, cutting the banks from 1.2 to 7 m. Mean incision of the bed reached 32 cm, and the maximum was 1.2 m (Niemirowski 1974).

This paper determines the types, duration, temporal variability, and magnitude of the Ochotnica River floods between 1972 and 2011. To properly identify the floods, the characteristics of the basic meteorological and hydrological parameters are presented below; these include precipitation, runoff coefficient, discharge regime, and maximum discharges. To show changes in the river channel morphology caused by floods, the dynamics of the position of river channel bottoms were also analyzed, based on long-term observation series of minimum water levels.

2 Methods

Data from the Institute of Meteorology and the Water Management Station were used to analyze floods. Discharges were analyzed based on limnigraphic records of water levels at the Tylmanowa gauging station closing the catchment (Figure 1) and precipitation data from the rain gauge in Ochotnica Górna. A forty-year period (1972–2011) of hydrometeorological observations was selected for detailed analysis.

It is assumed that a flood is an event in which discharges (Q) equal or exceed the discharge threshold (Q_t). The selection of the criterion of flood threshold that is part of the definition of the event has a decisive influence on the results (e.g. Ramos, Bartholmes and Thielen-del Pozo 2007). The discharge threshold of the flood (Q_t) was calculated using the following equation (Ozga-Zielińska and Brzezinski 1994):

$$Q_t = \tfrac{1}{2}\,(NWQ + WSQ),$$

where NWQ is the minimal maximum discharge during the multiyear period and WSQ is the maximum mean discharge of the multiyear averages.

In order to show the variability of flooding in a small mountain catchment, floods were divided into three types: low, normal, and high. WSQ is the threshold value of low floods, NWQ is the critical value of normal floods, and the average maximum discharge of the multiyear period (SWQ) is used for high floods. Selecting the criteria for flood threshold as part of the definition of the event has a decisive influence on the results.

Floods usually depend on the season, and the seasonality approach opens the way to studying mixed flood frequency distributions (Sivapalan et al. 2005; Ouarda et al. 2006). This article presents floods from the summer (May–October) and winter (November–April) half of the hydrological year.

The probability of the maximum discharges (Qmax) during floods was also calculated based on the decile method found in Dębski (1954).

A statistical analysis was conducted to determine the months with the highest frequency of floods. For each month of the hydrological year, the coefficient of variation (C_v) of average monthly discharge was calculated. Based on the discharge coefficient (k), the river regime was calculated using the following equation (Pardé 1957):

$$k = SQ_M / SQ_R,$$

where SQ_M is the average monthly discharge and SQ_R is the average annual discharge. The minimum water level was used to identify the dynamics of the Ochotnica channel (aggradation and erosion processes) after floods.

3 Driving force: precipitation

The average annual precipitation in the Upper Ochotnica from 1972 to 2011 was 838.7 mm, showing a variability of 629.2 mm (1984) to 1,109.9 mm (2007). Based on the forty-year study period, an increasing trend of annual precipitation was observed in the study area, averaging 4.3 mm per year (Figure 2). During the twentieth century in Europe, the mean annual precipitation has increased in northern Europe and has decreased in southern Europe (New, Hulme and Jones 1999).

According to the precipitation classification by Kaczorowska (1962), nineteen years (Figure 2) were within the normal range, similar to the average of the multiyear period. In the forty-year period analyzed, as many as thirteen years had above-average rainfall (i.e., 917 mm; Figure 2). On average, 64% of the precipitation occurs in the summer half of the hydrological year (May–October). During the period analyzed, there were 170 days with precipitation on average; during the summer half-year, the average number of days with precipitation was ninety, and in the winter half-year seventy-five days. The maximum number of days with precipitation in the summer half-year was 120 days in 1974 and the minimum sixty-two days in 1982, whereas in the winter half-year these were 105 days (1993) and fifty days (1987), respectively.

The highest monthly total precipitation was recorded in July and June, at 123 and 109 mm, respectively (Figure 3). In the Carpathians and the northern part of the Alps, the annual precipitation maxima typically occur in July and August (Parajka et al. 2010).

In small catchments in central Europe, under moderate climate conditions, floods are caused by local convective precipitation events with high intensity (Bryndal 2014). The highest daily rainfall occurred in the Ochotnica catchment on the following days: June 30th, 1973 (94.9 mm), May 17th, 1985 (92.3 mm), July 8th, 1997 (70.0 mm), July 23rd, 2008 (76.3 mm), and September 1st, 2010 (94.6 mm). A number of studies have documented increases in intense precipitation based on records (Alpert et al. 2002; Klein Tank and Können 2003). According to Parajka et al. (2010), lower variability in the mean date of occurrence of annual maximum daily precipitation is observed over the Alps than over the Carpathians. They also found that the greatest daily precipitation is consistently produced by similar atmospheric regimes, whereas a broader variety of processes are responsible for smaller events.

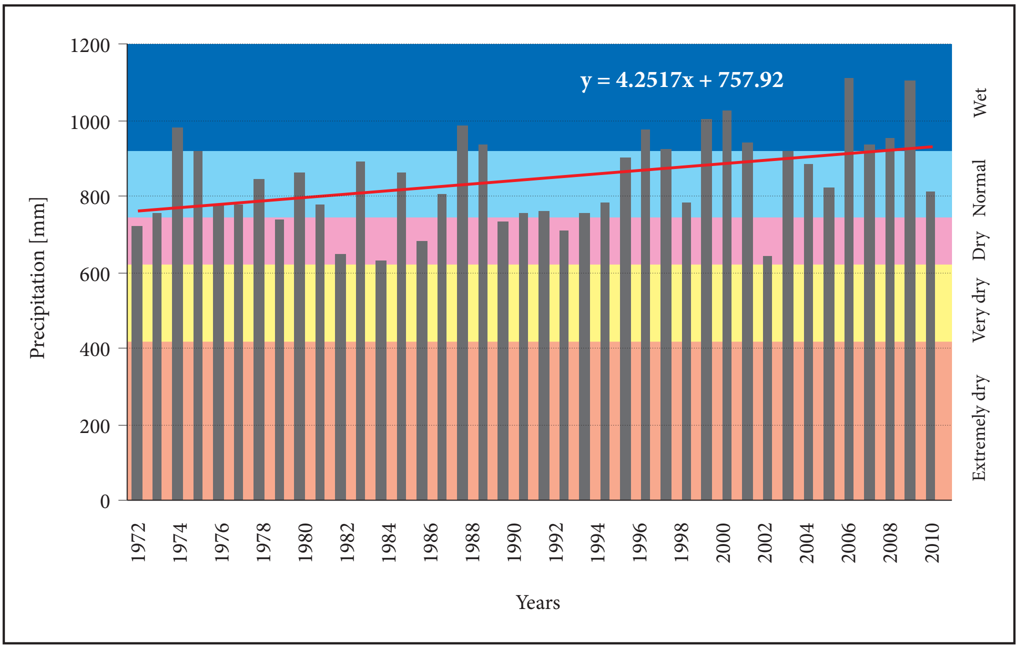

Figure 2: Annual precipitation from 1972 to 2011 at the Ochotnica Górna station based on the classification of precipitation ranges proposed by Kaczorowska (1962).

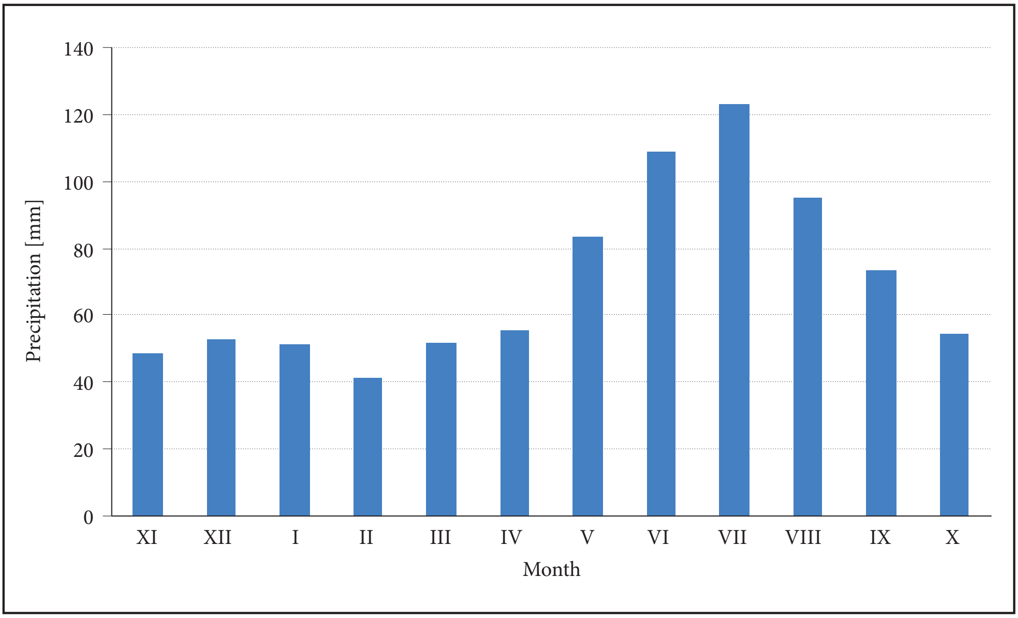

Figure 3: Average monthly precipitation from 1972 to 2011 at the Ochotnica Górna station (Institute . . . 2015).

4 Results

4.1 Runoff coefficient and the probability of maximum discharges

The runoff coefficient is a key concept in hydrology and floods, and is an important diagnostic variable for catchment response. Examination of runoff coefficients is useful for catchment comparison to understand how different landscapes filter rainfall into a flood event (Holko, Herrmann and Kulasova 2006; Marchi et al. 2010). According to Schaake (1990), it is possible to determine the size of floods based on runoff and precipitation.

The average runoff coefficient from 1972 to 2011 was 62.8%. The highest runoff coefficient (91.8%) was recorded in 1980 (Figure 4).

The greater variation of runoff in western Europe, compared to eastern Europe, reflects the greater variability in topography, and hence rainfall. Across most of lowland Europe, runoff is between 25 and 45%, whereas it exceeds 70% in high precipitation areas such as the Alps (Arnell 1999; Magnuszewski 2000; Marchi et al. 2010).

The runoff coefficients in the Ochotnica catchment do not show any significant trends. Similar results were obtained by Pekarova, Miklanek, and Peka (2006) for European rivers over the last 150 years.

The runoff irregularity coefficient (the ratio of the annual maximum to minimum runoff) in the Ochotnica River ranged from 3.4 mm in 1978 to 17.9 mm in 2000, and it shows an increasing trend (Figure 4). High recent values of the coefficient are due to the great diversity of total monthly precipitation. Compared to other Carpathian rivers, this coefficient is not high, and it is determined by a continuous water supply during the summer and the autumn lows.

The average discharge in the Ochotnica River in the multiyear period analyzed was 1.81 m^3/s. Ziemońska (1973) proposed eight river classes with different average discharges in the Polish Carpathians. The Ochotnica River is in the second class, with discharges ranging from 1 to 3 m^3/s. On average, for approximately 234 days annually, the Ochotnica River had a discharge of 0.5 to 2 m^3/s, and the discharge was 2 to 5 m^3/s for seventy-seven days (Figure 5). A discharge greater than 10 m^3/s was recorded for an average of four days. There are no differences in average discharges during the summer and winter hydrological half-year during the period analyzed.

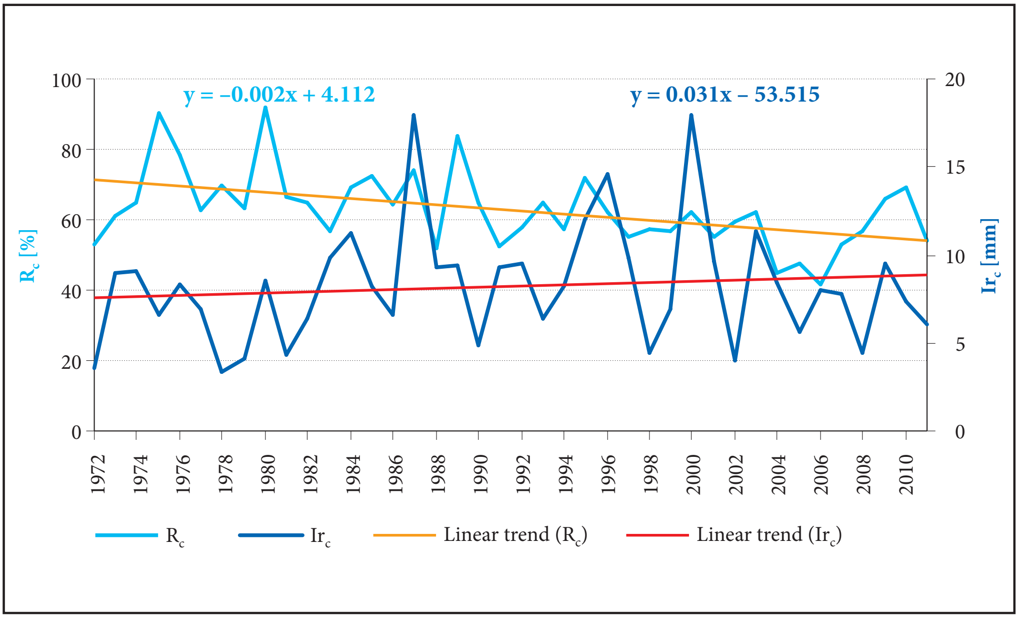

Figure 4: Runoff coefficient (R_c) and irregular runoff coefficient (I_{rc}) in the Ochotnica River from 1972 to 2011.

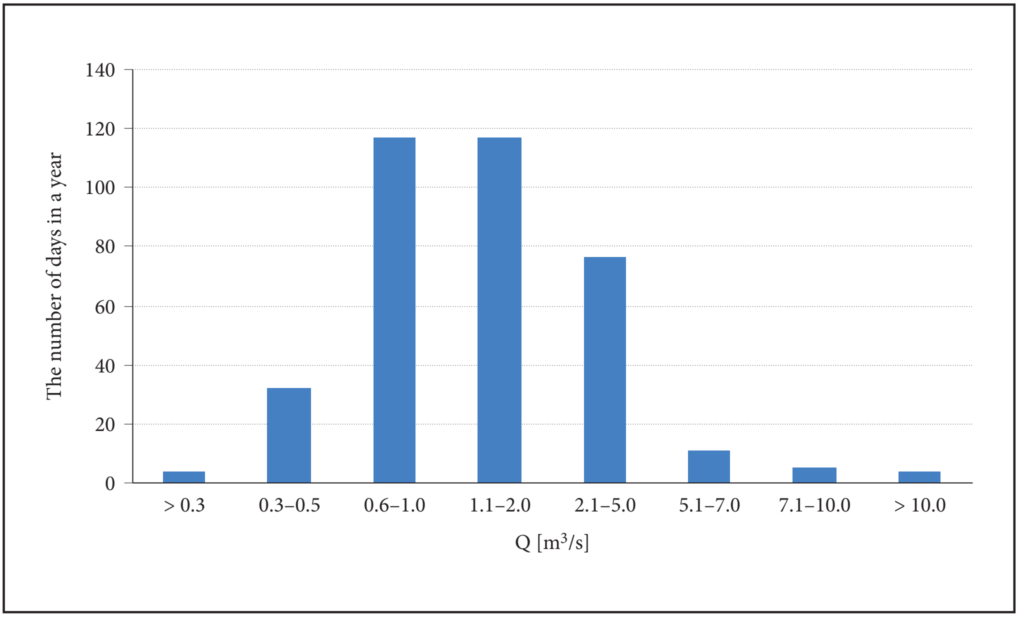

Figure 5: Frequency of average daily discharge in the Ochotnica River from 1972 to 2011.

On the basis of forty years of observations of water discharge in the Ochotnica River, a theoretical probability curve was plotted for the maximum discharge using a Pearson distribution (Type III), starting from a value of 1% (Table 1). Maximum discharges are directly related to floods (Patton and Baker Konrad 1976).

Table 1: Probability (%) of maximum discharges (m^3/s) and recurrence period (*T*) in the Ochotnica River based on the Pearson distribution (Type III).

Probability (%)	Discharge (m^3/s)	*T* (Year)
1	92	100
2	80	50
5	70	20
10	38	10
20	25	5
50	15	2
100	4	1

4.2 Discharge regime

A discharge regime describes the average seasonal behavior of a river, as determined by its genetic sources and its ambient climate. The discharge regime is a useful tool for identifying spatial and temporal variations in the magnitude and seasonality of discharge, and for determining the periods more susceptible to floods (Wrzesiński 2012). The Ochotnica River is an example of a river with a complex, primary, snow-rain regime with its peak discharge in the second half of winter and in the summer (Figure 6). The first, higher discharge peak occurs in April, and the second, lower one in July. Low discharges in the autumn and winter are the consequence of reduced precipitation (especially in the autumn) and snow retention. Discharge coefficient values in the Ochotnica River were close to $k = 1.5$ in the spring, which is characteristic of the Carpathian rivers west of the Dunajec River (Chełmicki, Skąpski and Soja 1998–1999).

In the Ochotnica River, the spring months (March, April, $C_v = 0.4$) are characterized by the lowest variability in discharge. This relationship is due to a high degree of reproducibility in the water supplied by snowmelt (Chełmicki, Skąpski and Soja 1998–1999). The greatest discharge variability ($C_v > 0.7$) is in May, September, and December. High values of the coefficient of variation in May and September are associated with limited recurrence of floods in individual years. In December, winter thawing may be a destabilizing factor. The average value of the coefficient of variation from 1972 to 2011 is 0.63, indicating high stability of the rhythm of discharge in the river analyzed.

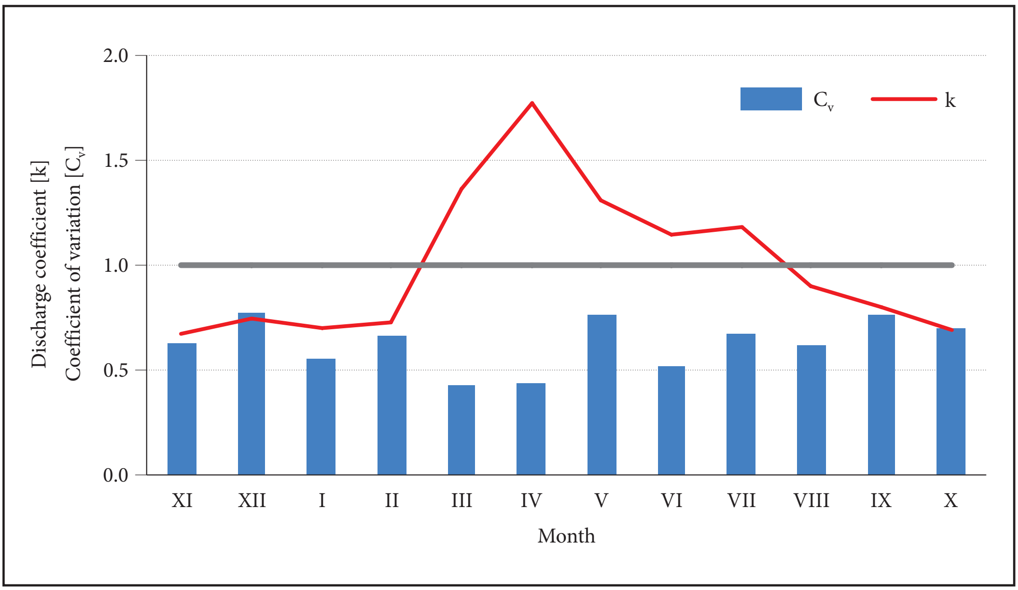

Figure 6: Differences in the monthly annual course of the discharge coefficient (*k*) and coefficient of multiyear variability of monthly discharge (C_v) for hydrological years from 1972 to 2011 in the Ochotnica River.

5 Discussion

5.1 Characteristics of floods

Low, normal, and high floods occurring in the hydrological winter and summer half-years were analyzed. Using the criteria for defining floods given in the Methods section, it was assumed that low floods occur when the culminating discharge is greater than 3.26 m^3/s during winter and 4.22 m^3/s in summer (Table 2).

Table 2: Quantitative character of floods in the Ochotnica channel from 1972 to 2011.

Measure	Value
Mean discharge	1.8 m^3/s
Mean specific discharge	0.017 $m^3/s/km^2$
Maximum daily discharge	79.8 m^3/s
Winter hydrological half-year	
Low flood	3.26–3.80 m^3/s
Normal flood	3.80–11.94 m^3/s
High flood	> 11.94 m^3/s
Summer hydrological half-year	
Low flood	4.22–4.74 m^3/s
Normal flood	4.74–16.40 m^3/s
High flood	>16.40 m^3/s
Maximum duration of flood	55 days
Mean duration of flood in winter/summer hydrological half-year	24 days 7 h / 12 days 17 h

In the forty years of observations (1972–2011), 295 floods were calculated. The average for each hydrological year was seven floods. There is a decreasing trend of the flood numbers in the hydrological winter half-year and an increasing trend in the summer half-year. The trends are not statistically significant.

Low floods accounted for approximately 17% and 15% of all floods in the winter and summer hydrological half-years. High floods in the entire multiyear period accounted for only 14% of the total number of floods (12% in the winter hydrological half-year and 15% in the summer half-year; Figure 7).

Floods are closely linked to the type of water source flowing into the river channel. The magnitude and course of floods in winter are related to the amount of water from melting snow in a time unit. Rapid snowmelt often causes major spring floods. In mountainous regions, spring floods are usually not as high as the summer rainfall floods, but they have an increased frequency of single snowmelt floods (January–March) and floods from mixed water supply (April). Snowmelt flood formation (especially thaw) is influenced by a southern catchment exposure. In the winter half-year during the period analyzed, 146 floods were recorded. The average flood duration was 24.29 days (7% of the year), longer than summer floods. This is connected with the water supply from various parts of the asymmetric catchment. Over the forty years, April was characterized by the highest number of floods (forty-nine).

Summer floods are more dynamic than winter floods. In the multiyear period analyzed, a total of 149 floods were recorded in the hydrological summer half-year. During this time, floods are caused by torrential and extreme rainfall. Summer floods occurred in the channel of the Ochotnica River irregularly and lasted shorter than the floods during the winter months (an average of 12.71 days). High floods accounted for 15% of these, or 2 percentage points more than in the hydrological winter half-year. The average value of the maximum daily discharge during all of the floods in summer half-year amounted to 16.4 m^3/s, and the absolute maximum discharge of 79.8 m^3/s was recorded on May 2nd, 1989. This was 144 times greater than the average discharge.

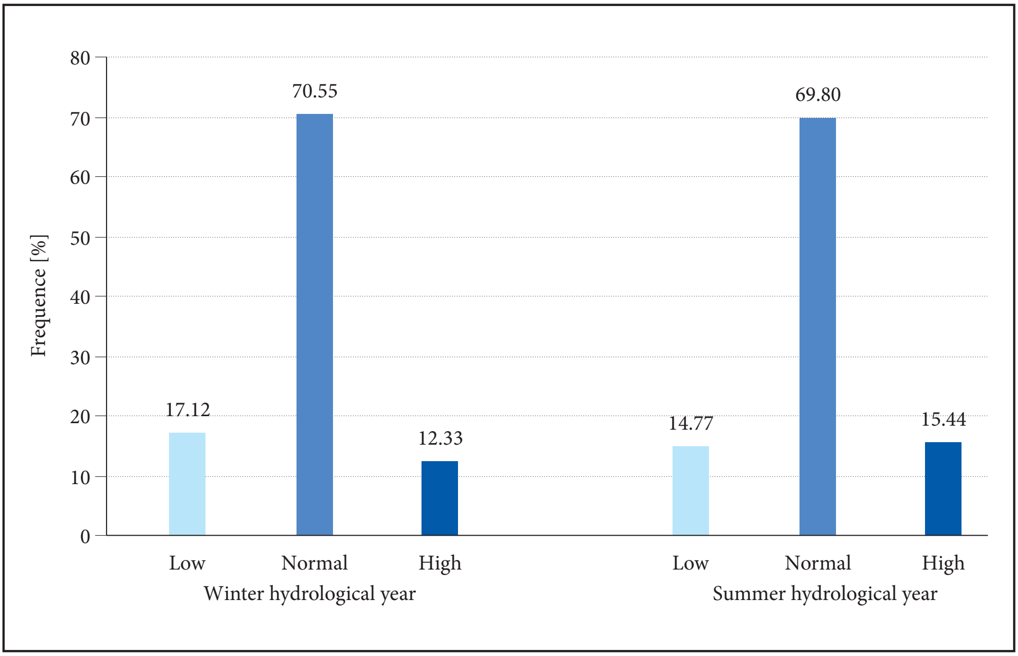

Figure 7: Frequency of flood types in the Ochotnica River in the winter (November–April) and summer (May–October) hydrological half-years from 1972 to 2011.

5.2 The dynamics of the Ochotnica channel

Analysis of changes in the position of river channel bottoms can be performed based on the minimum conditions of the river (e.g. Wiejaczka and Kijowska-Strugała 2015; Tamang and Mandal 2015). The use of data on water levels in the river provides reliable information about the direction of change (incision or raising) and its intensity. Incision is a common response of alluvial channels that have been disturbed such that they contain excess amounts of flow energy or stream power relative to the sediment load (Simon and Rinaldi 2006). If the river capacity is less than the load, deposition would be expected.

On the basis of an analysis of the minimum water levels from 1972 to 2011, two periods can be identified with different tendencies in changing the position of the Ochotnica channel bottom. The first covers the period from 1972 to 1996, when aggradation was the predominant process, whereas from 1997 to 2011 incision dominated (Figures 8, 9).

A clear decrease, by 70 cm, during the lowest minimum water level in 1997, as compared to 1996, was due to extreme floods. In July, the maximum water level was 344 cm, corresponding to a discharge of 17.6 m^3/s. Such a high discharge was caused by daily rainfall exceeding 70 mm. In July, the rainfall total was 291 mm and was 2.5 times higher than the average value from 1972 to 2011 (Froehlich 1998; Bucała 2012).

Between 1972 and 1996, the minimum water levels ranged from 186 cm (1973) to 286 cm (1993), whereas between 1997 and 2011 they ranged from 158 cm (2011) to 216 cm (2003). In 1983, at the level of 276 cm, the discharge recorded was 3.16 m^3/s, whereas it was only 0.45 m^3/s in 1996. This proves that the bed of the Ochotnica rose between 1972 and 1996. The course of the lowest monthly water levels during this period also shows a tendency to raise the channel bottom, amounting to 3.9 cm/year (Figure 8). In 1997, the lowest water level was 206 cm, with a discharge of 0.81 m^3/s, and in 2010 at the same water level the discharge recorded was 2.24 m^3/s. The examples show that the same water level in the multiyear period corresponds to increasingly higher discharges, which is clear evidence of the river channel deepening. The average rate of the annual lowest water level decreasing from 1997 to 2011 is 3.2 cm/year (Figure 9).

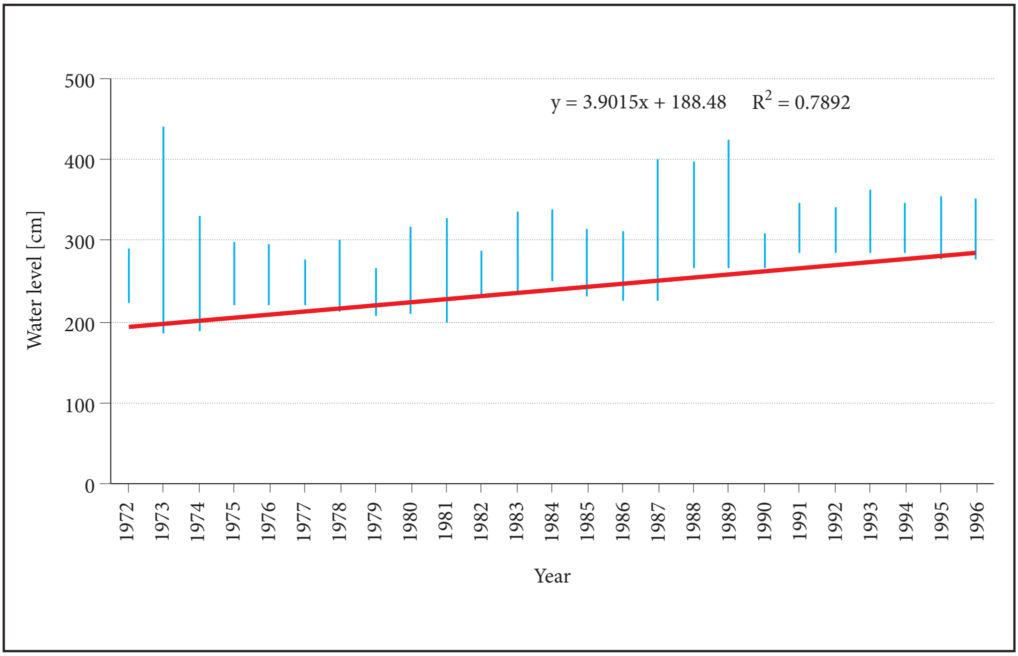

Figure 8: Minimum and maximum annual water level in the Ochotnica River from 1972 to 1996.

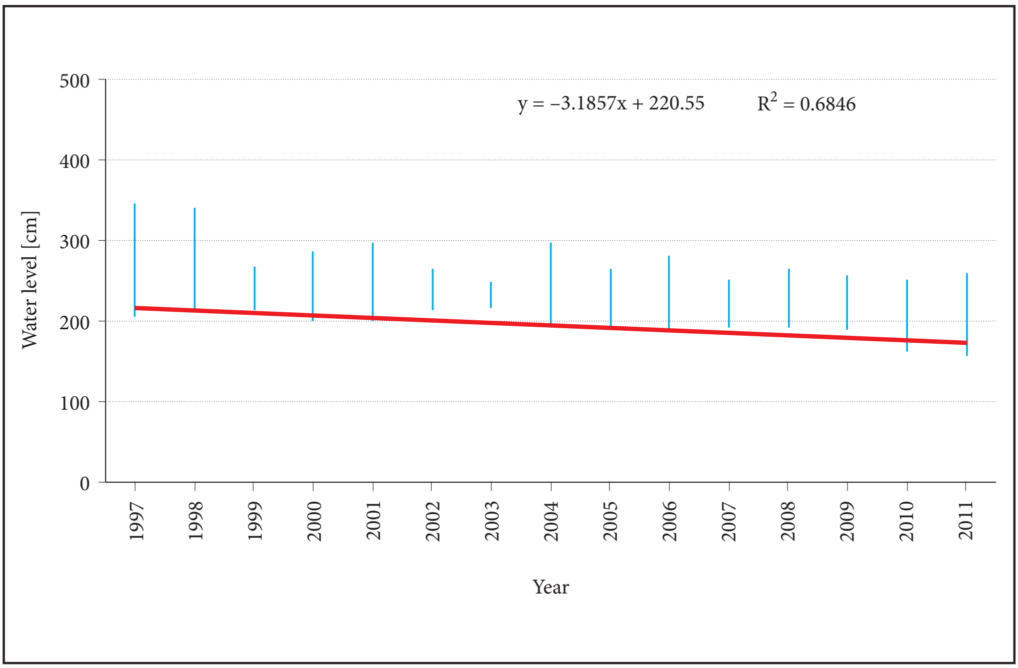

Figure 9: Minimum and maximum annual water level in the Ochotnica River from 1997 to 2011.

Processes occurring in recent times in the Carpathian environment (e.g., incision of channel bottoms) are related to an increase in the sum and intensity of precipitation and are probably caused by changes in land use (Klimek 1987; Kijowska-Strugała and Demczuk 2015). Land-use changes leading to forest expansion at the expense of agricultural land and, related to this, conversion of braided rivers to incised, single-thread channels have also been noted in other European mountains (Wohl 2006).

6 Conclusion

In terms of the types, duration, variability, and magnitude of floods, the forty-year period analyzed (1972–2011) shows the basic regularities observed in small mountain catchments in Europe. The analysis of measured floods does not indicate an increasing frequency. The runoff coefficient and number of floods in the last two decades do not show significant differences with regard to values that occurred in the previous two decades. Similar results have been observed in other mountain rivers in Europe. However, in the Ochotnica River in the last two decades a greater number of high floods has been noted. This can be related to an increased sum and intensity of precipitation over the last forty years, which is also documented in other European catchments.

Floods on the Ochotnica River usually occur in April and June, which is connected with its snow-rain river regime. Winter floods last longer than summer floods. This is related to the way the river channel is supplied with water from snowmelt in various parts of its asymmetric catchment.

The analysis of the minimum water levels showed significant changes in the dynamics of the position of the Ochotnica River channel bottom over time. Since 1997, the predominant process in the channel, as in the case of other Carpathians rivers, has been incision. The deep erosion observed in Carpathian rivers in the last decade is probably associated with changes in land use (a decrease in arable land and increase in forest area), which have intensified due to the economic transformation of the country and, in recent years, Poland's accession to the EU.

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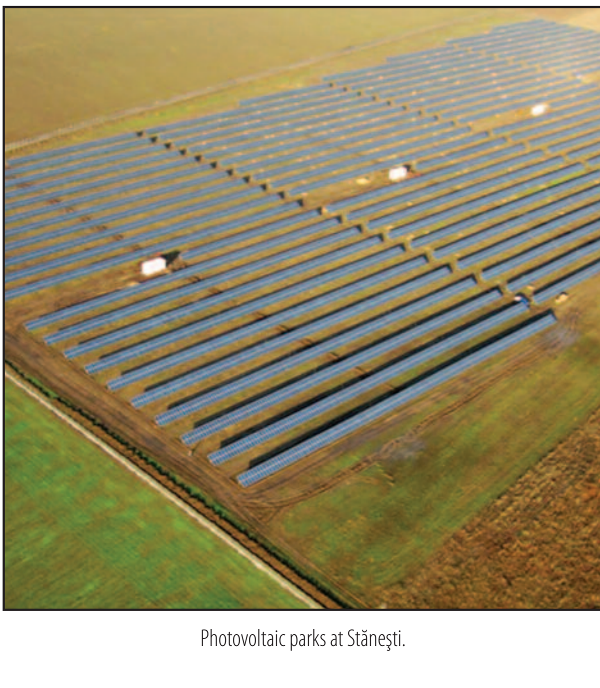
SOCIO-ECONOMIC IMPACT OF PHOTOVOLTAIC PARK: THE GIURGIU COUNTY RURAL AREA, ROMANIA

Irena Mocanu, Bianca Mitrică, Mihaela Persu



Photovoltaic parks at Stăneşti.

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Socio-economic impact of photovoltaic park: The Giurgiu County rural area, Romania

ABSTRACT: The paper aims to analyse the socio-economic territorial impact of photovoltaic parks in the rural area of Giurgiu County. The analysis valorises two types of data: the statistical information on the local socio-economic features provided by the National Institute of Statistics and the Giurgiu County Statistics Office, and the specific information about the photovoltaic parks revealed by the interviews applied to the local authorities during field investigation. The case-studies discussed in this paper reflect the socio-economic effects of building and operating the six photovoltaic parks as in the three rural local administrative units – LAU2: Izvoarele, Stăneşti and Malu. This study emphasizes four types of the socio-economic effects of investment in a photovoltaic project on: local rural economy, land use changes, local investments, budget and local labour market.

KEY WORDS: geography, solar park, land use, regional development, rural space, Romania

Socialnoekonomski vpliv fotovoltaičnega parka: podeželsko območje Giurgiu v Romuniji

POVZETEK: V članku avtorice analizirajo socialnoekonomski teritorialni vpliv fotovoltaičnih parkov na podeželskem območju okrožja Giurgiu. Pri analizi so ocenjevale dve vrsti podatkov: statistične podatke o lokalnih socialnoekonomskih značilnostih, ki so jih pridobile na nacionalnem statističnem uradu in statističnem uradu okrožja Giurgiu, ter podatke o fotovoltaičnih parkih, ki so jih med terensko raziskavo pridobile v intervjujih z lokalnimi oblastmi. Predstavljene študije primera izražajo socialnoekonomske vplive gradnje in upravljanja šestih fotovoltaičnih parkov v treh lokalnih upravnih enotah (LUE2): Izvoarele, Stanešti in Malu. Izsledki raziskave so razkrili štiri različne vrste socialnoekonomskih vplivov naložb v fotovoltaične projekte, in sicer vplive na lokalno podeželsko gospodarstvo, spremembe v rabi tal, lokalne naložbe, proračun ter lokalni trg dela.

KLJUČNE BESEDE: geografija, solarni park, raba tal, regionalni razvoj, podeželje, Romunija

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1 Introduction

The low-carbon energy transition, a long-term structural change in energy system (Hauff et al. 2014), represents a geographical process (Bridge et al. 2013) which implies the reconfiguration of current patterns and scales of economic and social activity (Smil 2003). Geography offers the concepts which allow us to assess the territorial impacts of energy transition, such as the location, the territoriality, the unequal development, and the scale/level concept (Bridge 2011). The territorial impact of renewable energy, including photovoltaic energy, is one of the many topics emerging from the new geography of energy (Zimmerer 2011) being linked with other concepts such as energy landscape (Nadaï and Van der Horst 2010; Pasqualetti 2012), and brightfield (Kunc, Frantál and Klusáček 2011; Kunc et al. 2014). Photovoltaic (PV) parks are »*large-scale photovoltaic systems designed to supply merchant power to the electricity grid*« (Wolfe 2012, 994).

Romania is an ideal location for the installation of the PV systems (Oprea 2008; Pavlíček 2012; Paulescu et al. 2013), the most common being photovoltaic parks and solar thermal systems. Production of renewable energy affects the environment and involves the use of land resources (Sliz-Szkliniarz 2013); also, the development of any type of energy project generates direct and indirect effects on the demand of goods and services as well as employment generation (Caldes, Santamaria and Sáez 2009).

Recent worldwide investigations on the socio-economic impacts of solar park implantation refer to:

- social impacts of photovoltaic parks on rural development (Mezei 2008; Pelin et al. 2014; Frantál et al. 2014);
- expansion of residential photovoltaic systems (Fekete, Klaić and Majdandžić 2012) and
- public acceptance of renewable energies (Zoellner, Schweizer-Ries and Wemheuer 2008).

Kontogianni, Tourkolias and Skourtos (2013) and Gaigalis et al. (2014) bring into question the massive deployment of renewable energy sources from the perspective of the local economy and the local communities. Sliz-Szkliniarz (2013) focused the scientific interest on the risks linked to the use of an intensified renewable energy source use, which should be adequately taken into consideration in any planning of rural areas. The concept of multi-functionality of the rural space relies on the recognition that agriculture, in addition to producing food, also produces non-market goods and services, shapes the environment, affects social and cultural systems, biodiversity conservation and contributes to economic growth (Van Huylenbroek and Durand 2003, cv. Wilson 2010; Van Huylenbroek et al. 2007, cv: Knific and Bojnec 2015; Salvioni 2008). Recent investigation into green jobs shows that this type of employment means fewer jobs (Lyman 2016). The fact that photovoltaic systems require little labour participation is discussed by Pelin et al. (2014).

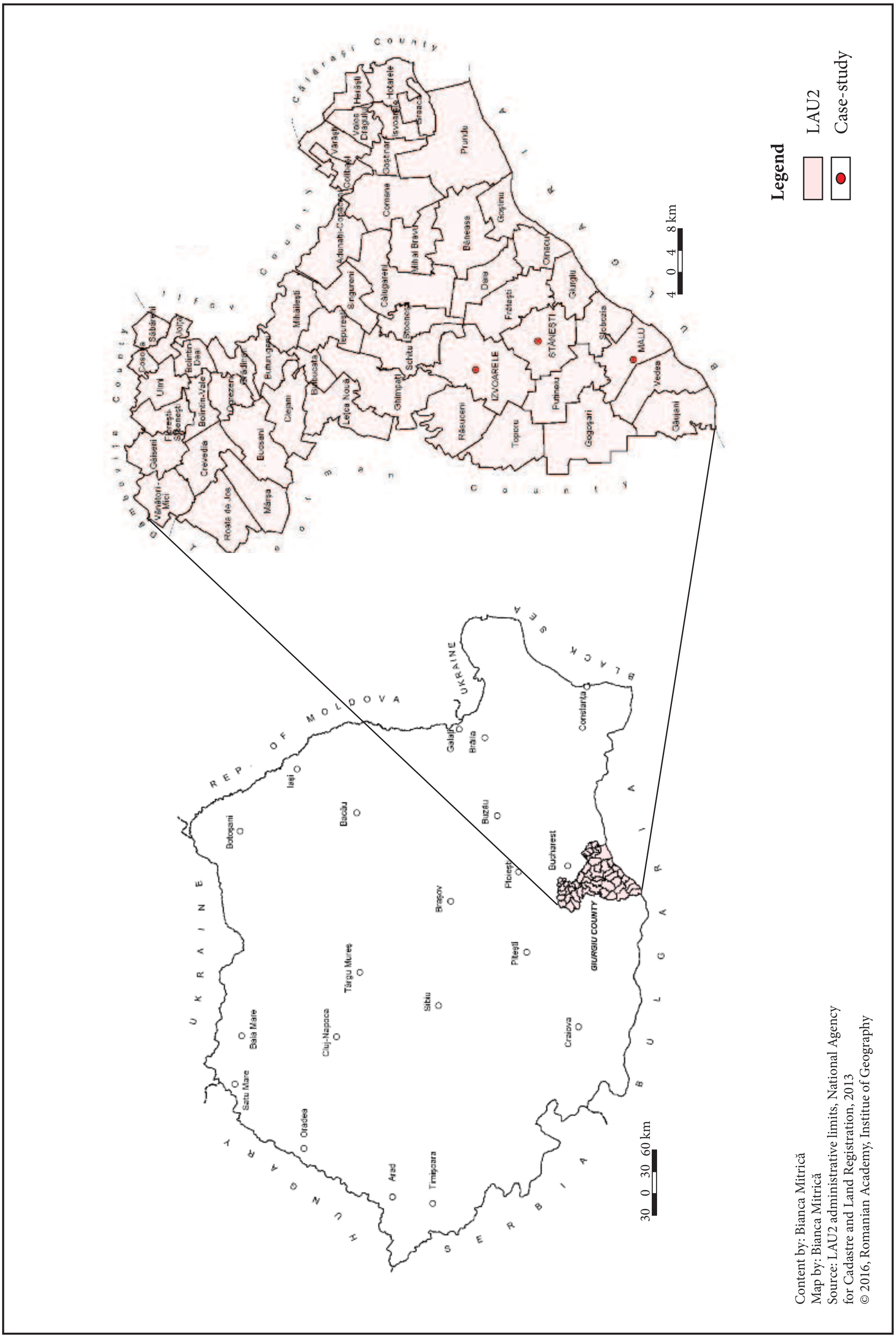
The issue of territorial impact of photovoltaic parks implanted in Romanian rural areas represents subject of only a few scientific works. Bănică and Istrate (2014) conclude that the jobs are less commun at manufacturing phase of the facilities and more in construction, operating and maintenance phases. Mocanu et al. (2015) hilight loss of farmland as a negative effects of solar park setting up in rural space in terms of land use changes. Pavlíček (2012) analysed markets of some European contries and concluded that the Romanian slow market development is caused by weak education on the photovoltaic technology and by slow bureaucracy in the subsidies system from the EU.

Given this picture, this study concentrates on specific research question: Do photovoltaic parks setting up contribute to the socio-economic development in certain Romanian rural areas? This study attempts to enlarge the current body of literature by analysing at micro-scale the socio-economic impacts of photovoltaic parks setting up, specifically in three rural local administrative units (LAU2): Izvoarele, Malu and Stănești (Giurgiu County). In order to estimate such impacts in Romanian rural space, four types of socio-economic impacts were considered: the rural economic profile before and after the implantation of photovoltaic parks, land-use and land-cover changes, the effects of investments in the photovoltaic industry on the local budget, the real new job opportunities.

1.1 Study area

Giurgiu County is located in the Romanian Plain, also known as the Lower Danube Plain (Bălteanu et al. 2006) (Figure 1).

Figure 1: Geographical setting of the study area in Romania. ➤ p. 40


Legend
LAU2
Case-study
GIURGIU COUNTY
Bucharest
REP. OF MOLDOVA
UKRAINE
HUNGARY
SERBIA
BULGARIA
BLACK SEA
30 0 30 60 km
4 0 4 8 km
IZVOARELE
STĂNEȘTI
MALU
Content by: Bianca Mitrică
Map by: Bianca Mitrică
Source: LAU2 administrative limits, National Agency for Cadastre and Land Registration, 2013
© 2016, Romanian Academy, Institue of Geography

The Giurgiu County includes 3 towns: Giurgiu City (county-seat, an urban pole with regional development potential), Bolintin Vale and Mihăileşti, two urban poles with local influence (Giurgiu County Council 2014). Within the Giurgiu County administrative bonds one finds 51 rural LAU2 with 167 villages (Giurgiu County Statistics Office 2012) with low and very low socio-economic development levels (Mocanu et al. 2015). Over the past decade (2002–2012) the county's population fell by 16,437 inhabitants (–6%) because of high population ageing, the ageing process increasing the economic dependency rate and inactivity rate values (Kerbler 2015). Iordan (1973; 1998), Gherasim (2003), Ianoş (1999), Săgeată (2004) and Ianoş et al. (2012) show that, in terms of administrative characteristics, the case-studies reported herein are rural areas, although functionally they are located in the peri-urban area of Giurgiu Municipality, inside the Bucharest Metropolitan Area. In turn, this territory is characterised by the alternating countryside with a new emerging urban landscape founded in the former villages surrounding Bucharest City (Mihai, Nistor and Simion 2015).

2 Key driving factors

Key driving factors of the photovoltaic energy industry in Romania and in Giurgiu County are:

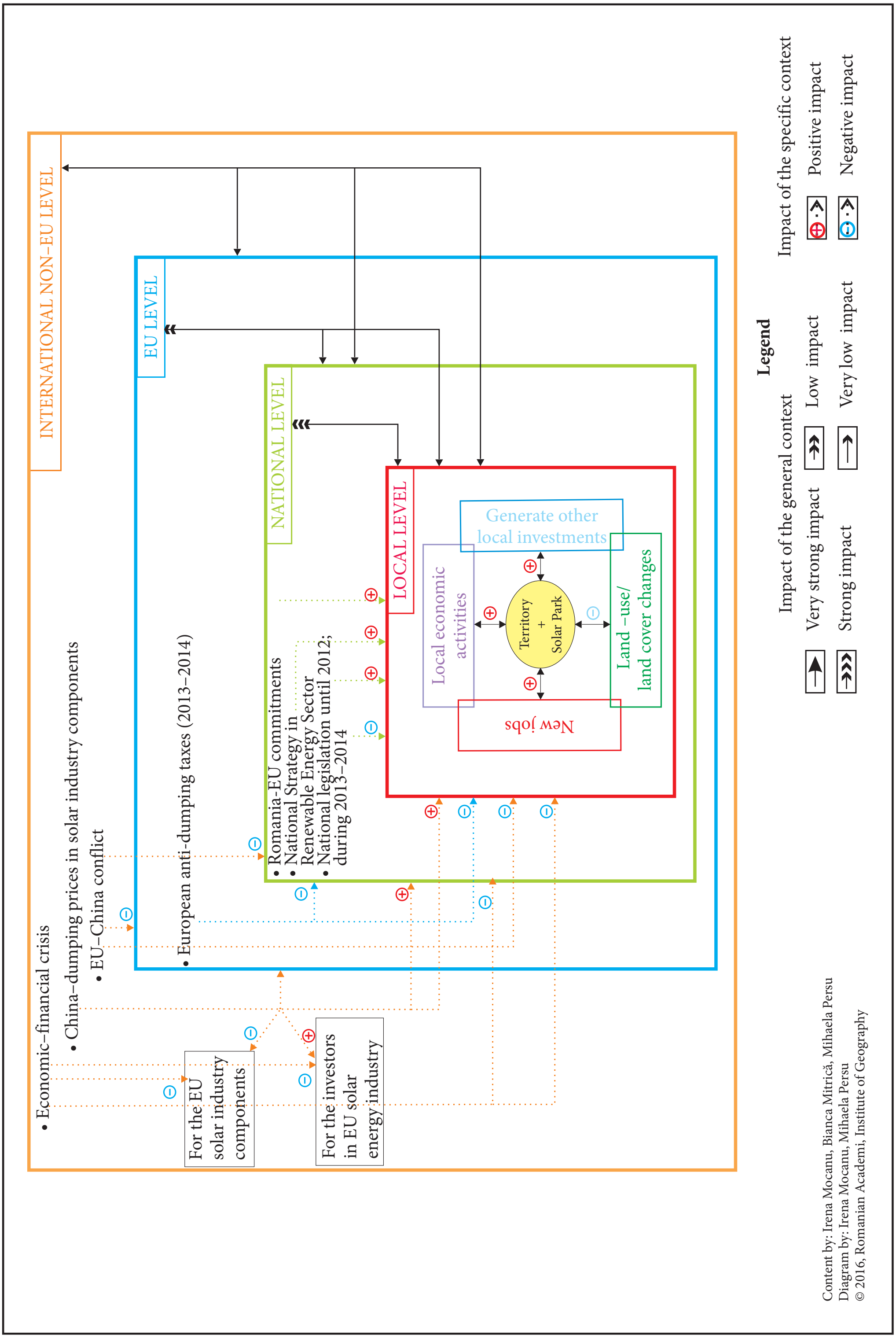
- *High annual average sunshine duration* – the Giurgiu County receives over 2,100–2,200 hours of annual average sunshine duration (Oprea 2008). The most important solar regions in Romania are the Black Sea Coast, Dobrogea and the South of the Romanian Plain, with global horizontal irradiation of 1,400 kWh/m^2 (Paulescu et al. 2013).
- *The EU commitments* represent the main background for the photovoltaic energy industry to develop in Romania. In this respect the Giurgiu County Council elaborated two important strategic documents: The 2008–2013 Sustainable Development Strategy and The 2010–2020 Action Plan for Sustainable Energy (Giurgiu County Council 2014).
- *The national legislation* on renewable energy production (Legea … 2008) establishing the system that promotes energy from renewable sources, was modified many times. Despite continuous legislative changes, the Romanian renewable energy sector had attracted investments of 3 billion Euro until 2013 (Câmpeanu and Pencea 2014). Beginning with 2014, the legislation intended to reduce the number of green certificates accredited to photovoltaic energy producers, the investors not being eligible to the support scheme if the photovoltaic park is located on cultivable agricultural land (Emergency Government Ordinance 2013). In Giurgiu County (Băneasa municipality), this legal provision was one of the main reasons for the first case of insolvency of photovoltaic industry producers.
- *The economic-financial crisis* made it difficult for the renewable energy industry to implement the EU provisions, because the generous subsidiaries earmarked to the photovoltaic industry were reduced, as a more stringent budgetary discipline was being imposed (Ghani-Eneland and Chawla 2009). The trade conflicts between China and the EU multiplied the negative impact of the financial-economic crisis and the photovoltaic projects became unprofitable (Zhao et al. 2011; Berger et al. 2012).

These driving forces act in a very complex way, distinctively different at local, national, EU and non-EU levels (Figure 2).

3 Methods

To achieve the aims of this study both qualitative and quantitative methods were used (e.g. field investigation, official public statistical documents analysis and interviews (Chelcea 2006; Şandor 2011). The multi-functionality of economy, the issues related to land use and land cover changes and the effects of initial investment in photovoltaic parks on the local budgets were accomplished by using the following indicators: number of photovoltaic energy producers, percentage of farmland covered with photovoltaic parks per total agricultural surface, obtained by an unobtrusive research method, studying official public documents and statistical documents (Babbie 1998; Marshall and Gretchen 2016). The sources of these

Figure 2: The economic, financial and legislative background of the solar energy industry and the socio-economic changes at local territorial level in Romania. ➤ p. 42


INTERNATIONAL NON–EU LEVEL
EU LEVEL
NATIONAL LEVEL
LOCAL LEVEL
• Economic–financial crisis
• China–dumping prices in solar industry components
• EU–China conflict
• European anti-dumping taxes (2013–2014)
• Romania-EU commitments
• National Strategy in Renewable Energy Sector
• National legislation until 2012; during 2013–2014
For the EU solar industry components
For the investors in EU solar energy industry
Territory + Solar Park
Generate other local investments
Local economic activities
Land –use/ land cover changes
New jobs
Legend
Impact of the general context
Very strong impact
Strong impact
Low impact
Very low impact
Impact of the specific context
Positive impact
Negative impact
Content by: Irena Mocanu, Bianca Mitrică, Mihaela Persu
Diagram by: Irena Mocanu, Mihaela Persu
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official documents were county and local institutions (Giurgiu County Statistics Office, Giurgiu County Environment Protection Agency, and mayoralties) and national institutions, such as National Institute of Statistics and the National Regulatory Authority for Energy. Also, it was used the *Intelligent decision support system for the low voltage grid with distributed power generation from renewable energy resources – InDeSen Project* database (Intelligent decision … 2012).

The official and statistical data were completed with the results of field investigation in the rural settlements of Stăneşti, Malu and Izvoarele. The interviews were conducted with a total of 30 persons from the three mayoralties during summer 2014. The interviews focused on four issues: land-use and land-cover changes, new jobs, consequences for the local budget (types of taxes) and the community's perception.

4 Results

Field investigation has shown the main socio-economic effects of photovoltaic park implantation in a rural area, namely:
- new investments in local economy;
- loss of farmland;
- growth of local budgets;
- new job opportunities.

4.1 New investments in local economy

In Giurgiu County, since 2012 new investments in the photovoltaic energy industry have diversified the county's economic profile and have increased the number of companies involved in this field (National Regulatory … 2014). According to the data provided by National Regulatory Authority for Energy (National Regulatory … 2014) and the *InDeSen Project* database (Intelligent decision … 2012), there are 25 photovoltaic energy producers in Giurgiu County which are operating in 19 rural LAU2 and in Giurgiu Municipality.

The largest photovoltaic parks were setting up in Bucşani, Colibaşi, Izvoarele and Bulbucata rural LAU2. In 2012, the Altius Photovoltaic Company (Bomax Group) began producing photovoltaic panels in Giurgiu Free Zone area, following an investment of 8 million Euros. It is the only manufacturer of photovoltaic panels in Romania. The Company doubled its production capacity to 220,000–230,000 panels/year in 2014 (Altius … 2016) (Figure 3).

Table 1: The main characteristics of the six photovoltaic parks at Izvoarele, Malu and Stăneşti (Giurgiu County Agency . . . 2014).

Investor	Location	Station of connection	Installed power (MW)	Distribution company	Surface (ha)
S.C. BORRA ENERGY PLANT SRL	Izvoarele	Ghizdaru 110/20 kV	30	Enel Distributie Muntenia	72
S.C. LJG GREEN SOURCE ENERGY BETE SRL	Izvoarele	Ghizdaru-Videle 110kV	20	Enel Distributie Muntenia	48
S.C. LJG GREEN SOURCE ENERGY GAMMA SRL	Izvoarele	Ghizdaru-Videle 110 kV	50	Enel Distributie Muntenia	120
S.C. ECO TRADING ENERGY SRL	Malu	Pietrişu 110/20 kV	4	Enel Distributie Muntenia	9.6
S.C. LONG BRIDGE MILENIUM SRL	Stăneşti	Ghizdaru 110/20 kV	7.5	Transelectrica	18
S.C. MONTANA ENERGY ROM SRL	Stăneşti	Ghizdaru 110/20 kV	5.5	Enel Distributie Muntenia	13.2

4.2 Loss of farmland

In the Giurgiu County, agricultural land is the main land-use category (75–90% of total land fund).

In terms of land use and land cover, the photovoltaic parks studied lay on very valuable arable land (Bălteanu et al. 2006), the three photovoltaic parks at Izvoarele occupy 240 ha of farmland with almost 470,000 solar panels. Compared with these large photovoltaic parks, the two parks at Stănești cover with photovoltaic

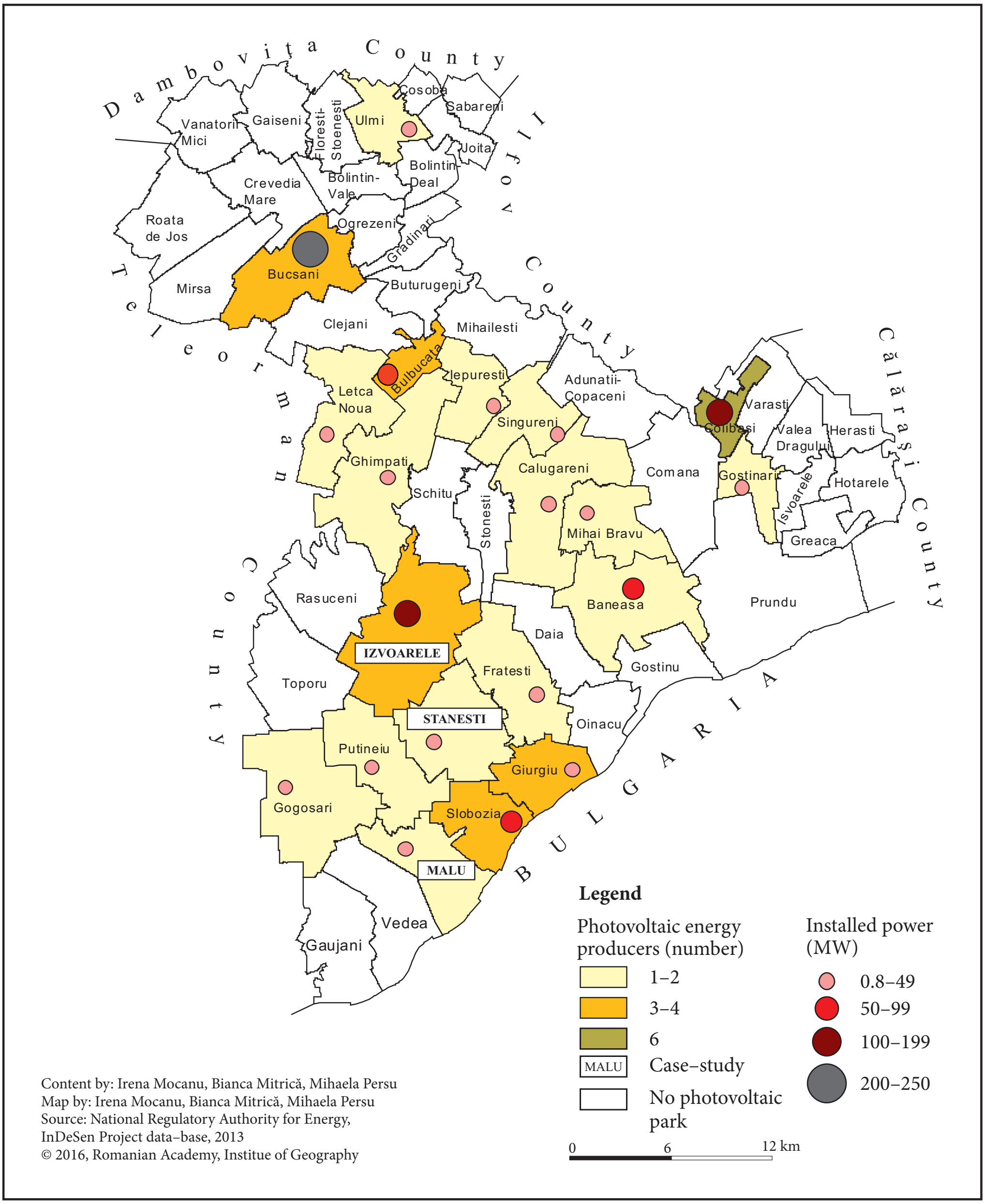

Figure 3: Photovoltaic energy producers in Giurgiu County.

panels only 30 ha farmland; the photovoltaic park at Malu is built on 9.6 ha of non-agricultural land (19,000 solar panels) (Mocanu, Mitrică and Persu 2015). Our field investigation revealed that farmland areas used for the construction of photovoltaic parks were bought from local farmers (Izvoarele) at prices of 2,000 €/ha, and 1,300 €/ha (Stăneşti), or conceded for 500 €/ha/year (Izvoarele).

Loss of farmland can be described by the percentage of farmland covered with photovoltaic parks per total agricultural surface, the highest losses being registered at Colibaşi (13.08%). In our case-study, photovoltaic parks occupy small farmland at Stăneşti (0.47%) and Izvoarele (2.16%), while the photovoltaic park at Malu extends on non-farming land. As revealed by the field investigation, in Izvoarele and Stăneşti, the main land cover category changed by the construction of photovoltaic parks is represented by cultivated areas regularly ploughed and generally under a rotation system (Mocanu, Mitrică and Persu 2015).

4.3 Growth of local budgets

Field investigations have shown positive impact of initial photovoltaic parks investments on the local budgets. Interviewing the local authorities from Izvoarele, Stăneşti and Malu we found that the taxes perceived by the mayoralties target the land concession for the setting up of photovoltaic parks, the land sale to investors for setting up solar projects, the building licenses, tax on land, tax on special buildings and a special tax on the installed operation power of each solar project (Figure 4). This type of revenue had a positive impact only if consistently paid annually during the lifetime of a photovoltaic park.

4.4 New job opportunities – a disputable socio-economic impact

Investment in a photovoltaic project stimulates new temporary and permanent jobs, directly connected with the building and operation of a solar park and indirectly with other economic activities produced by the initial investment (Figure 5).

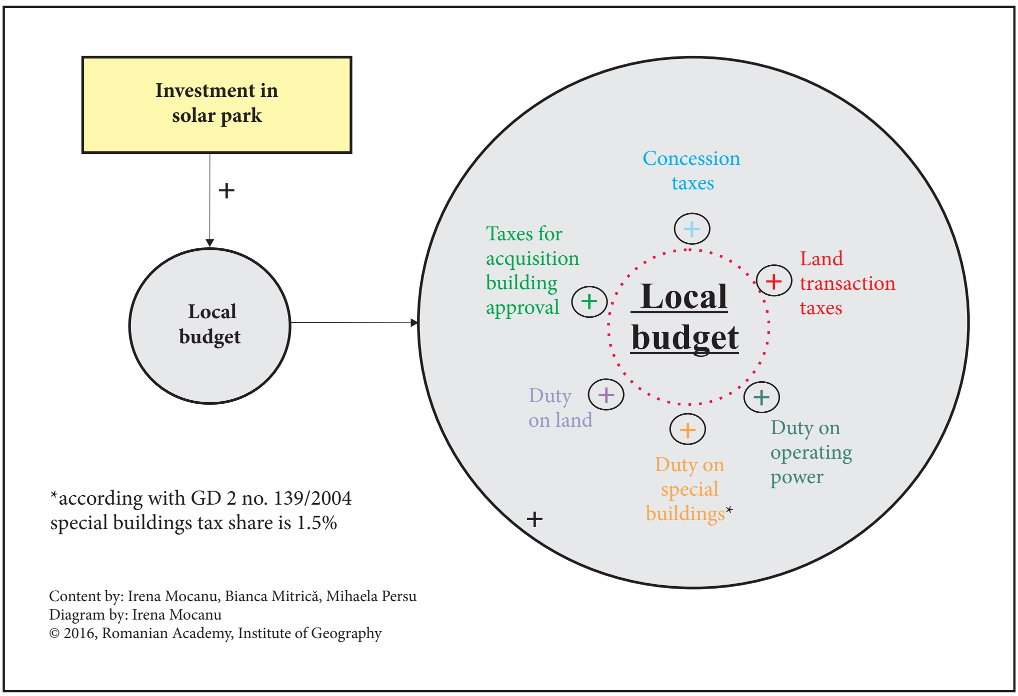

Figure 4: Local investments in solar/photovoltaic parks and the surplus to local budgets.

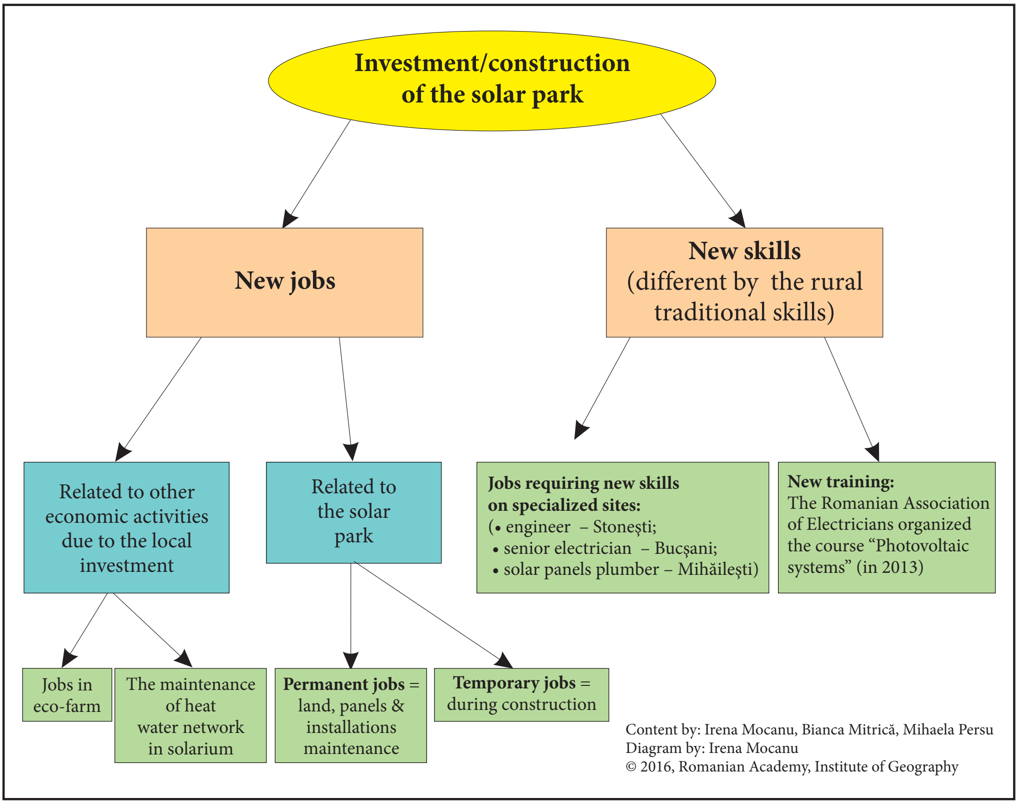

Figure 5: Local investments in photovoltaic parks and new job opportunities.

Field investigations revealed that most new jobs had only a temporary character (during the construction of solar parks), most lower- and medium-skill jobs being occupied by local community members. Thus, for the construction of photovoltaic parks at Izvoarele they employed 50 workers for a period of 12–18 months (depending on the spatial expansion of the park), the building of the Malu photovoltaic park provided jobs for 20 workers over an eight-month interval.

Permanent jobs are scheduled for the maintenance of park grounds (mowing the lawn and up-keeping the road), of photovoltaic panels and the entire specific infrastructure, as well as guards for park protection. At local level, the impact on labour employment is insignificant (2.6% workers employed for the construction of photovoltaic parks out a total of 1,903 employed in Izvoarele), more people getting jobs (usually unskilled labour) when the site is arranged for mounting the photovoltaic panels and the infrastructure is developed. Only a few guards are employed when the photovoltaic park is operating. The firms entrusted the administration of photovoltaic parks at Izvoarele and Malu are the clients of the *Renovatio Assest Management* firm in Bucharest, therefore the impact on local employment is nil.

5 Disscussion

Both, the authorities and the population were content with the construction of the photovoltaic parks which brought benefits to the local budget and provided jobs for the locals.

The big photovoltaic projects in Giurgiu County had disputable positive impact on rural development. A short-time positive impact is visible only in the case of low- and medium-skilled workers, and also a positive effect is marked only when, and if, taxes and duties are collected.

At the local level, positive impact on the economy of photovoltaic park implantation is strongly underlined by the local authorities, and the locals' general opinion on solar park is a very good one. Local economy has a multi-functional character only from two viewpoints: firstly, photovoltaic energy actors have joined the economic agents in agriculture and secondly, some farmland has been given other uses, than agricultural. This last aspect of multi-functionality is not necessarily a positive one.

The surplus to local budgets is used to finance several investment projects, e.g. updating some communal roads, equipping and modernising the school and finalising the network of water supply to the households of Radu Vodă Village (Izvoarele). According to Malu Mayoralty, the photovoltaic park provides for the energy consumption of the school, the House of Culture and for public lighting.

Among negative effects of solar project setting up in the rural area (of which are mentioned by Cameron et al. 2012 the temperature and rainfall distribution changes and the damage of biodiversity and soil), we would recall the loss of farmland. This issue was mentioned as a negative effect of solar parks setting up by Hernandez, Ho and Field (2014) and Hernandez et al. (2015). The photovoltaic parks in Izvoarele and Stănești cover almost 271 ha farmland, but this negative effect was not mentioned by the local authorities simply because this impact was not being perceived.

According to the officials of the National Regulatory Authority for Energy, the lack of co-ordination between renewable energy deployment and the national grid (due to oversized photovoltaic projects) is quite a problem. However, the local authorities interviewed by us did not mention the surplus of renewable energy resources registered by the rural areas in which solar parks are places.

The photovoltaic parks studied are not functionally integrated into the local communities (according to OECD 2012), because their scale did not reflect local opportunities and the parks are not conceived to serve local demand; moreover do not reflect the local socio-economic and are not managed by the local networks either.

Field investigations revealed that the local communities are not aware of the negative implications of photovoltaic parks for the environment and their unintended climatic consequences, so that the fastgoing development of photovoltaic projects takes advantage of people's ignorance, the of investors's short-term goal being to profit from the legal facilities provided by an investment in the renewable energy industry.

6 Conclusion

Despite the dynamics of renewable industry and technology, we noticed that building a photovoltaic park has both negative and positive effects in a rural area, being influenced (even conditioned) by the local context. Field investigations have shown that taxes have a positive impact on the local budgets provided they are paid annually during the lifetime of a photovoltaic park. Regarding the new job opportunities, the positive impact is disputable because most new jobs are temporary and only lower-and-medium skill jobs are occupied by local community members. In terms of land use and land cover, the photovoltaic parks studied are located on very valuable arable land. Loss of farm-land is very much present in the three case-studies discussed in this paper, obviously a negative effect of solar project implantations in the rural area.

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THE SIZE OF THE AREA AFFECTED BY EARTHQUAKE INDUCED ROCKFALLS: COMPARISON OF THE 1998 KRN MOUNTAINS (NW SLOVENIA) EARTHQUAKE (M_W 5.6) WITH WORLDWIDE DATA

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Very large rockfall on Osojnica Mountain in the Tolminka valley induced by the 1998 earthquake.

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The size of the area affected by earthquake induced rockfalls: Comparison of the 1998 Krn Mountains (NW Slovenia) earthquake (M_w 5.6) with worldwide data

ABSTRACT: The 1998 Krn Mountains M_w 5.6 earthquake had widespread effects on the natural environment, among which rockfalls prevail. All rockfalls were evaluated to estimate the total affected area. The 180 km^2 area (r = 7.6 km) was established and compared with two worldwide datasets. The affected area is considerably below the upper bound limit established from both datasets. The same is valid for the nearby 1976 Friuli M_w 6.4 earthquake with a 2050 km^2 affected area. However, comparison with the ESI 2007 scale definitions has shown that the area affected by the 1998 I_{max} VII–VIII event is significantly larger than the one proposed by this scale, but smaller for the 1976 I_{max} X event. This could not be explained by differences in hypocentral depth or focal mechanisms of both events. The results of the study have implications for seismic hazard assessment and for understanding environmental effects caused by moderate earthquakes in mountain regions.

KEY WORDS: earthquake effects, intensity, rockfall, macroseismic investigations, Environmental Seismic Intensity scale, Krn Mountains, Slovenia

Velikost območja pojavljanja skalnih podorov zaradi potresa: primerjava potresa M_w 5,6 leta 1998 v Krnskem pogorju (SZ Slovenija) s svetovnimi podatki

POVZETEK: Potres leta 1998 v Krnskem pogorju z M_w 5,6 je imel obsežne učinke v naravnem okolju, med katerimi so prevladovali skalni podori. Vse podore smo raziskali z namenom ocene velikosti celotnega območja pojavljanja. Ugotovili smo 80 km^2 veliko območje (r = 7.6 km) in ga primerjali z dvema svetovnima zbirkama podatkov. Celotno prizadeto območje ob Krnskem potresu je znatno manjše od zgornje meje pojavljanja ugotovljene za obe zbirki. Enako velja za bližnji potres leta 1976 v Furlaniji z M_w 6,4, pri katerem je bila velikost prizadetega območja 2050 km^2. Po drugi strani pa je primerjava z ESI 2007 pokazala, da je celotno prizadeto območje ob potresu leta 1998 z I_{max} VII–VIII izrazito večje od opredelitve v tej letvici in manjše za potres leta 1976 z I_{max} X. Te razlike ni mogoče pojasniti z razliko v globini žarišča ali razliko v žariščnem mehanizmu obeh potresov. Rezultati te študije so pomembni za ocenjevanje potresne nevarnosti in za razumevanje učinkov na okolje pri srednje močnih potresih v goratih območjih.

KLJUČNE BESEDE: učinki potresa, intenziteta, skalni podor, makroseizmične raziskave, lestvica Environmental Seismic Intensity, Krnsko pogorje, Slovenija

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1 Introduction

Earthquakes have long been recognized as an important trigger of slope movements in areas with pronounced topography. For some earthquakes, especially in Asia and Latin America, they have more dramatic consequences than ground shaking itself, through damming narrow valleys (e.g. Komac and Zorn 2016) or burying complete settlements (Guerrieri and Vittori 2007). In areas with unfavourable geomorphic and geologic settings landslides or rockfalls can become a primary source of damage and death toll. For example, in the Peruvian earthquake in 1970, almost half of the 54,000 fatalities were due to an immense landslide that descended from Nevado Huascaran, burying two villages (Reiter 1990).

In spite of their geomorphic and economic significance, earthquake-induced slope movements are still poorly understood, especially how do the number, size and distribution of landslides or rockfalls depend on the magnitude and intensity. For hazard assessment, it is necessary to establish correlations between seismic ground shaking and landslides or rockfalls in different geological, topographical, and climatic conditions. One of the first systematic studies was done by Keefer (1984) who analysed 40 strong historical earthquakes distributed worldwide in the period 1811–1980 with the magnitude range of 5.2–9.5 in order to determine the characteristics, geological environments, and hazards of slope movements. He identified 14 types of slope movements and found out that rockfalls, disrupted soil slides, and rock slides were the most common. Correlations between earthquake magnitude and slope movements distribution show that the maximum affected area increases from approximately 0 km^2 at M = 4.0 to 500.000 km^2 at M = 9.2. Keefer also discovered that each type of earthquake-induced slope movement occurs in a particular geological environment. The work of Keefer (1984) was extended by Rodriguez, Boomer, and Chandler (1999) who studied additional 36 earthquakes in the magnitude range of 5.4–7.8 which occurred between 1980 and 1997 and compared the results of both studies. Their correlation between earthquake magnitude and the total area affected by slope movements differs somewhat from Keefer's. For the intermediate magnitude range of 5.4–7.0, a modified relation was suggested. However, the scatter of data from which the correlation was derived was greater than that found by Keefer.

Both studies analysed the world's largest earthquakes with relatively few examples of weaker events in the magnitude range of 5.2–6.0 or intensities smaller than VII. However, recent studies in Spain have shown that landslides also resulted from lower magnitude (M_w<5.0) earthquakes (Delgado et al. 2011). They were observed at greater distances (> 10 km) in comparison to previous studies. Another study of a M_w 4.7 earthquake with the I_{max} V EMS-98 in central Spain (Delgado et al. 2015) has shown that this event triggered many small rockfalls at distances of 20–30 km from the epicentre. Weak ground-motion attenuation was identified as the most probable reason for occurrence of slope instability at large distances. Maximum epicentral distance of landslide occurrence and the total affected area were both far above the upper bound curves derived by Keefer (1984) or Rodriguez, Boomer, and Chandler (1999). Identification of variations in ground-motion attenuation or areas which are especially prone to slope movements due to geological setting is important for realistic seismic hazard assessment in problematic areas (Papanikolaou 2011).

Various macroseismic scales developed during the 20th century (MCS, MSK, MM, EMS-98) only partly included the effects of earthquakes on the natural environment. But recent studies offered new evidence that coseismic environmental effects (e.g. Komac 2015) provide precious information on the earthquake intensity field, complementing the damage-based macroseismic scales. Therefore, the definition of the higher intensity degrees can effectively take advantage of the diagnostic characteristics of the environmental effects (Guerrieri and Vittori 2007).

The EMS-98 scale, which is predominantly used in Europe, considers four categories (Grünthal 1998): the effect on humans and objects, as well as the damage to buildings and the natural environment. However, environmental effects are only briefly described. The main problem is that the same phenomenon is attributed to a very wide range of intensity degrees, which prevents its practical application.

In 2007, the ESI 2007 was introduced as a scale based only on the effects on the natural environment (Guerrieri and Vittori 2007). According to this scale, secondary effects induced by the ground shaking include ground cracks, slope movements, liquefaction, anomalous waves, and hydrogeological anomalies. The ESI 2007 describes each type's characteristics and size (volume) as a diagnostic feature in a range of intensity degrees. One of the diagnostic characteristics for intensities higher than VI is also the total affected area (Table 1).

Table 1: Extraction from the ESI 2007 scale with a description of slope movements characteristic for each intensity degree (after Guerrieri and Vittori 2007).

Intensity		Slope movements	Total affected area
IV	Largely observed	Exceptionally, rocks may fall and small landslide may be (re)activated, along slopes where the equilibrium is already near the limit state, e.g. steep slopes and cuts, with loose and generally saturated soil.	–
V	Strong	Rare small rockfalls, rotational landslides and slump earth flows may take place, along often but not necessarily steep slopes where equilibrium is near the limit state, mainly loose deposits and saturated soil.	–
VI	Slightly damaging	Rockfalls and landslides with volume reaching ca. 10^3 m^3 can take place, especially where equilibrium is near the limit state, e.g. steep slopes and cuts, with loose saturated soil, or highly weathered/ fractured rocks.	–
VII	Damaging	Scattered landslides occur in prone areas, where equilibrium is unstable (steep slopes of loose/saturated soils), while modest rockfalls are common on steep gorges, cliffs). Their size is sometimes significant (10^3–10^5 m^3); in dry sand, sand-clay, and clay soil, the volumes are usually up to 100 m^3.	10 km^2
VIII	Heavily damaging	Small to moderate (10^3–10^5 m^3) landslides are widespread in prone areas; rarely they can occur also on gentle slopes; where equilibrium is unstable (steep slopes of loose/saturated soils; rockfalls on steep gorges, coastal cliffs) their size is sometimes large (10^5–10^6 m^3).	100 km^2
IX	Destructive	Landsliding is widespread in prone areas, also on gentle slopes; where equilibrium is unstable (steep slopes of loose/saturated soils; rockfalls on steep gorges, coastal cliffs) their size is frequently large (10^5 m^3), sometimes very large (10^6 m^3).	1,000 km^2
X	Very destructive	Large landslides and rockfalls (>10^5–10^6 m^3) are frequent, practically regardless of equilibrium state of slopes, causing temporary or permanent barrier lakes. River banks, artificial embankments, and sides of excavations typically collapse.	5,000 km^2
XI	Devastating	Large landslides and rockfalls (>10^5–10^6 m^3) are frequent, practically regardless of equilibrium state of slopes, causing many temporary or permanent barrier lakes. River banks, artificial embankments, and sides of excavations typically collapse. Significant landslides can occur even at 200–300 km distance from the epicenter.	10,000 km^2
XII	Completely devastating	Large landslides and rockfalls (>10^5–10^6 m^3) are frequent, practically regardless to equilibrium state of the slopes, causing many temporary or permanent barrier lakes. River banks, artificial embankments, and sides of excavations typically collapse. Significant landslides can occur at more than 200–300 km distance from the epicenter.	50,000 km^2

The 12 April 1998 earthquake in Krn Mountains (Figures 1 and 2) had prominent effects on the natural environment, mainly expressed as massive rockfalls. The earthquake magnitude (M_w) was 5.6 and its I_{max} was VII–VIII EMS-98 (Zupančič et al. 2001). It caused severe damage to buildings in the Upper Soča valley but no casualties. Some of its effects have already been discussed in this journal (e.g. Zorn 2002). The affected area is predominantly a sparsely inhabited mountainous environment. The application of the EMS-98 scale for intensity assessment was therefore limited to only a few settlements in the epicentral area. There was an early attempt to also use environmental effects to assess the intensities using the EMS-98 scale (Vidrih, Ribičič, and Suhadolc 2001), but it was determined that this scale is not sufficiently detailed in descriptions of effects characteristic for particular intensity degrees. After the ESI 2007 was presented, Gosar (2012) performed a study aimed to evaluate its applicability to this event. It was proved that the ESI 2007 can be successfully applied in the epicentral area to supplement the EMS-98 scale for intensity assessment, although the ESI 2007 is mainly aimed to evaluate much stronger earthquakes.

The 1998 earthquake, an event with a relatively moderate magnitude, was not expected to cause such a large number of rockfalls, including some large and very large ones. Since the damage was concentrated mainly to buildings with poor seismic design (Komac, Zorn, and Kušar 2012) or to areas with pronounced site effects (Gosar 2007), rockfalls were the most prominent characteristic of this event (Vidrih and Ribičič 1998). It is therefore a challenge to compare the extent of environmental effects with other earthquakes worldwide and especially with the nearby 1976 Friuli Mw 6.4 earthquake. The latter occurred 35 km to the West in NE Italy (Aoudia et al. 2000; Carulli and Slejko 2005) in mountains with a similar geological setting (Govi and Sorzana 1977). Since the type of environmental effects depends largely on the geological setting (for

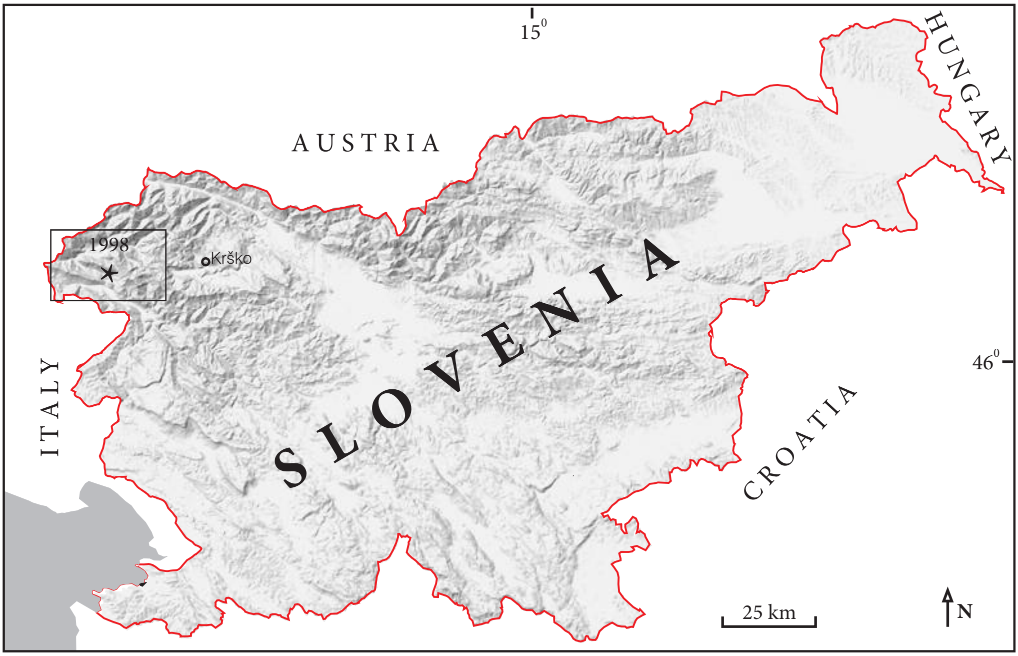

Figure 1: Location map of the study area with the epicentre of the 12th April 1998 earthquake in Krn Mountains.

example landslides prevail in looser rocks and rockfalls in harder rocks), one of the possibilities for comparison included in the ESI 2007 scale is the size of the total affected area. The aim of this study was therefore to compare the total affected area of the 1998 earthquake with available data from worldwide studies to see if this earthquake deviates from established relationships between the magnitude or maximum intensity of the event and the total area affected by slope movements.

2 Methods

The extensive effects of the 1998 earthquake on the natural environment were spread over a large area and therefore required a systematic approach in data collection and analysis. Soon after the earthquake occurred it became apparent that rockfalls were the most frequent phenomenon and the only one spread over the total affected area (Vidrih and Ribičič 1998). A systematic approach was particularly important because the wider epicentral area is situated in high mountains, where access roads are only available in certain valleys. Data collection and analysis were therefore based on a combination of field surveys and analyses of aerial photographs.

Rockfalls and landslides were surveyed in the field in the months following the earthquake and a database of rockfalls was prepared. A regular aerial photography survey of the NW part of Slovenia was carried out in July 1998, just three months after the earthquake, which was very useful for this study. Rockfalls were clearly visible on these images because the newly exposed surfaces or rock debris and blocks were still fresh, before lichens and vegetation started to change their surfaces. Stereo pairs of aerial images were analysed using stereo glasses while Digital Ortho Photos were analysed with GIS software.

Quantitative assessment of the rockfall and landslide size (volume) is important for the application of various criteria in the ESI 2007 scale, but not so much for the assessment of the total affected area. For landslides this is normally easier, because it is possible to measure the area and estimate the average thickness of the landslide body. Rockfalls are much more irregular than landslides, which is why estimation of their volume is usually more difficult and requires more experience. Krn Mountains are built of Mesozoic carbonates, predominantly of Upper Triassic limestones and dolomites (Zupančič et al. 2001). The area is cut by several faults which extend mainly in the NW-SE direction. In general the rocks are highly fractured, loose, and prone to slope movements.

3 Rockfalls induced by the 12th April 1998 earthquake

Detailed investigations showed that the earthquake caused at least 78 rockfalls (Figure 2). These were classified into five groups according to their estimated volume (Table 2). The distribution of very small rockfalls, which predominate in number (53), is quite uneven. On the other hand, medium to very large rockfalls are clearly distributed in a zone approximately 5 km wide and 9 km long, which extends in a NW-SE direction, along the seismogenic Ravne fault (Figure 2). The termination of rockfalls occurrence is very sharp to the SE of the epicentre, in the Tolminka valley, but more gradual to the NW, W, and N. The strong motion data inversion revealed that the Ravne fault ruptured in a length of 12 km between the Bovec basin and the Tolminka valley (Bajc et al. 2001). The majority of the medium, large, and very large rockfalls occurred along the same segment.

Table 2: Distribution of rockfalls caused by 12 April 1998 earthquake according to their size.

Size of rockfall	Estimated volume (m^3)	Number
Very small	10^2	53
Small	10^3	13
Medium	10^4	6
Large	10^5	4
Very large	$>10^6$	2

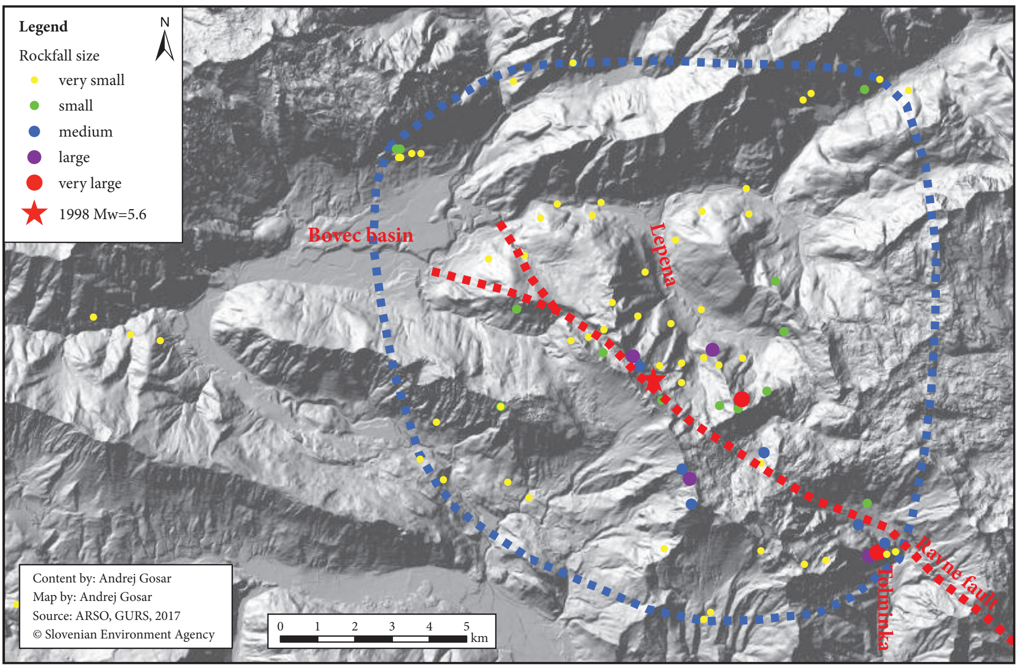

Figure 2: Locations of rockfalls in the Upper Soča valley caused by the 12 April 1998 earthquake with a contour of the total affected area (blue dashed line) and the trace of the seismogenic fault (red dashed line).

Figure 3: Larger rockfalls in Krn Mountains: a) Osojnica in Tolminka valley, b) Krn and Krnčica, c) Veliki Šmohor, d) Škril in Lepena valley. ➤


a)
b)
c)
d)

The largest rockfall occurred on Veliki Lemež in the Lepena valley. Its volume was estimated as 15×10^6 m^3 by comparing two digital elevation models which show the topography of the area before and after the earthquake. The second largest rockfall with the estimated volume of 3×10^6 m^3 occurred on Osojnica Mountain above the Tolminka valley (Figure 3a). Four rockfalls were classified as large. On the slopes of Krn and Krnčica Mountains several massive planar rockslides occurred (Figure 3b), developed along cracks or bedding planes within limestone dipping downslope. The Škril rockfall (Figure 3d) is a typical example of a wedge-shaped rockslide (Vidrih 2008). There were six rockfalls of medium size. An example is the Veliki Šmohor rockfall (Figure 3c), where the top of the mountain collapsed even though the slope is not very steep.

4 Comparison of the total area affected by rockfalls induced by the 1998 earthquake with worldwide data and the ESI 2007 intensity scale

Figure 2 shows the distribution of all 78 rockfalls classified according to their volume. The density of rockfalls over the affected area is quite uneven, depending on the spatial distribution of slope failure prone areas. On average there were three rockfalls per km^2, but the number ranges from one rockfall at larger distances from the epicentre to more than five rockfalls per km^2 in the closest epicentral area. A detailed analysis has

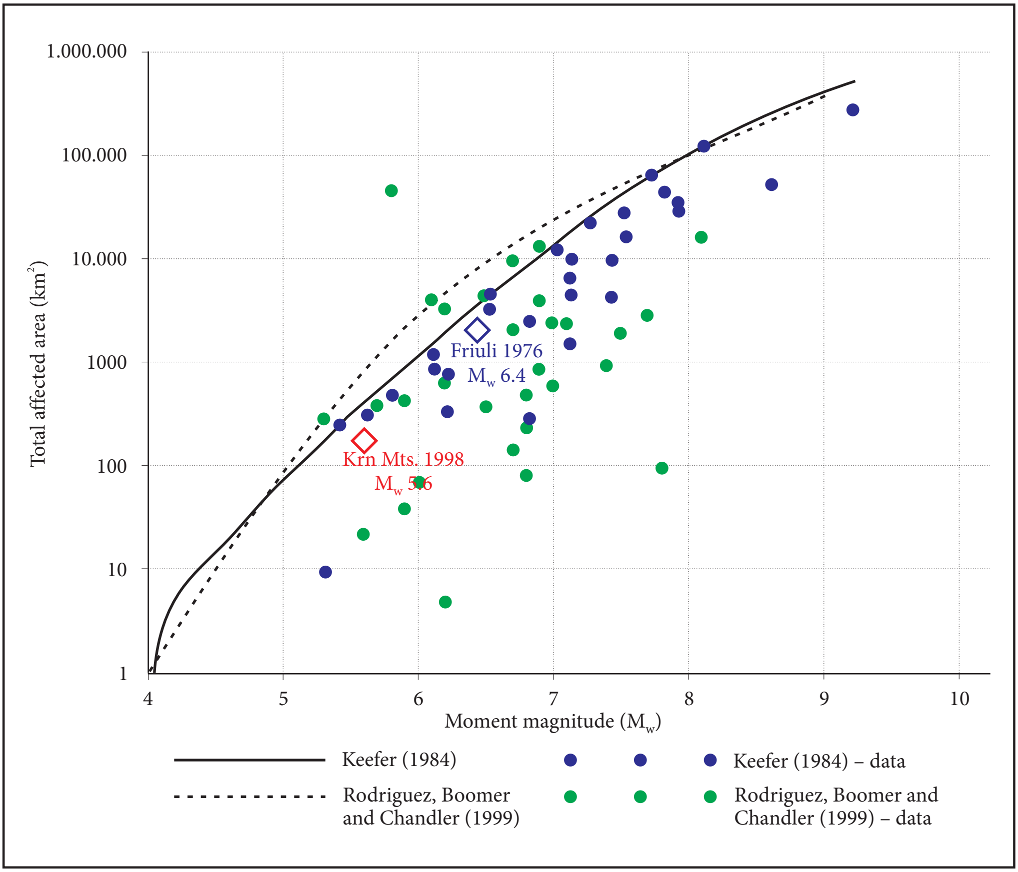

Figure 4: The area affected by rockfalls or landslides as a function of earthquake magnitude for 40 events which occurred worldwide in 1811–1980 (Keefer 1984) and 36 events in 1980–1997 (Rodriguez, Boomer and Chandler 1999), and the data for the 1976 Friuli and 1998 Krn Mountains earthquakes. The solid line is the upper bound determined by Keefer (1984) and the dashed line is the one determined by Rodriguez, Boomer, and Chandler (1999).

shown that all very small rockfalls (10^2 m^3) cannot reliably determine the total affected area because some of them occurred quite far from other observed phenomena. Such examples are the very small rock slides that occurred in the westernmost part of the investigated area (Figure 2). Therefore, we decided to draw a contour which delimits the total affected area as a limit of continuous (nearly spaced) observations of rockfalls which includes all small (10^3 m^3) and large (10^5 m^3) rockfalls (Figure 2), missing only a few very small ones. The area is nearly circular with a radius of approximately 7.6 km and a size of 180 km^2. As already mentioned, the distribution of medium, large, and very large rockfalls clearly shows an elongated shape along the strike of the seismogenic Ravne fault (NW–SE) terminating sharply in the SE. The distribution of small and very small rockfalls is more uniform, with fewer observed occurrences only in the eastern part, characterized by karstified surfaces and less prominent topography and thus less prone to slope failures.

The obtained results were first compared with the 1976 Friuli Mw 6.4 earthquake for which Govi and Sorzana (1977) made a detailed evaluation of slope movements based on aerial photo interpretation and field mapping. They discovered that photo interpretation is a very effective method, that rockfalls occurred mainly in places where they had already occurred in the past, and that the weakening of rocks by tectonic fracturing is an important factor for rockfall distribution. However, this study does not include a map of rockfall distribution. The total affected area was estimated by Keefer (1984), based on studies of Ambraseys (1976) and Govi (1977), to be 2050 km^2 large. This corresponds to a circle with r = 25.5 km. A significantly stronger earthquake in a geologically similar area where Mesozoic carbonates prevail resulted in the considerably larger affected area, as expected (Govi and Sorzana 1977).

The results of the 1998 earthquake were then compared with the results for worldwide datasets, and established relations for the upper bound limit in the relation between the total affected area and earthquake magnitude according to Keefer (1984) and Rodriguez, Boomer, and Chandler (1999). Even though rockfalls were the most prominent and widespread phenomenon of this earthquake, the total affected area (180 km^2) is still much smaller than the established upper bound limits (Figure 4). For the Mw 5.6 earthquake the upper bound limit of the affected area is 430 km^2 according to Keefer (1984) and 880 km^2 according to Rodriguez, Boomer, and Chandler (1999).

Comparison of the relation between the total affected area and the macroseismic intensity using the ESI 2007 scale has shown that the area affected by the 1998 earthquake with I_{max} VII–VIII significantly exceeds the value expected from the ESI 2007 scale (Figure 5). According to the ESI 2007 an area of about 30 km^2 is expected at this intensity, interpolated between 10 km^2 at intensity VII and 100 km^2 at intensity VIII (Table 1, Figure 5). On the other hand, the area of 2050 km^2 affected by the 1976 earthquake with I_{max} X (Giorgetti 1976) is lower than the value expected from the ESI 2007, which assigns a total affected area of 5000 km^2 to intensity X (Table 1, Figure 5).

The affected area depends not only on the magnitude of the earthquake but also on its hypocentral depth. When comparing the 1998 and the 1976 earthquakes, the difference in hypocentral depth is minimal, namely 7.6 km for the former and 6 km for the latter. For the Friuli event the focal depth was first estimated at 25 km (Console 1976) due to the large distance from the epicentre to the nearest seismic station in Trieste. However, the relocation study of Aoudia et al. (2000) estimates it at 6 km. The second parameter which can affect the shape and size of the affected area is the focal mechanism which influences the radiation of seismic energy from the source. It was a reverse one (a W–E trending fault) for the Friuli event (Console 1976) and almost a pure dextral strike-slip (a NW–SE trending fault) for the Krn Mountains event (Zupančič et al. 2001). The elongated shape of the area affected by medium to very large rockfalls in Krn Mountains is related to the direction of the strike-slip fault, but the total affected area seems to be more or less circular (Figure 2).

5 Conclusion

Although the 1998 Krn Mountains earthquake was an event with a relatively moderate magnitude (Mw 5.6), it had prominent and widespread environmental effects expressed mainly as rockfalls of different sizes. Nevertheless, comparison of the total affected area of 180 km^2 with established relations for worldwide datasets of mainly stronger earthquakes has shown that this area is still considerably below the upper bound limit determined by Keefer (1984) and Rodriguez, Boomer, and Chandler (1999). The same is true for the 1976 Friuli Mw 6.4 earthquake which had a total affected area of 2050 km^2. However, comparison with the ESI 2007

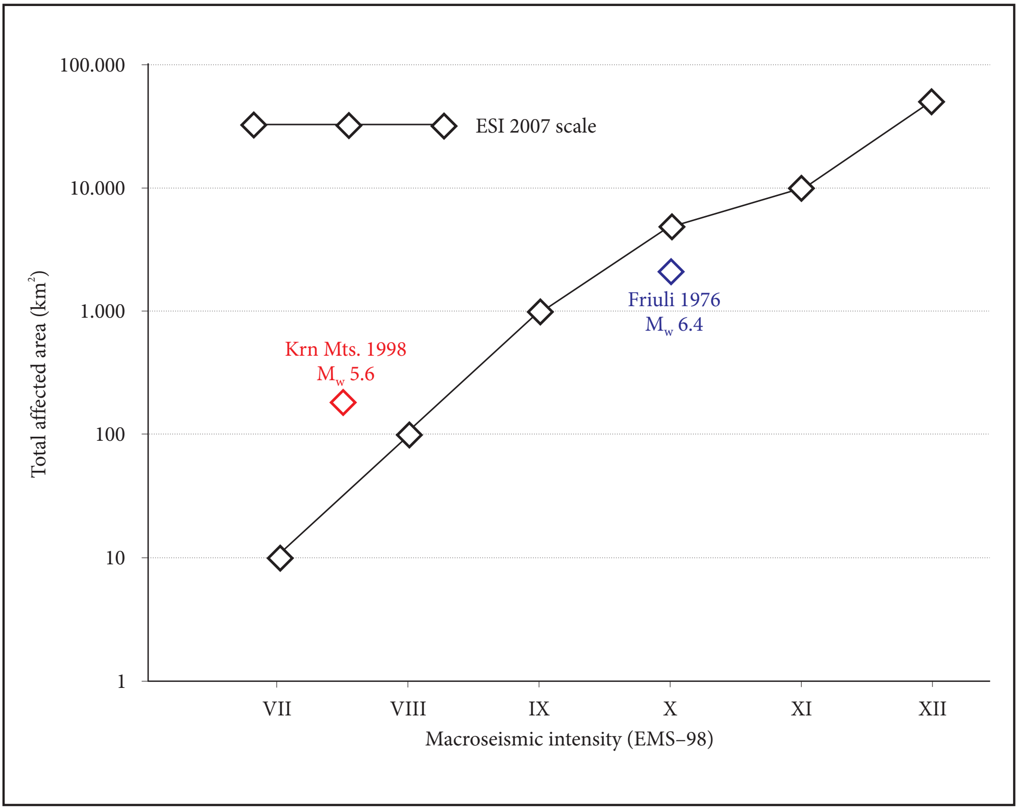

Figure 5: The area affected by earthquake environmental effects as a function of maximum intensity according to the ESI 2007 scale (Guerrieri and Vittori 2007) and the data for the 1976 Friuli and 1998 Krn Mountains earthquakes.

scale has shown that the total affected area in the Krn Mountains earthquake is significantly larger than what this scale proposes for an I_{max} VII–VIII event. For the Friuli I_{max} X earthquake, the affected area is much lower than expected from the ESI 2007 scale. This difference could not be explained by diffeences in hypocentral depth or focal mechanisms of the two earthquakes. The results of this study have implications for realistic seismic hazard assessment – identification of slower ground-motion attenuation or areas prone to slope movements due to geological setting. They also provide insight into environmental seismic effects caused by moderate magnitude earthquakes in mountain regions, built of carbonate rocks prone to slope failures.

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LAND-USE CHANGES IN SLOVENIA FROM THE FRANCISCEAN CADASTER UNTIL TODAY

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Extensification of agriculture and afforestation in Kanomlja Valley in the Alpine region.

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UDC: 911:711.14(497.4)"18/20"
COBISS: 1.01

Land-use changes in Slovenia from the Franciscean Cadaster until today

ABSTRACT: The Franciscean Cadaster from the first half of the nineteenth century is an excellent source for studying land use and its changes. However, to date it has only rarely been used in geographical and historical research at the regional or national level. Setting up a digital database of land use recorded in the Franciscean Cadaster at the level of cadastral municipalities covering all of Slovenia and incorporating it into a geographic information system has provided an opportunity for detailed studies of land-use changes spanning two centuries. This article presents the first analyses of changes in individual land-use types and the typology of changes across two centuries.

KEY WORDS: geography, land-use, land-cover, Stable Cadaster, Central Europe

Spremembe rabe zemljišč v Sloveniji od franciscejskega katastra do danes

POVZETEK: Franciscejski kataster iz prve polovice 19. stoletja je odličen vir za preučevanje rabe zemljišč in njenih sprememb. Kljub temu je bil doslej v geografskih in zgodovinskih znanstvenih razpravah redko uporabljen za raziskave na regionalni ali državni ravni. Z vzpostavitvijo podatkovne baze o rabi zemljišč franciscejskega katastra na ravni katastrskih občin za ozemlje celotne Slovenije v digitalni obliki in njeno vključitvijo v geografski informacijski sistem se odpirajo možnosti poglobljenih študij sprememb rabe zemljišč v časovnem razponu dveh stoletjih. V prispevku so prikazane prve analize sprememb posameznih vrst rabe in tipologija sprememb v obdobju dveh stoletij.

KLJUČNE BESEDE: geografija, raba zemljišč, pokrovnost zemljišč, stabilni kataster, Srednja Evropa

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1 Introduction

A high-quality set of land-use data spanning two centuries is available for the territory of the former Austrian monarchy in central Europe. The Franciscean or Stable cadaster from the first half of the nineteenth century is unique in the world because, in addition to written records, it also includes 1:2,880 cadastral maps showing land use (Bičík et al. 2015). The majority of Slovenian territory was covered in the cadaster as early as in the 1820s, with the exception of Prekmurje, which belonged to the Hungarian part of the monarchy and was included in the cadaster around 1860 (Petek and Urbanc 2004). Land use in the Franciscean Cadaster was elaborately inventoried for the needs of the tax administration (Jeleček 2006). The nineteenth-century cadaster has been used (with certain modifications) until the present regardless of political changes, which makes it possible to compile a high-quality land-use database, incorporate it into a geographic information system, and determine the factors influencing land-use changes (Harvey, Kaim and Gajda 2014).

Land-use changes are influenced by many interdependent factors arising from the relationship between people and their needs on the one hand, and the environment and its characteristics on the other. Changes in this relationship occur in various times and places, depending on how the society is organized and connected with the environment (Briassoulis 2000; Lambin and Geist 2006). In the nineteenth century, differences in the processes related to land-use changes in Austria-Hungary were largely connected with different natural conditions, whereas in the twentieth century they were largely the result of different political systems in the newly established countries. Hence, because of the reliable data available and the differences in the natural and social conditions, this territory is a perfect laboratory for exploring land-use changes.

Even though the Franciscean Cadaster is one of the most important historical sources, until recently it was overlooked in scholarly research; this was especially true of its written part (Drobesch 2013b). The **graphic part** was often used because its large scale (1:2,880) allows detailed analyses of factors influencing local land-use changes. These types of studies conducted in Slovenia, including many bachelor's theses (Gabrovec 1995; Petek and Urbanc 2004; Domijan 2006; Urbanc 2009; Erjavec 2009; Božič 2010; Paušič and Čarni 2012; Prelog 2013; Verderber 2013; Ažman Momirski and Gabrovec 2014; Golob 2014; Šmid Hribar 2016), and in the Czechia (Rašín and Chromý 2010; Bičík, Kupkova and Štych 2012; Štych et al. 2012) facilitated the interpretation of these processes at the national level. Outside central Europe, a larger set of high-quality cadastral maps is available in Sweden, where land-use changes spanning three hundred years were examined in a 6 km^2 study area (Cousins 2001).

The **written part** was first used at the national level by Czech geographers, who created a land-use database covering the period from the mid-nineteenth century to 2010 and used it to study the factors influencing land-use changes (Bičík, Jeleček and Štěpánek 2001; Bičík et al. 2015). In Austria, the Franciscean Cadaster data were used by Krausmann (2001; 2006) in his articles on factors affecting land-use changes, but he only explored them at the national level and partly at the level of municipalities. Historians prepared a comprehensive publication and analysis of the cadaster's material for Austrian Carinthia (Drobesch 2013a; Rumpler 2013) and Bukovina (Rumpler, Scharr and Ungureanu 2015). Petek (2005a, 2005b) used the cadaster's written part in his analyses of land-use changes across the entire Slovenian Alps.

This article presents new methods that can be used to compare land use in Slovenian cadastral municipalities when the Franciscean Cadaster was made and in later periods. In addition, it presents the first results of applying this method. Compared to Gabrovec and Kladnik (1997), this article examines a significantly longer period and uses different techniques in cases where the borders of the cadastral municipalities have changed.

2 Data and methods

2.1 Input data

The written part of the Franciscean Cadaster was the main source for this study and was used to gather data on land use in the first half of the nineteenth century. The study used data collected at the level of cadastral municipalities. The written part of the land cadaster is presented in a table (a land-use statement) for each cadastral municipality separately, featuring the areas of individual land-use types. The spatial measures are provided in *Joch* and *Klafter*, and therefore all of the data were first converted into the metric system. The forms for Carniola, Carinthia, Styria, and part of the Littoral are provided in German and envisage the entry of twenty-nine land-use categories (marked green in Table 1). The surveyors also added new categories to the majority of cadastral municipalities, whereby they struck out the categories that did not appear in a given cadastral municipality and added new ones on the printed form. The most frequent categories added included meadows or pastures with trees or shrubs. The forms used for some cadastral municipalities in the Littoral region were adapted to a more detailed classification of Mediterranean crops. These tables were lost for some of the cadastral municipalities. In this case, we used the table from an assessment report prepared later, during the 1830s, in which the division of land-use categories was simpler. Based on a comparison of data in the selected cadastral municipalities for which both tables were available, we conclude that the data are comparable. In Prekmurje, which belonged to the Hungarian part of the monarchy, the cadaster was not produced until around 1860, and the form used includes forty-six land-use categories. The data for Carinthia, Carniola, Styria, and Prekmurje are kept by the Slovenian Archives (Franciscejski kataster za Koroško 1823–1869; Franciscejski kataster za Kranjsko 1823–1869; Franciscejski kataster za Štajersko 1823–1869; Kataster za Prekmurje 1858–1860), and the data for Gorizia and Istria (Catasto franceschino 1818–1840) are kept by the Trieste State Archives.

We were only able to examine the changes in land use once we compared the land use recorded in the Franciscean Cadaster with current land use. Despite political changes, the concept of the land cadaster has not changed to this day. However, a significant change in terms of land-use data occurred in 2011 with the enforcement of a provision from the 2006 Real Estate Recording Act (Zakon o evidentiranju nepremičnin 2006) requiring that the land-use data entered in the land cadaster be taken from the Land Use data base. Therefore, the 2016 data were taken directly from the Land Use data base (Evidenca dejanske rabe … 2016). Žiberna (2013) reports that this database provides an excellent source for studying land-use changes after 2000.

2.2 Establishing comparable spatial units for land-use data from two different time periods

The key problem in comparing land use in two different periods is the variable size and different borders of cadastral municipalities. Any change in their borders means that the data for different years are no longer comparable. Previous comparable studies (Kladnik 1985; Gabrovec and Kladnik 1997 for Slovenia; Bičík, Jeleček and Štěpánek 2001; Bičík et al., 2015 for the Czech Republic) did not pay much attention to this issue and simply solved it by combining two or more cadastral municipalities and obtaining the least common multiple. However, with longer time intervals, comparable units become increasingly larger and increasingly less useful for comparative analyses due to their internal heterogeneity.

Slovenian cadastral municipalities were established in the nineteenth century, whereby each comprised one or several villages with appertaining land (Vrišer 1987). They are considered the most stable spatial unit and they have largely retained their original size and borders until today (Gabrovec and Kladnik 1997). Our research shows that changes in this regard primarily occurred due to 1) political changes or 2) urban expansion. When political changes occurred, the new national borders often did not correspond to the borders of cadastral municipalities. On the Italian border this happened in the Breginj in 1866, when Venetian Slovenia was annexed to Italy; after the First World War it happened in Rateče and Inner Carniola between Idrija and the Croatian border, when part of Carniola was awarded to Italy; and after the Second World War this occurred in the area between the Goriška brda Hills and the Muggia/Milje Peninsula. After the First World War, the new border with Austria divided many cadastral municipalities in places where it did not run along the old provincial borders. Similarly, the new border between Hungary and Yugoslavia cut through the cadastral municipalities east of Lendava and at Domanjševci. After the Second World War, a completely new border with Croatia was established in Istria, where in some places it also did not run along the borders of the cadastral municipalities, and a similar situation occurred on the southern edge of the Gorjanci Hills in Bela krajina and along the Mura River. The expansion of cities primarily led to border changes in the central part of the country. These changes largely occurred after the Second World War.

This study achieved the comparability of land-use data from two different periods by relying on the original sizes of cadastral municipalities. This is the level at which data provided in the Franciscean Cadaster were gathered, whereas data on current land use provided in the Slovenian Land Use data base (Evidenca dejanske rabe … 2016) are gathered at the level of parcels. The latter can be converted to any spatial unit or, in this case, to the original size of cadastral municipalities. Hence, the 2016 data were depicted by area of cadastral municipalities as recorded in the early nineteenth century. The greatest challenge in doing this was the time-consuming process of compiling a digital database of the sizes and borders of the original cadastral municipalities (Figure 1).

We used the current borders for cadastral municipalities whose size has not changed significantly, and for others we adjusted the borders using 1 : 115,200 index maps (Uibersichts … 1829; Uibersichts … 1890; Übersichts … 1850). To some extent, we also used later index maps (e.g., Pregledna karta … 1960). In individual cases, where the border changed before these index maps were published or these were not sufficiently precise, we adjusted the border using the graphic part of the cadaster or the sketches of the borders and location of the cadastral municipalities featured in the written part of the cadaster. We edited the borders of historical cadastral municipalities using *ArcGIS 10* software.

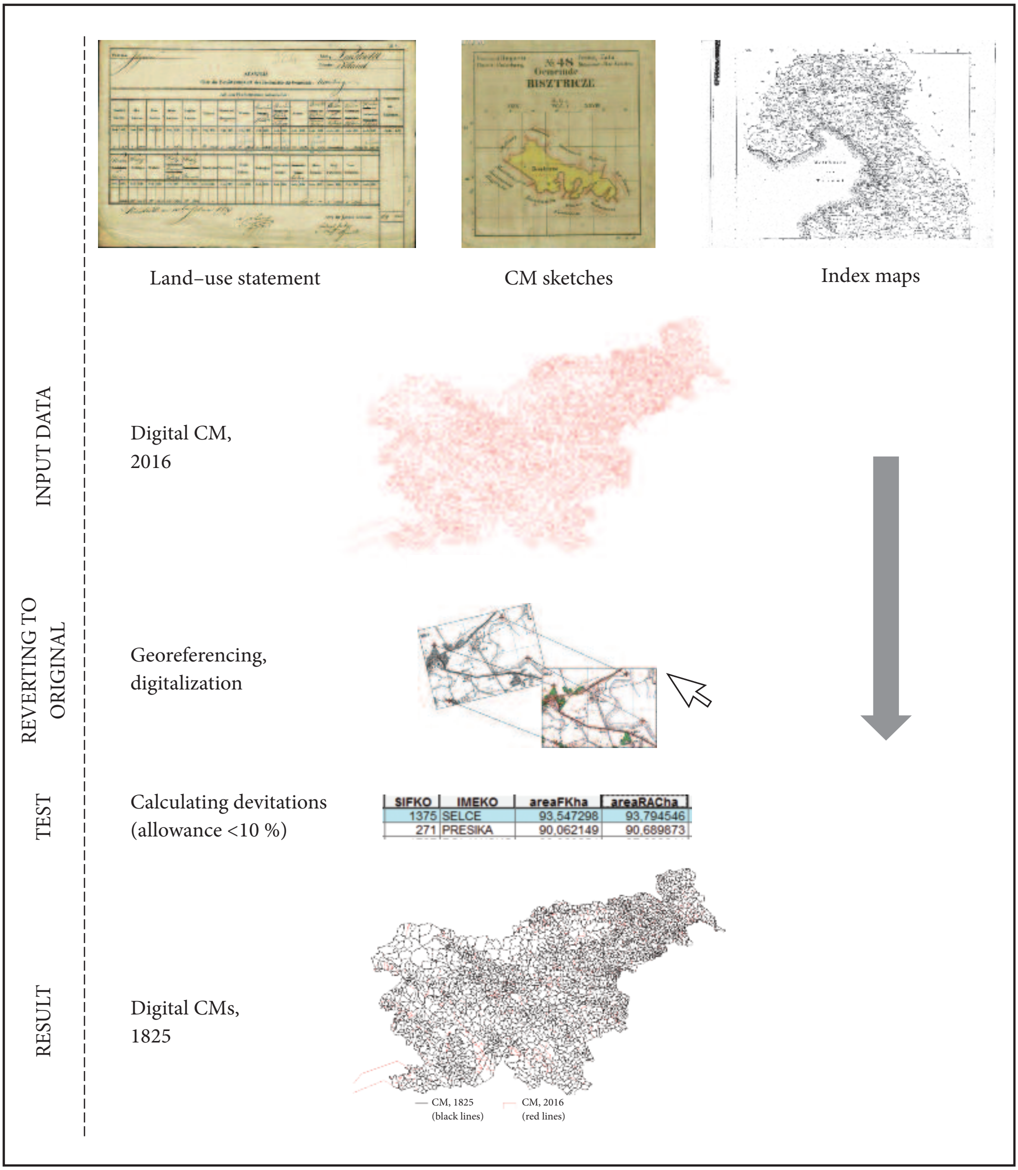


Figure 1: Compiling the digital database of sizes and borders of original cadastral municipalities (CMs).

2.3 Achieving the comparability of land-use categories from two different time periods

After we compiled the digital database, we analyzed the changes in land use. This was the first attempt at using the database compiled. The 2016 data were obtained from the Land Use data base (Evidenca dejanske rabe … 2016), where land use is presented in twenty-five categories (Interpretacijski ključ … 2013). The Franciscean Cadaster used a different land-use typology than today's Land Use data base, and therefore we combined the individual categories of both sources to obtain shared comparable categories (Table 1). Petek (2005a) combined land-use categories in a similar way, with the exception of extensive orchards, which he classified under grassland. The Franciscean Cadaster categorizes these orchards as meadows with fruit trees. For 1896 this category is shown together with meadows, and so in his analysis, which also included this year, Petek had no other choice but to address meadows and extensive orchards together. He combined intensive orchards with arable land, under which he also classified permanent crops.

Table 1: Land-use types in the Franciscean Cadaster and the Slovenian Land Use data base (with the standard types in the Franciscean Cadaster marked green).

Land Use data base			Franciscean Cadaster
Group of land-use types	Code	Land-use type	Land-use type
Arable land	1100	Arable land	Vegetable garden
			Ornamental garden
			Arable land
			Arable land with chestnuts
			Arable land with meadows
			Arable land with trees
			Newly cleared land (*Rottacker*)
	1160	Hop plantation	Hop plantation
	1190	Greenhouse	–
Permanent crops	1211	Vineyard	Vineyard
			Arable land with grapevines
			Arable land with trees and grapevines
			Arable land with fruit trees and grapevines
			Arable land with grapevines and mulberries
			Vineyard with fruit trees
			Vineyard with fruit trees and chestnut trees
			Arable land with fruit trees, grapevines, and olive trees
			Arable land with grapevines and olive trees
			Vineyard with olive trees
			Meadow with fruit trees and grapevines
			Meadow with grapevines
			Pasture with fruit trees and grapevines
			Pasture with grapevines and olive trees
			Pasture with grapevines
	1221	Intensive orchard	–
	1222	Extensive or meadow orchard	Orchard
			Meadow with fruit trees
			Pasture with fruit trees
			Arable land with fruit trees
			Pasture with mulberries
	1230	Olive grove	Arable land with olive trees
			Olive grove
			Pasture with olive trees
	1240	Other permanent crops	–

Grassland	1300	Permanent grassland	Meadow
			Pasture
			Mountain pasture
			Common pasture
	1321	Swampy meadow	Wet meadow
			Wet pasture
	1800	Farmland with forest overgrowth	Meadow with trees
			Meadow with shrubs
			Meadow with shrubs and trees
			Wet meadow with trees
			Pasture with trees
			Pasture with shrubs
			Pasture with shrubs and trees
			Pasture with chestnuts
			Wet pasture with trees
			Wet pasture with shrubs
Other agricultural land	1410	Old-field succession	–
	1420	Forest plantation	–
	1500	Trees and shrubs	Shrubs
	1600	Uncultivated farmland	Abandoned land
Forest	2000	Forest	Forest
			Deciduous forest
			Coniferous forest
			Mixed forest
			Young-growth forest
			Oak forest
			Willow forest
			Chestnut forest
			Riparian forest
			Walnut plantation
Other non-farmland	3000	Built and similar land	Gravel pit
			Clay pit
			Quarry
			Buildings
			Roads
	4100	Bog	–
	4210	Reed bed	Swamp with reeds
			Reed bed
			Wet meadow with reeds
	4220	Other swampy land	Swamp
	5000	Dry, open land with specific plant cover	–
	6000	Open land without or with insignificant plant cover	Bare rock
			Gravel bed
	7000	Water	Rivers and creeks
			Lakes and ponds
			Salt pans
			Common fishing ground
			Sea channel
			Embankments (in the sea)

2.4 The typology of land-use changes

The synthetic map of the typology of land-use changes was based on the method developed by Medved (1970), who used it to show the typology of changes between 1954 and 1967. He distinguished between the following four main processes:

- Afforestation: farmland changing into forest;
- Grass overgrowth: arable land changing into meadows or pastures or an increase in grassland area;
- Urbanization: increase in building land for the needs of urbanization; and
- Intensification: increase in the area of arable land and permanent crops.

A modified version of this method was used in many studies in Slovenia and the Czech Republic (Kladnik 1985; Gabrovec and Kladnik 1997; Gabrovec, Petek and Kladnik 2001; Petek 2005a; Bičík, Kupkova and Štych 2012) because it allows a good comparison of processes in different periods. The Slovenian studies mentioned only covered the twentieth century, whereas this article compares land use in the early nineteenth century with land use in the early twenty-first century. The maps show the predominant processes in individual cadastral municipalities. The significance of each process is presented at three levels. A strong process refers to over 75% of all changes, a moderate one to 50 to 75% of all changes, and a weak one to less than half of all changes, although it is still the predominant process in the cadastral district.

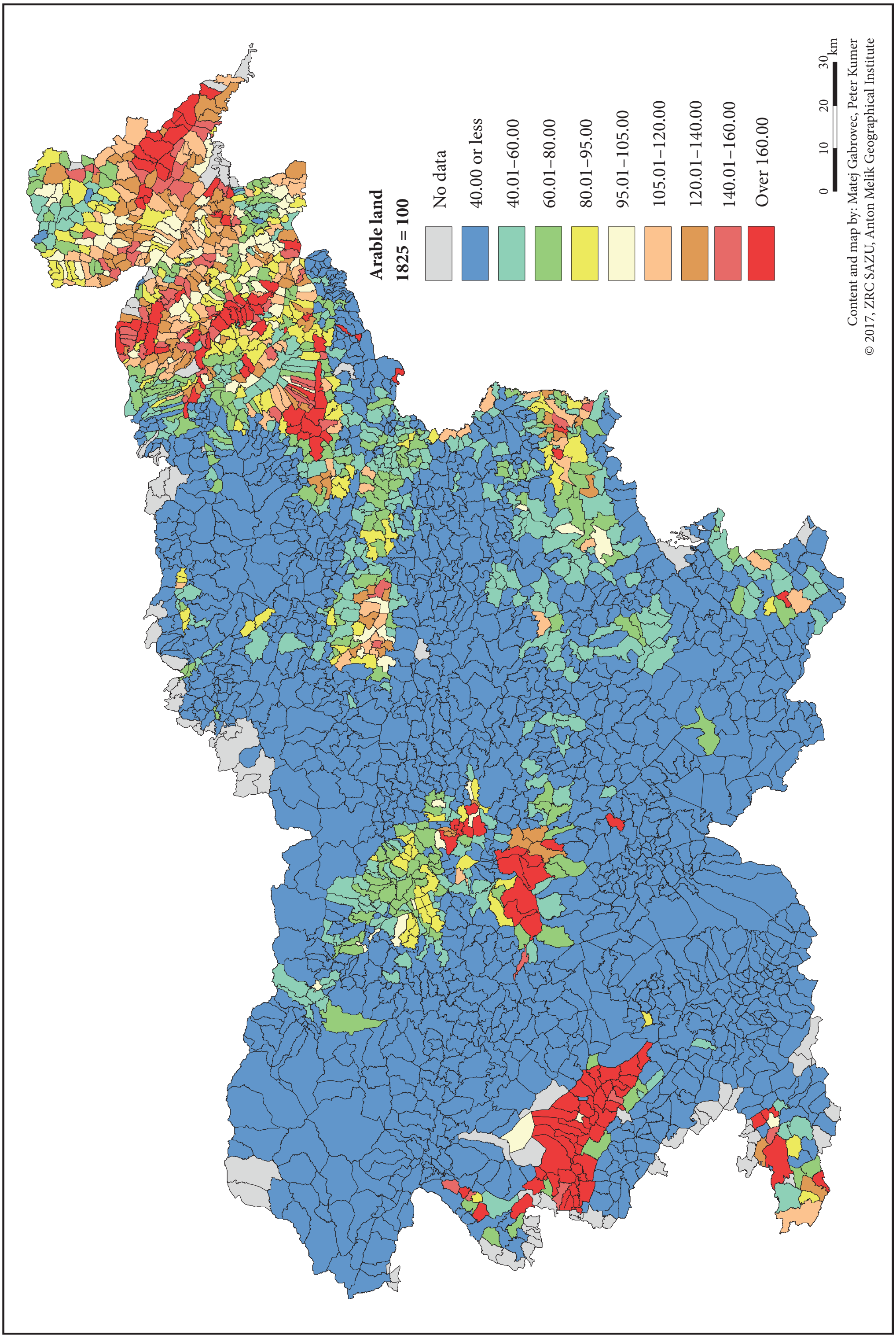
3 Results

Within the available space limits, this section highlights the differences in the processes of land-use changes by Slovenian regions, resulting from Slovenia's exceptional landscape diversity (Perko 1998; Perko, Hrvatin and Ciglič 2017). However, we do not explore the social-geographical factors influencing land-use changes in Slovenia by individual historical periods because these were already presented on a timeline for the period from 1800 to 2000 by Petek (2005a). Kladnik and Andrič (Jepsen et al. 2015) discuss the resulting changes in land management systems. In individual historical periods, these factors were similar across all of Slovenia, except in western Slovenia, which was part of Italy during the interwar period.

In the early nineteenth century, arable land covered 16% of what is now Slovenia. Land use at that time points to the predominantly subsistence farming typical of the preindustrial period. Based on the farming methods used at that time, approximately 1.3 ha of farmland per capita were required for sufficient food production (Krausmann 2006; Gabrovec, Komac and Zorn 2012). Farmers optimized the use of land at the local level, and the area covered by farmland (especially tilled fields) depended more on the number of inhabitants than natural conditions. Therefore, the differences in the share of arable land between individual Slovenian regions were smaller than today. Within two centuries, the area covered by arable land decreased to 9%. In the majority of cadastral municipalities, this decrease was even greater, but in some the area covered by arable land increased significantly (even by more than 60%; Figure 2). All cases involved flatland, but differences can also be seen between individual cases of flatland. The greatest increase in arable land can be observed on wetland or floodplains that were drained during the period studied. The most typical example is Ljubljansko barje (the Ljubljana Marsh), where drainage began as early as the nineteenth century (Melik 1927). In other areas, such as the Vipava Valley or the Pesnica and Ščavnica valleys in the Slovenske gorice Hills, land amelioration was carried out in the second half of the twentieth century, and in the wetland area on the Drava Plain hydroamelioration was carried out as late as the 1980s (Žiberna 2010).

Vineyards cover only 1% of Slovenia's territory today, but they play an important economic and visual role in the Mediterranean and Pannonian cultural landscapes. They account for less than half of the area they covered in the first half of the nineteenth century. During the nineteenth century, winegrowing was already market-oriented and hence economic and political changes had a stronger impact on it than on other agricultural activities. At the end of the nineteenth century, a large portion of vineyards were destroyed by grape diseases. Despite their later renovation, they never covered an area as large as they did in the mid-nineteenth century. Figure 3 shows a decrease in the share of vineyards across all of Slovenia. This decrease was less significant in the Mediterranean landscapes, as shown in Figure 3, because they were characterized by mixed crops, which are also listed in the land register. In our analysis, all land-use categories that

Figure 2: Index of changes in the area covered by arable land between 1825 and 2016. ➤


Arable land
1825 = 100
No data
40.00 or less
40.01–60.00
60.01–80.00
80.01–95.00
95.01–105.00
105.01–120.00
120.01–140.00
140.01–160.00
Over 160.00
0 10 20 30 km
Content and map by: Matej Gabrovec, Peter Kumer
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also included grapevines were included under vineyards, and so the nineteenth-century areas that we calculated for vineyards are larger than the ones that actually existed, subsuming areas also planted with olives in particular. The development of winegrowing in the Koper countryside was analyzed in detail by Titl (1965) and in the Haloze Hills (in Pannonian Slovenia) by Bračič (1967). During the period studied, the area covered by vineyards increased only in individual cadastral municipalities. This increase resulted more from local initiatives for vineyard renovation and expansion than from natural conditions. The most significant increase can be observed in the Bizeljsko Hills.

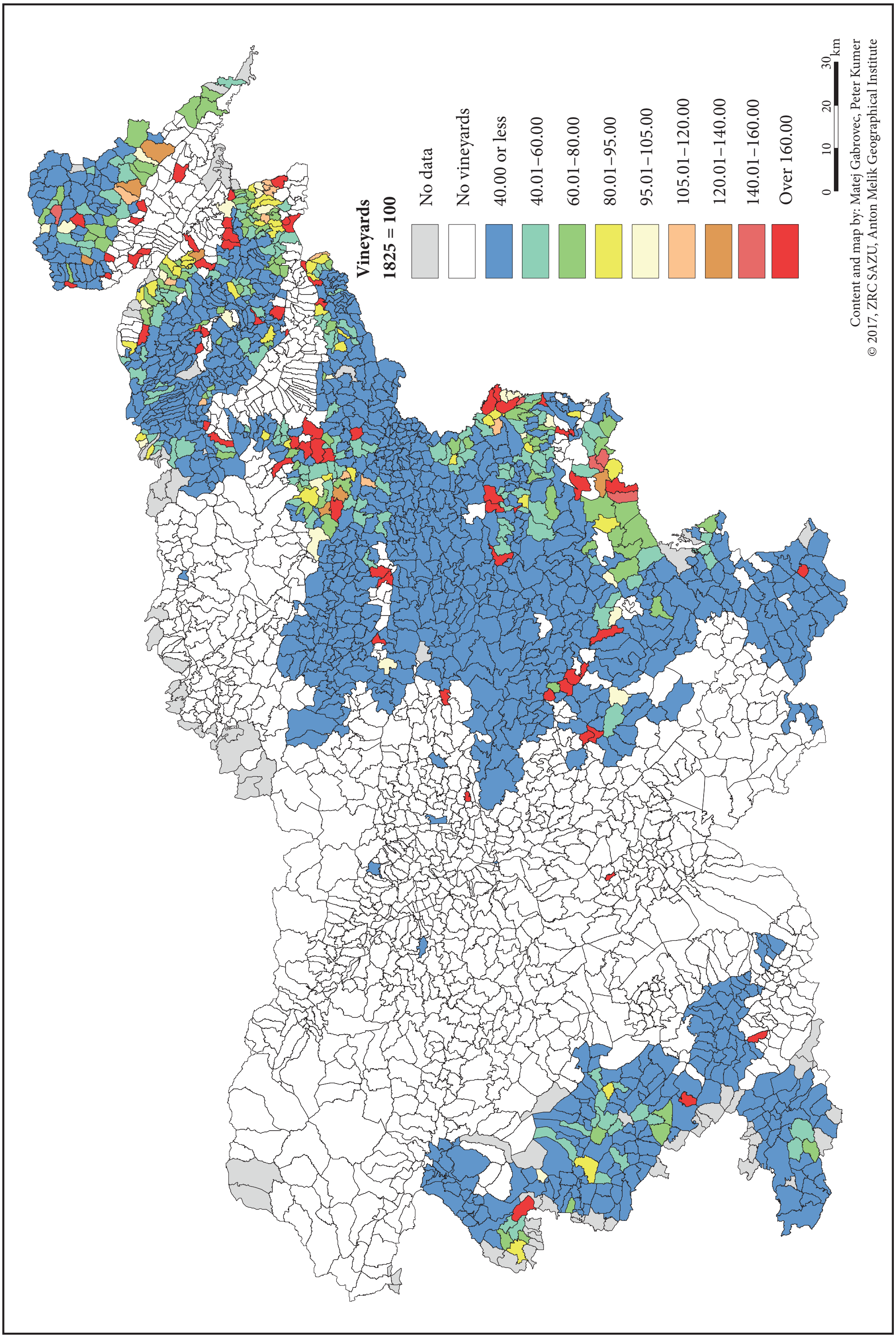
Grassland now covers 18% of Slovenia, which is also less than in the nineteenth century, when it covered a third of Slovenian territory. Changes in grassland area are connected with natural landscape elements (Figure 4). In mountainous and karst landscapes, the decrease in grassland results from old-field succession. This process is typical of a major portion of the Dinaric and Alpine macro-region of western Slovenia and is especially pronounced in the Soča Valley, the Karst Plateau, and the Kočevje region. In the case of the Kočevje region, it is connected not only with unfavorable natural conditions, but also with the relocation of the Kočevje (Gottschee) Germans during the Second World War (Mares, Rasin and Pipan 2013). On the Pannonian plains of eastern Slovenia, the decrease in grassland is the result of agricultural intensification, which is reflected in the growth of arable land at the expense of grassland. A reverse process is typical of the hills in eastern Slovenia, where an increased share of meadows is the result of the agricultural extensification, or a decrease in arable land.

The area covered by forests increased the most among all of the land-use types analyzed (Figure 5). Forests covered 39% of Slovenian territory in the first half of the nineteenth century and a full 61% in 2015. The increased share of forests in the hills and mountains of the alpine macro-region is connected with the abandonment of farmland and old-field succession. The Franciscean Cadaster shows that among all Slovenian regions natural forest vegetation was cleared the most on the Kras. In some cadastral municipalities forest was not even recorded at all, and so at that time the Kras was synonymous with the barren and desolate karst landscape. Today forest covers more than half of the Kras, 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 afforestation of meadows and pastures. Forests also grew in size in certain places on the plains, most notably on the Drava Plain, where the needs for cultivated farmland decreased as early as the nineteenth century due to the abolition of the fallow land requirement and people began to abandon their fields in areas with the shallowest soil (Pak 1969; Žiberna 2010).

The greatest relative increase can be observed with built-up land, which covered only 1.4% of the territory in the early nineteenth century, whereas now its share is over 5%. Figure 6 shows a predominance of cadastral municipalities with an index of changes over 160. An above-average increase can be observed in major cities and their surroundings, and along the main roads. Built-up land decreased only in the Kočevje region due to the eviction of the Kočevje (Gottschee) Germans during the Second World War. Roads cover a larger area than buildings in terms of built-up land types. The Franciscean Cadaster distinguishes between these two types, which also allows interesting comparisons with later periods (Gabrovec and Bole 2013).

In individual cadastral municipalities, changes in specific land-use types occur in different shares of their total area. The predominant process is presented on the map of typology of land-use changes (Figure 7), which was produced based on Medved's methodology described above (Medved 1970). Considering the increase in the area covered by forests during the period studied, it is logical that afforestation is the predominant process. This contrasts with urbanization in western Slovenia, the only exception being Ljubljansko barje (the Ljubljana Marsh), which is experiencing intensification. Eastern Slovenia is more diverse. Grass overgrowth predominates on the lower hills and afforestation dominates in the eastern Goričko Hills. In eastern Slovenia, strong urbanization is typical primarily in the Lower Savinja Valley and in Maribor and its surroundings and intensification is common on the Mura Plain and in wet meadows that were drained in the twentieth century.

Figure 3: Index of changes in the area covered by vineyards between 1825 and 2016. ➤
Figure 4: Index of changes in the area covered by grassland between 1825 and 2016. ➤ p. 74
Figure 5: Index of changes in the area covered by forests between 1825 and 2016. ➤ p. 75
Figure 6: Index of changes in the built-up area between 1825 and 2016. ➤ p. 76
Figure 7: Types of land-use changes between 1825 and 2016. ➤ p. 77


Vineyards
1825 = 100
No data
No vineyards
40.00 or less
40.01–60.00
60.01–80.00
80.01–95.00
95.01–105.00
105.01–120.00
120.01–140.00
140.01–160.00
Over 160.00
0
10
20
30
km
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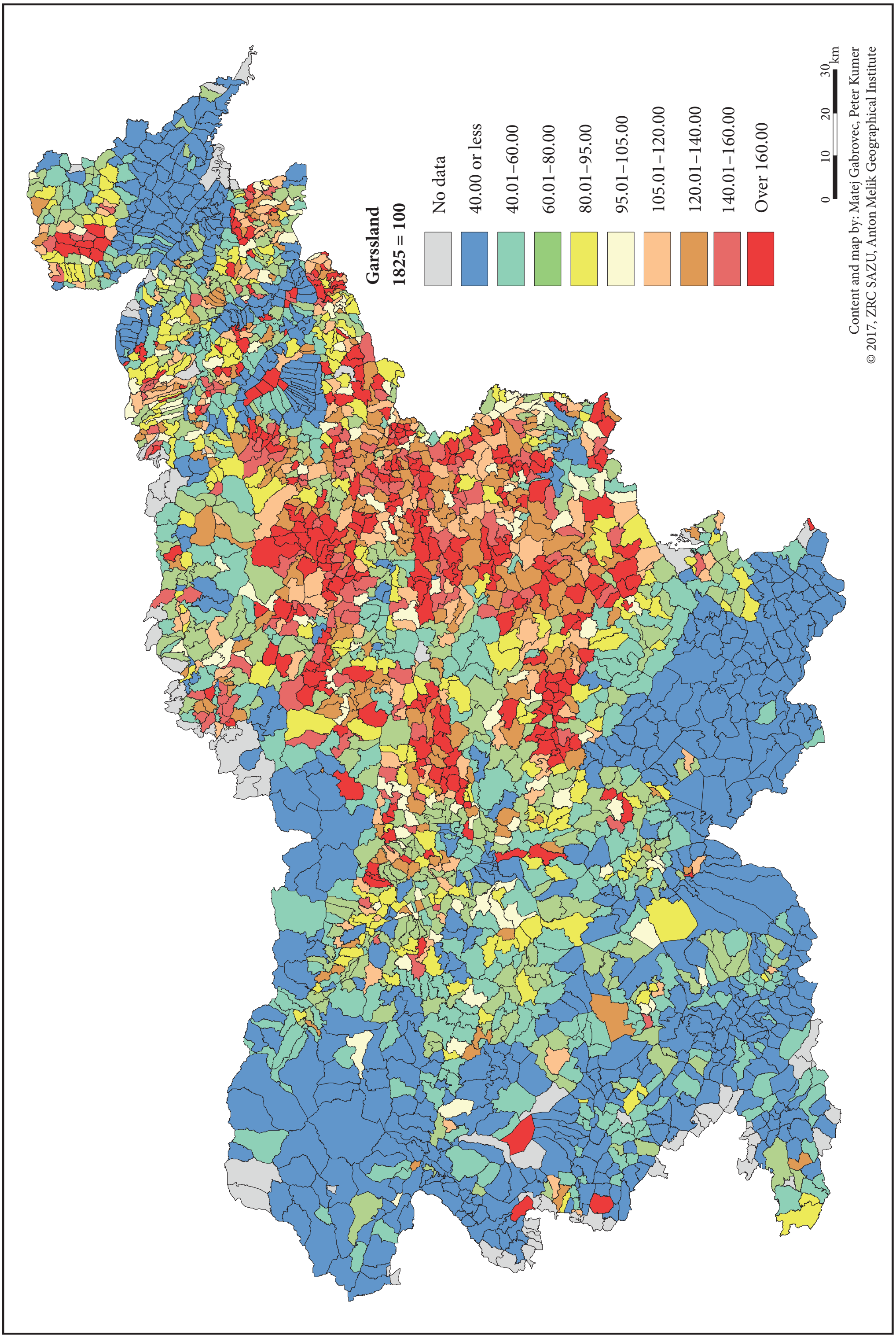
Garssland
1825 = 100
No data
40.00 or less
40.01–60.00
60.01–80.00
80.01–95.00
95.01–105.00
105.01–120.00
120.01–140.00
140.01–160.00
Over 160.00
0 10 20 30 km
Content and map by: Matej Gabrovec, Peter Kumer
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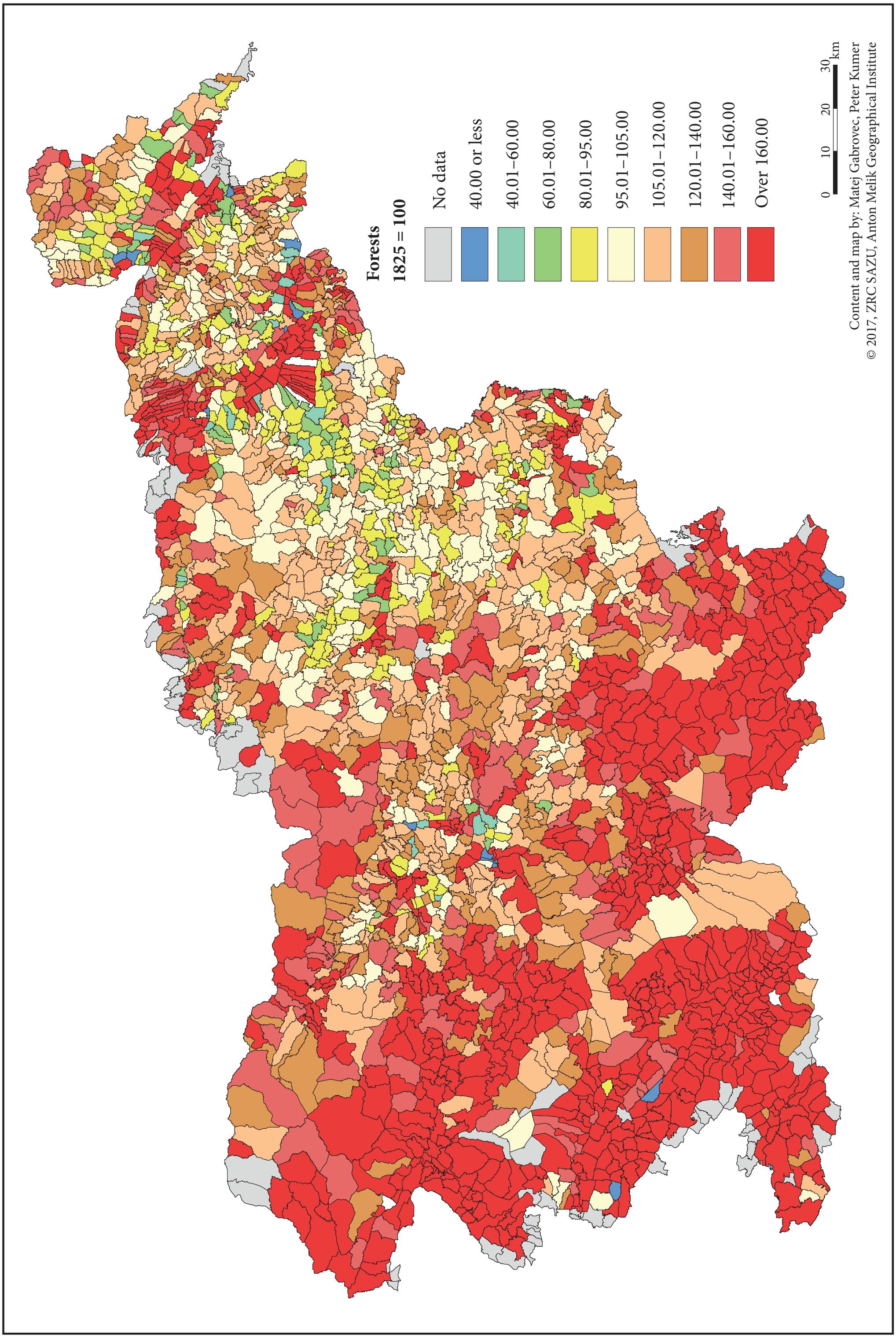
Forests
1825 = 100
No data
40.00 or less
40.01–60.00
60.01–80.00
80.01–95.00
95.01–105.00
105.01–120.00
120.01–140.00
140.01–160.00
Over 160.00
0 10 20 30 km
Content and map by: Matej Gabrovec, Peter Kumer
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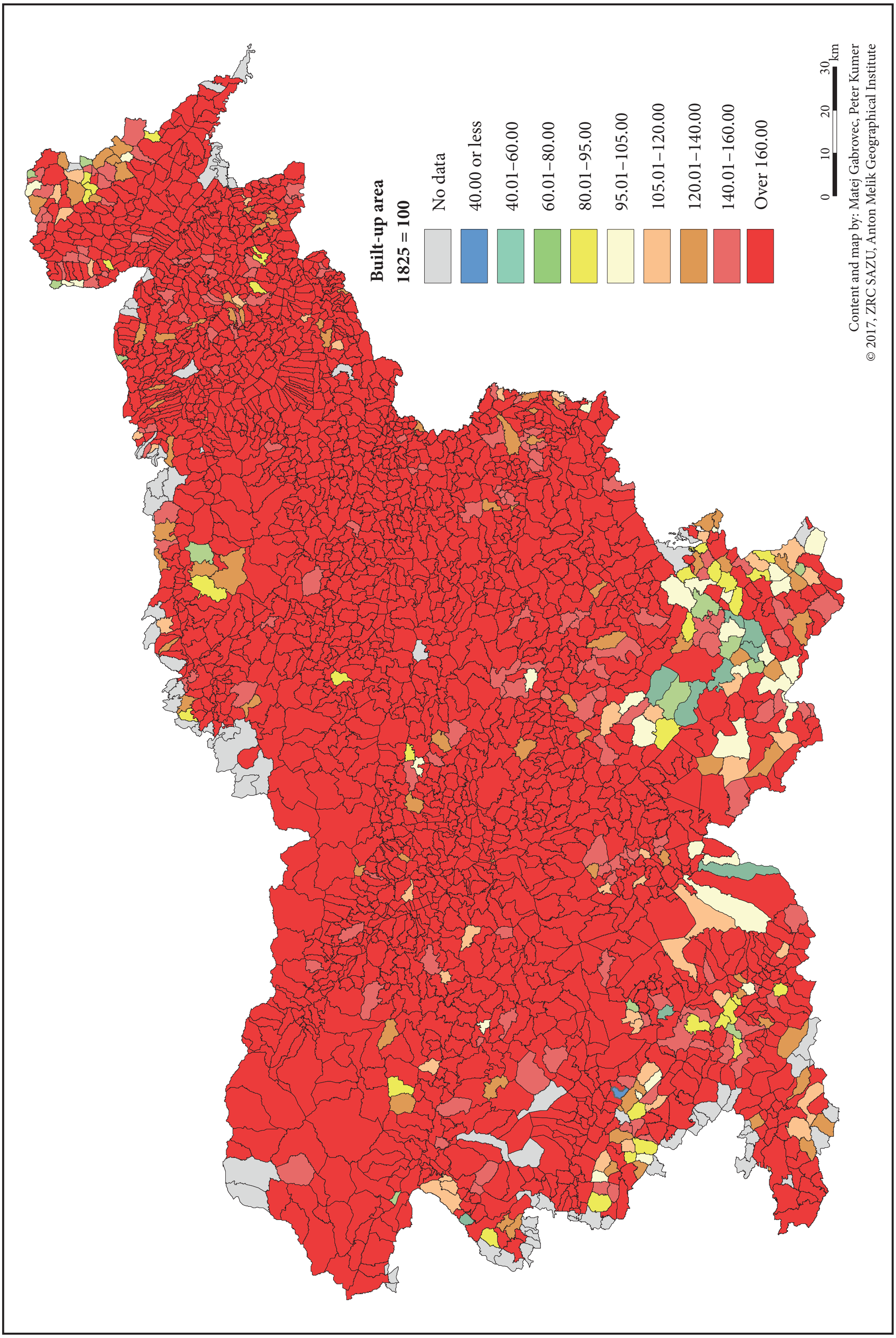
Built-up area
1825 = 100
No data
40.00 or less
40.01–60.00
60.01–80.00
80.01–95.00
95.01–105.00
105.01–120.00
120.01–140.00
140.01–160.00
Over 160.00
0
10
20
30
km
Content and map by: Matej Gabrovec, Peter Kumer
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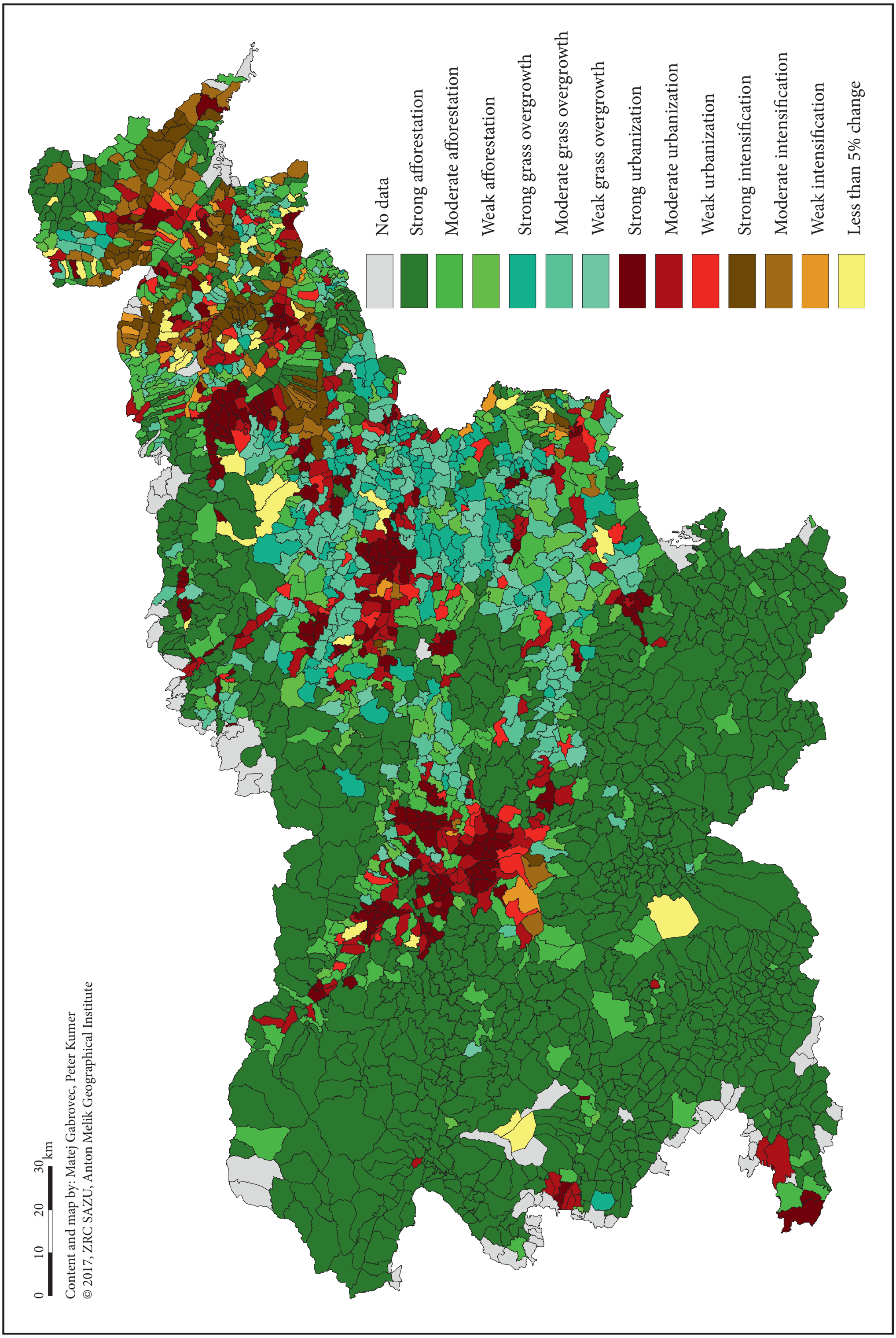
No data
Strong afforestation
Moderate afforestation
Weak afforestation
Strong grass overgrowth
Moderate grass overgrowth
Weak grass overgrowth
Strong urbanization
Moderate urbanization
Weak urbanization
Strong intensification
Moderate intensification
Weak intensification
Less than 5% change
0 10 20 30 km
Content and map by: Matej Gabrovec, Peter Kumer
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4 Discussion

Our analysis was intentionally limited to the period for which a high-quality data source (i.e., the Franciscean Cadaster) is available for all of Slovenia. Land-use data of similar quality are not available for Slovenia for older periods, although land use during the second half of the eighteenth century can be deduced from the Josephine military maps (Zorn 2007; Ribeiro, Burnet and Torkar 2013). Outside Slovenia, these maps were often used as a source of data on the nineteenth- and eighteenth-century land use in countries that had no cadastral or other statistical data available (Mishina 2015; Kaim et al. 2016). There are no maps of sufficient quality available for the period before the eighteenth century and land use for that time can only be estimated based on the number of inhabitants (Goldewijk 2001; Gabrovec, Komac and Zorn 2012).

In recent decades, satellite images have been key for obtaining land-use data and in Europe the CORINE Land Cover database makes it possible to perform comparative studies between countries (Feranec et al. 2010). Unfortunately, due to the different methodology used for collecting data, the comparability of this data with older data provided in the cadasters has been limited.

Two centuries is a long period, during which the factors leading to changes in land use changed several times. Two opposing processes might have alternated in the same cadastral district. It would also be vital to include data for individual years in the database in order to better interpret the factors affecting land-use changes. These data are actually available for individual years (Kladnik 1985; Gabrovec and Kladnik 1997; Gabrovec, Petek and Kladnik 2001), but their comparability with previous and later periods is limited due to changes in the cadastral municipalities' borders. Therefore, in the future it would make sense to also include the cadastral borders for individual years in a uniform geographic information system.

With its detailed land-use typology, the Franciscean Cadaster makes it possible to conduct in-depth research. Individual subcategories, such as pastures and meadows with trees and/or shrubs, allow a detailed explanation of forest development in Slovenia. The written part of the cadaster also has great potential for future research. Until now, it has only been used for case studies at the level of settlements, mentioned above. If the 1:2,880 cadastral maps, which are already available in digital form, were converted into vector format, changes in land use could be examined at the national or regional level, which would yield higher-quality results. This is especially relevant to studying the links between natural geographical factors and land use.

5 Conclusion

The Franciscean Cadaster is an invaluable historical source for studying nineteenth-century land use. The land-use tables provided in the written part of the cadaster were used to compile a database of nineteenth-century land use by Slovenian cadastral municipalities. Changes in land use over the past two centuries were analyzed, in which the focus was on the changes resulting from differences in natural geographical conditions. Afforestation predominates in western Slovenia, whereas eastern Slovenia is more diverse in terms of processes involving land-use changes: agricultural intensification predominates on the plains and grass overgrowth dominates in the hills, although afforestation also takes place in certain natural geographical regions less favorable for agriculture. Urbanization is the predominant process around major cities across all of Slovenia. The nineteenth-century land-use database produced provides the basis for further detailed research into factors influencing land-use changes and this article presents the procedures for setting up the database and the first analysis results.

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USING THE PARCEL SHAPE INDEX TO DETERMINE ARABLE LAND DIVISION TYPES

Mojca Foški

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The shapes or individual parcels are often well distinguished in the landscape.

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Using the parcel shape index to determine arable land division types

ABSTRACT: This paper presents a new index for determining the shape of land parcels. Parcel shapes are usually represented descriptively (i.e. ribbon-shaped, rectangular, irregularly shaped), which is useless for automated distinguishing between parcel shapes or for determining and distinguishing between the patterns formed by parcels. Thus, we developed a Parcel Shape Index (IOP) to describe parcel shape characteristics, and then tested it in the test area of Gorenje pri Divači to analyse selected fields – as irregular blocks, enclosures, continuous strips, and furlongs. We found that IOP allows for a differentiation of parcels according to their shape as well as parcel patterns formed due to the individual types of dividing arable land.

KEY WORDS: agricultural land, parcels, Parcel Shape Index, parcel shape, descriptive statistics, hierarchical clustering, Slovenia

Uporaba indeksa oblike parcel (IOP) za določanje tipa poljske razdelitve

POVZETEK: V prispevku predstavljamo nov indeks za določanje oblike parcel. Obliko parcel najpogosteje podajamo opisno (trakasta, pravokotna, nepravilnih oblik), kar je neuporabno za avtomatizirano razločevanje parcel po obliki in ugotavljanje ali razločevanje vzorcev, ki jih tvorijo parcele. Za opis oblikovnih značilnosti parcel smo izdelali indeks oblike parcele (IOP), ga preverili na testnem območju Gorenja pri Divači ter z njim analizirali izbrana polja v grudah, celkih, sklenjenih progah in delcih. Ugotovili smo, da IOP omogoča razlikovanje parcel po obliki, kakor tudi razlikovanje parcelnih vzorcev, ki jih tvorijo parcele v posameznem tipu poljske razdelitve.

KLJUČNE BESEDE: kmetijska zemljišča, parcele, indeks oblike parcel, oblika parcel, opisna statistika, hierarhična analiza, Slovenija

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1 Introduction

The shape describes the geometric form of two- or three-dimensional spatial objects (MacEachren 1985), while according to The Standard Slovene Dictionary (Slovar slovenskega knjižnega jezika 2000) it is the appearance of a phenomenon in space. The shape is one of the most important characteristics of a spatial element and is usually represented descriptively, i.e. the lake is elongated, the parcel is rectangular, the city is irregularly shaped. People perceive standard shapes (round, rectangular, triangular) similarly; however, it is difficult to represent irregular shapes in such a way that people perceive them similarly, i.e. in a unified manner. It is even more difficult to compare irregularly-shaped spatial phenomena with each other and observe their changing over time.

The process of defining shape was particularly of relevance to geographical study in the 1960s (Boyce and Clark 1964). Already in 1822, Ritter compared the area of a geographical phenomenon to that of the smallest circumscribing circle (Frolov 1975). The usefulness of knowing and determining shapes in geography was described in detail by Wentz (2000); for economic geography purposes Simons (1974) determined the shape of cities. In ecology (Eason 1992; Gutzwiller and Anderson 1992; Comber, Birnie and Hodgson 2003) topics such as the impact of territory shape in habitats on the distribution of plant and animal species are addressed; in landscape planning the impact of the shape of landscape structures on landscape appearance (hereinafter: landscape) is investigated (Krummel et al. 1987; Milne 1991; Rutledge 2003; McGarigal and Marks 1995; McGarigal 2013, 2015). The distinguishing between various shapes of spatial phenomena is relevant in remote sensing (Zhang et al. 2006). The shape of a phenomenon is significant in computer sciences (Sagiv, Reps and Wilhelm 2003) both in terms of visualisation or interpretation, i.e. computer geometry. The detection and distinguishing between shapes attracted the interest of psychology (Landau, Smith and Jones 1988).

Land parcels are an important spatial phenomenon. They reflect the diversity of natural conditions and human adaptation to the landscape (Kladnik 1999). In agricultural, forest, and built-up areas, parcels are distinguished by shape. Based on the parcel shape and the parcel pattern we can draw conclusions about natural geographic features of space, such as relief shapes, gradient, and altitude (Fialkowski and Bitner 2008). Accordingly, Ilešič (1950) considered parcel shape to be the key factor for field pattern classification. A field is a continuous area of arable land in a settlement (Slovar slovenskega knjižnega jezika 2000).

The shape of field parcels is the consequence of settlement, land cultivation methods (plough, ploughshare), and the agricultural regime (Ilešič 1950; Blaznik 1970). The changing of parcel shapes at the contact of agricultural and built-up spaces points to the pressures of urban growth (Irwin and Bockstael 2004). The shape of parcels is important for agriculture as it influences the economic viability of machining operations (Coelho, Pinto and Silva 2001; Touriño et al. 2003; Gonzalez, Alvarez and Crecente 2004; Gonzales, Marey and Alvarez 2007; Aslan, Gundogdu and Arici 2007; Amiama, Bueno and Alvarez 2008; Libecap and Lueck 2009; Zondonadi et al. 2013). Bielecka and Gasiorowski (2014) drew conclusions about land fragmentation in relation to parcel shapes. Oksanen (2013) studied land parcel shapes in Finland in relation to the automation of agricultural processes, and Demetriou, Stellwell and See (2012), Demetriou, See and Stellwell (2013), and Demetriou (2013, 2014) studied parcel shapes when developing an application for land consolidation planning in Cyprus.

In studying the parcel shape it is essential that the shape is changed into a numerical value – index of shape (Wentz 2000). This way we can compare and observe the changing of parcel shapes and parcel patterns formed by the parcels.

Shape indices fall into two classes: indices with one variable (single-parameter indices), which give a value for only one property, and indices with several variables (multiple parameter indices), which describe the characteristics of a shape with the use of more complex mathematical functions. Shape is usually too complex to be described using a single parameter (Ehler, Cowen and Mackey 1996; Wentz 2000), or rather several independent single-parameter indices are needed to describe a complex shape (Oksanen 2013; Demetriou 2014), and these indices should meet certain criteria (Lee and Sallee 1970; Wentz 1997; Wentz 2000; Demetriou, See and Stillwell 2013):

- different numerical values must be ascribed to different shapes,
- similar shapes must have similar values,
- indices must be useful both with concave and convex phenomena,
- indices must identify holes in polygons,

- indices must be independent of the size of phenomena,
- indices must be independent of movements, rotations, and scale,
- the input data must be prepared simply,
- indices must be easy to understand and the results easy to interpret,
- indices must have a value range (as a rule, the value increases from 0 to 1) and it must be determined which shape has the value of 1, and
- the values obtained must reflect human perception of a spatial phenomenon.

In terms of the shape feature that we want to describe, we distinguish between indices describing the perimeter, plane characteristics, and geometry (Zhang and Lu 2004; Chaudhuri 2013).

The basic hypothesis is that using a numerical value – the shape index – we describe the shape of a spatial phenomenon, such as a parcel. Accordingly, we developed a Parcel Shape Index (IOP). The study was narrowed down to those parcels that are in fields. Ilešič (1950) proposed a system of dividing arable land based, in fact, on parcel shape; he divided Slovenian fields into basic types (irregular blocks, furlongs, continuous strips, and enclosures) and transitional types (transitional shapes between irregular blocks and furlongs, division into irregular or block furlongs, combination of continuous strips and regular furlongs). Accordingly, parcels in areas with blocks and enclosures have distinctly irregular shapes, while parcels in areas with furlongs are generally rectangular, with a side ratio up to 1 : 10, while continuous strips are distinctly belt-like or rectangular with a side ratio even up to 1 : 100. The index's adequacy was checked against the basic arable land types, while their applicability was checked in the classification of various types of arable and division.

2 Methods

The method consists of four steps:
- IOP determination,
- testing of IOP on a sample case of the field at Gorenje pri Divači (hereinafter: Gorenje),
- determination of IOP for parcels of basic types of arable land division and statistical processing of IOP values, and
- hierarchical clustering of fields.

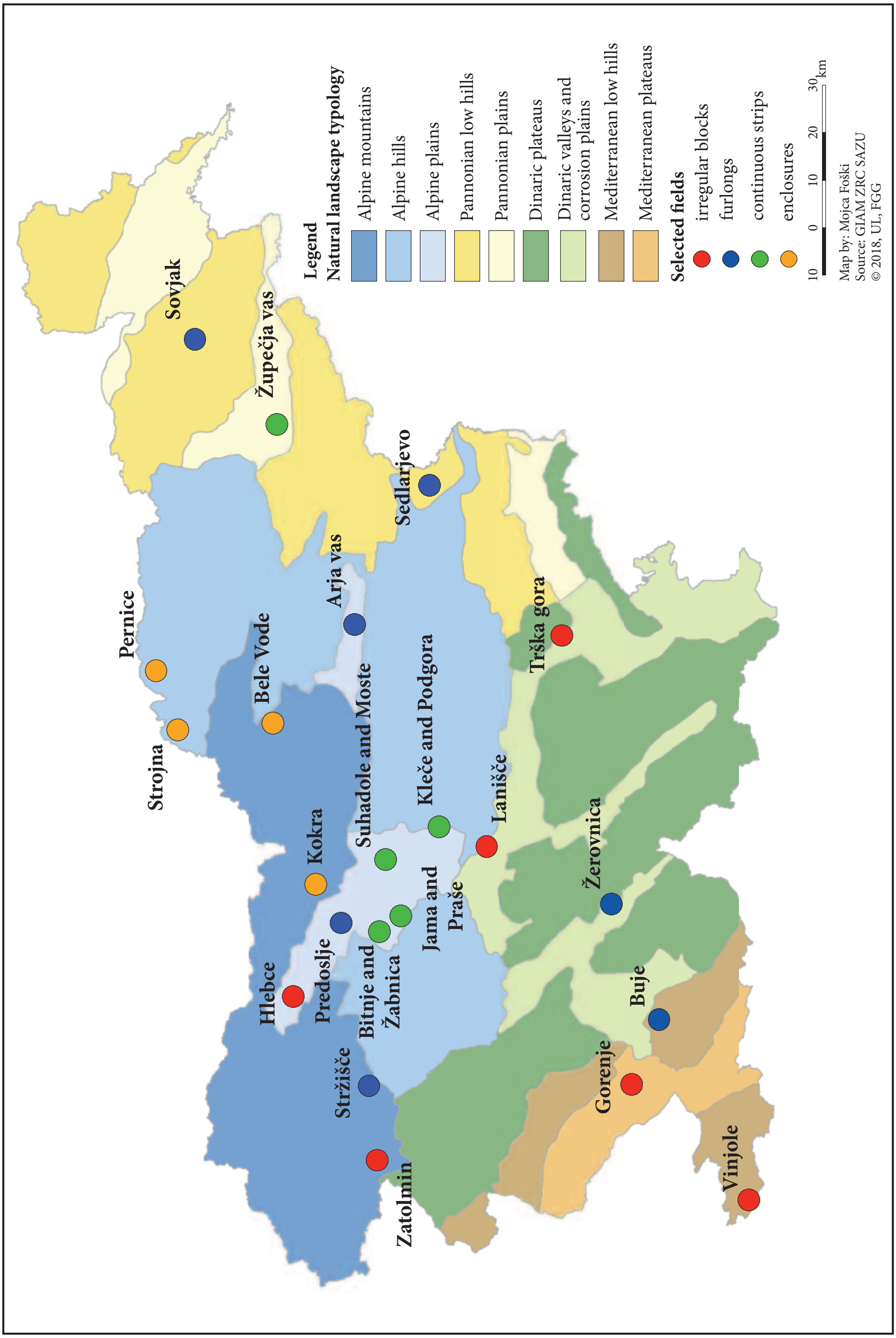
IOP determination was based on the literature and characteristics of arable land parcel shapes in Slovenia, using several single-parameter indices: indices for perimeter, plane, and parcel geometry description. The indices were standardised using a value function (Beinat 1997; Malczewski 1999, 2011; Sharifi, Herwijnen and Toorn 2004). A rectangular parcel with a 1 : 2 side ratio was selected as the reference parcel shape. This side ratio is the first whole side ratio value that distinguishes a rectangle from a square.

We selected 22 test fields among fields as irregular blocks, furlongs, continuous strips, and enclosures (Table 2). The areas of these fields were determined using Ilešič's original classification (1950) (e.g. Arja vas, Predoslje, Kokra, Bitnje and Žabnica, Zatolmin) and/or the data from the Franciscan Cadastre (Internet 1), digital orthophotos, and land cadastre data acquired through the Surveying and Mapping Authority of the Republic of Slovenia in 2015, whereby various landscape types were considered (Perko, Hrvatin and Ciglič 2015; Figure 1). The field divisions were based on geographical dividing lines (to the stream, road, forest, and village) or the cadastral municipality boundary. The fields were named after the closest settlement (e.g. Arja vas) or a geographical area (e.g. Trška gora).

The data from the land cadastre depiction, based on which the IOP was calculated, were organised by excluding all parcels designated as built-up or related land or body of water according to the Register of Existing Agricultural and Forest Land Use (Internet 2). In cases of agricultural buildings (e.g. a granary or a hayrack) with land under the building (parcel), this land was aggregated with the neighbouring parcel.

IOP was calculated for 13,725 land parcels in all test fields. Indicators of descriptive statistics were calculated for all test fields (Table 2): number of parcels in a field (N), minimum value (MIN), maximum value (MAX), average value (AVG), median (Me), mode (Mo), standard deviation (σ), asymmetry coefficient (y_1), and coefficient of kurtosis (y_2). The obtained IOP values were shown on histograms (10 classes, class width 0.1). Statistical values were demonstrated using a box-and-whiskers plot (Figure 8).

Figure 1: Distribution of test fields by various landscape types of Slovenia. ➤


Sovjak
Župečja vas
Sedlarjevo
Pernice
Bele Vode
Arja vas
Strojna
Suhadole and Moste
Kleče and Podgora
Tršká gora
Kokra
Lanišče
Žerovnica
Hlebce
Predoslje
Bitnje and Žabnica
Jama and Praše
Buje
Stržišče
Gorenje
Zatolmin
Vinjole
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: GIAM ZRC SAZU
© 2018, UL, FGG

In the last step, we classified the fields into groups using Ward's hierarchical clustering method (Breskvar Žaucer and Košmelj 2006; Bastič 2006; Figure 9). Indicators of descriptive statistics were used for the cluster analysis, and Euclidian distance was used as cluster criterion.

Statistical data processing and depiction using histograms and box-and-whiskers plots demonstrated whether IOP reflected the parcel shapes concerned and whether the parcel shape was, in fact, characteristic for the various types of arable land division according to Ilešič.

The analysis was based on the data from the land cadastre depiction by the Surveying and Mapping Authority of the Republic in Slovenia, acquired in 2015, in *ArcGis 10.3*; *Microsoft Excel* 2010 and *IBM SPSS* 23 software were used for calculations and statistical processing.

2.1 IOP determination and its verification on the sample case of Gorenje

2.1.1 Indices for describing plane characteristics: compactness index /I_{kom}

In this group we typically use indices describing the ratio between area (A) and perimeter (P) (Santiago and Bribiesca 2009; Li, Goodchild and Church 2013), which are often referred to as compactness indices.

Besides the initially produced factor P/A proposed by Ritter (Frolov 1975) other indices are also used, e.g. indices of ratios $4A/P^2$ (Miller 1953), A/P^2 (Gonzalez, Alvarez and Crecente 2004), $P/2\sqrt{\pi A}$ (Aslan, Gundogdu and Arici 2007) and $\sqrt{A}/0.282 \cdot P$ (Chan and So 2006). The most frequently used compactness index was developed by Osserman (1978) and is also used here; it is described by the equation

$$I'_{kom} = \frac{4\pi A}{P^2}$$

The equation's advantage is that π shifts the value area of the initial indices in the range of 0 to 1. The value of 1 describes the most compact phenomenon – the circle. Wentz (2000) found that this index is not the most appropriate for very diversified phenomena, but it is insensitive to scale, displacement, and rotation variations, independent of the size of the phenomenon, and applicable to both raster and vector data (Sonka, Hlavac and Boyle 1993; Santiago and Bribiesca 2009; Oksanen 2013; Bielecka and Gasiorowski 2014).

Indices from this group also have some shortcomings. In particular, they do not reflect the characteristics of a shape, but rather compactness according to a comparable geometric shape, i.e. a circle in our case (MacEachren 1985; Angel, Parent and Civco 2010). They cannot be used to measure features such as the presence of holes, expansion, or fragmentation. Parcel shapes should not be described using only these indices as they only take into account the area and perimeter characteristics (Demetriou, See and Stillwell 2013).

I'_{kom} was standardised to determine parcel compactness, because the parcels were, of course, not round. In determining the value function sixth degree polynomial was used (Demetriou 2014), while the function was determined so that for the parcels with a side ratio (of 1 : 2) whose I'_{kom} equals 0.70, the value $I_{kom} = 0.99$ was assumed, while for the parcels with I'_{kom} less than 0.33 (side ratio 1 : 8) the value of $I_{kom} = 0$ was assumed (Figures 2 and 3). Other values were determined using the value function (Figure 2):

$$I_{kom} = V(I'_{kom}) = -372.614(I'_{kom})_i^6 + 1319.19(I'_{kom})_i^5 - 1820.87(I'_{kom})_i^4 + 1$$

$$1227.22(I'_{kom})_i^3 - 414.436(I'_{kom})_i^2 + 66.207(I'_{kom})_i - 3.908$$

The value function is determined so that all parcels with a side ratio up to 1 : 4 get a higher compactness index, which allows for differentiation from longer parcels (with side ratio over 1 : 8) (Figure 3). The compactness index was calculated for the test case of Gorenje and graphically shown (Figure 5 A) in 10 equal classes with a degree of 0.1.

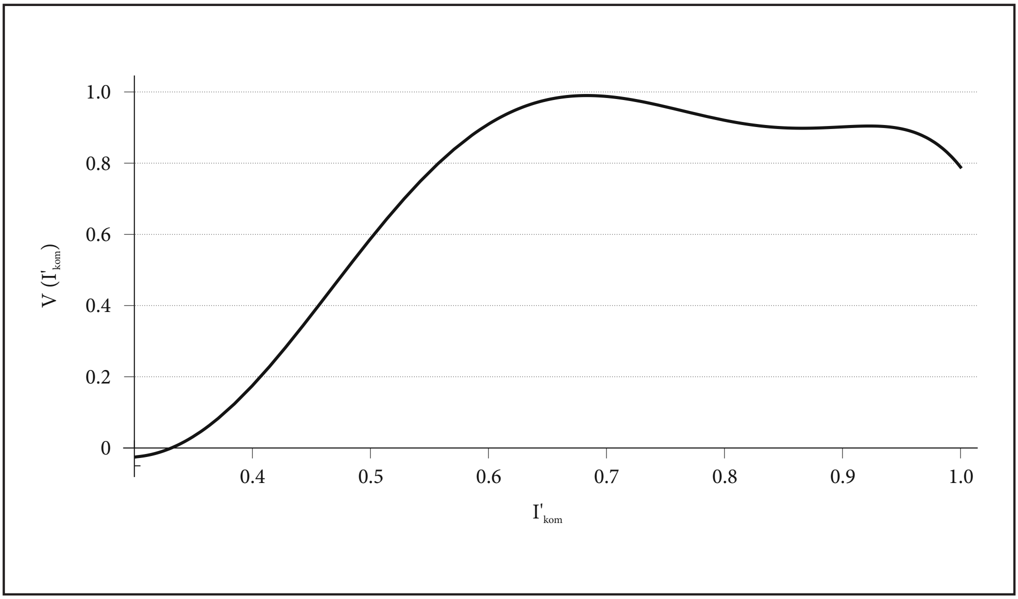


Figure 2: Value function for determining I_{kom}

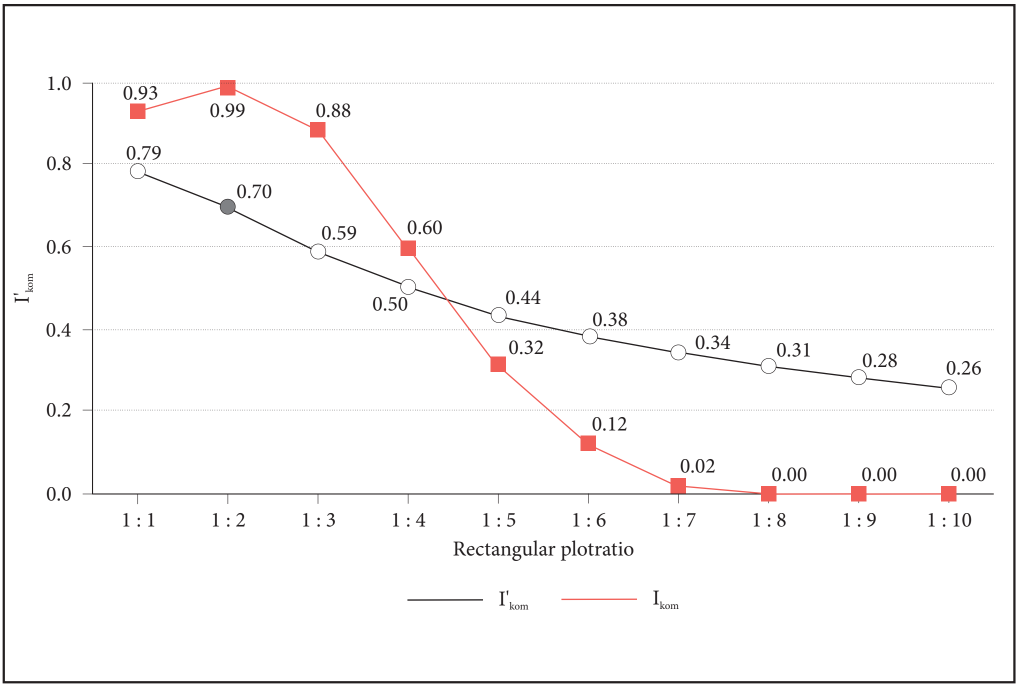


Figure 3: Ratio between index I'_{kom} and its standardised value I_{kom}. I_{kom} has the maximum value for parcels with a side ratio of 1 : 2; while it equals 0 with parcels with a side ratio above 1 : 8.

2.1.2 Indices of the special characteristics of the geometry of the phenomenon: Perforation Index/I_{luk}

Some characteristics of phenomena cannot be described using the compactness index, so we used Wentz's perforation index (2000), by subtracting it from 1:

$$I_{luk} = 1 - \frac{B_i}{A_i}$$

where B_i is the total area of all holes in object i and A_i is the total area of object i.

The parcels without holes were ascribed the maximum value of 1, while the value of 0 could not be reached. In the Gorenje test area (Figure 5 B) we only showed parcels with an I_{luk} other than 1, and due to reasons of clarity the parcels with the perforation index of 1 were not coloured.

2.1.3 Indices for perimeter description

Index of Edge Roughness/I_{naz}

These indices describe the roughness of the edge of a geographical object. On the basis of the ratio between an object and its corresponding convex hull, they are most frequently used to describe the perimeter characteristics. The amplitude index $((P – P_k) / P)$ considers the ratio between the perimeter of an object (P) and the perimeter of the convex hull (P_k), while the convexity index $((A_k – A) / A_k)$ considers the ratio between the area of object A and the area of the convex hull (A_k) (Brinkhoff et al. 1998). Chan in So (2006) used the comparable surface area ratio, Iivarinen et al. (1997), Angel, Parent and Civco (2010), and Zondonali et al. (2013) used the ratio between the perimeter of object P and its convex polygon P_k, which was also used here; the edge roughness index was written as:

$$I_{naz} = \frac{P}{P_k}$$

The index has the value of 1 if the parcel is convex. With the value nearing 0, diameter roughness increases. The value of 1 is ascribed to all convex parcels, while the value of 0 is unattainable. The calculation of I_{naz} in the test field of Gorenje is shown in ten equal classes with a rate of 0.1 (Figure 5 C), red shades indicating jagged-edged parcels, while the darkness of the blue indicates smoother edges.

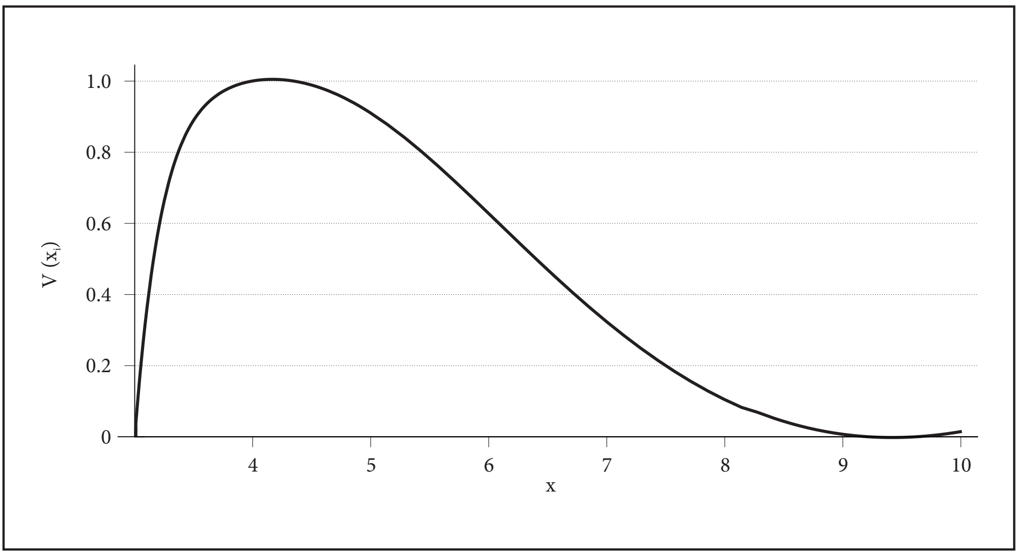
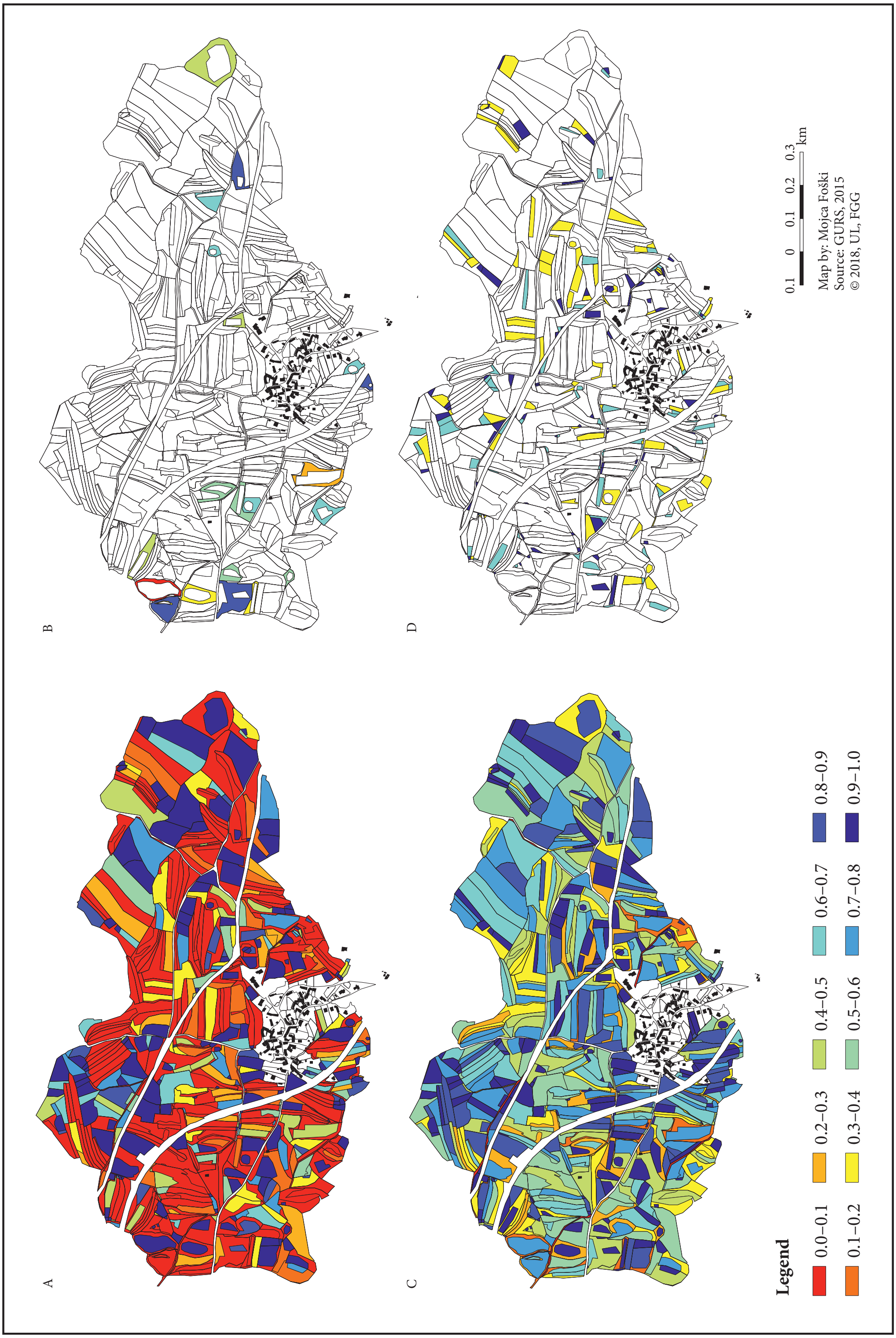


Figure 4: Value function for standardising the number of vertices (I_{ogl}).

Figure 5: Compactness Index (A), Perforation Index (B), Index of Vertices (C), and Edge Roughness Index (D) for Gorenje. ➤


A
B
C
D
Legend
0.0–0.1
0.1–0.2
0.2–0.3
0.3–0.4
0.4–0.5
0.5–0.6
0.6–0.7
0.7–0.8
0.8–0.9
0.9–1.0
0.1 0 0.1 0.2 0.3 km
Map by: Mojca Foški
Source: GURS, 2015
© 2018, UL, FGG

Index of Vertices (I_{ogl})
Indices of the number of perimeter vertices are frequently used to describe the characteristics of a parcel perimeter (Brinkhoff et al. 1998; Demetriou, Stellwell and See 2012). The reference parcel has four vertices; by increasing the number of vertices, the deviation from a rectangle increases. Parcels with three vertices also considerably deviate from a rectangle. The standardisation of the number of vertices in a value range from 0 to 1 was made using a value function after Demetriou (2014) (Figure 4), where x_i is the number of vertices:

$$I_{ogl}=V(x_i)=14.45-\frac{407.76}{x_i}+\frac{4280.97}{x_i^2}-\frac{20959.323}{x_i^3}+\frac{49141.25}{x_i^4}-\frac{45677.80}{x_i^5}$$

All parcels with more than 10 vertices were ascribed the value of 0. The index of vertices was calculated for Gorenje. We showed the parcels with I_{ogl} other than 0 (Figure 5 D).

2.2 Parcel Shape Index (IOP)

The parcel shape index can be written using the equation:

$$IOP=\frac{\sum_{j=1}^{n} I_j w_j}{n}$$

where I_j is one of the aforementioned indices and W_j is the index weight. If the indices are equally weighted (with a value of 1), then for each parcel i IOP is calculated as the arithmetic mean of four single-parameter indices:

$$IOP=\frac{I_{kom}+I_{naz}+I_{luk}+I_{ogl}}{4}$$

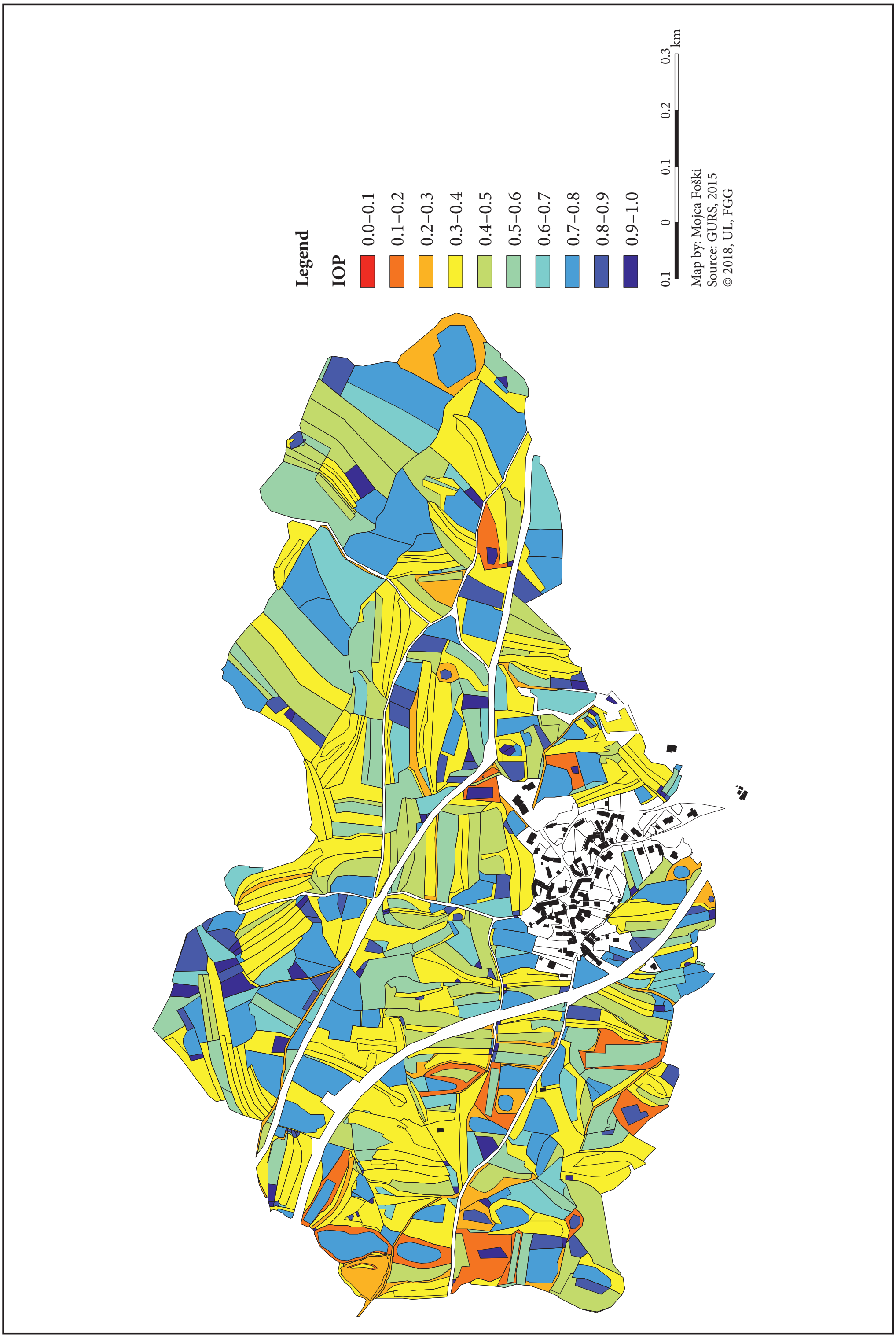
The Pearson correlation coefficient between the indices of compactness, roughness, perforation, and vertices for the 722 parcels in Gorenje is low (Table 1), indicating the indices' mutual independence, which satisfies one of the basic criteria for combining single-parameter indices.

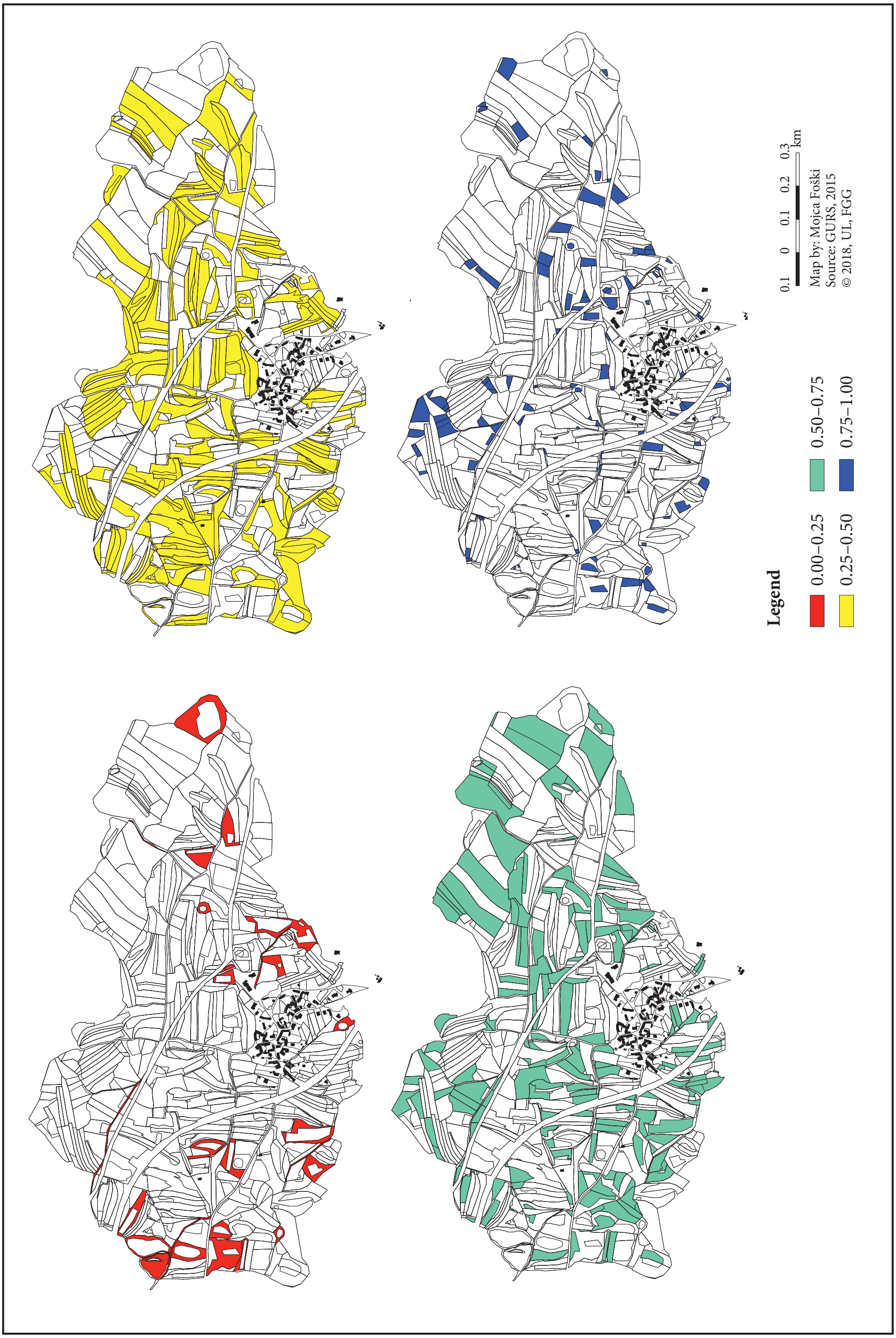
Table 1: The Pearson correlation coefficient between the indices for Gorenje.

Correlation coefficient	I_{kom}	I_{naz}	I_{ogl}	I_{luk}
I_{kom}		0.24	–0.19	0.045
I_{naz}			–0.30	0.20
I_{ogl}				–0.25
I_{luk}				

IOP is in the range of 0 to 1. Given the value functions in the standardisation procedure, the value of 1 is ascribed to the parcels with a side ratio of 1 : 2, without holes, with four vertices, and with a completely smooth edge. The depiction of IOP in the four value classes (Figure 6 below) shows that the parcels with distinctly irregular shapes (jaggedness, holes) are in the lowest class, while rectangular parcels with a low side ratio are in the highest class. The parcels within a class are visually similar (Figure 6); IOP is applicable both in convex and concave parcels, independent of parcel size, insensitive to scale and rotation variations, and easy to calculate, and thus meets all the criteria for determining indices.

Figure 6: IOP in 10 classes with a rate of 0.1 (page 93) and in four classes with a rate of 0.25 (page 94) for Gorenje. ➤ p. 93–94


Legend
IOP
0.0–0.1
0.1–0.2
0.2–0.3
0.3–0.4
0.4–0.5
0.5–0.6
0.6–0.7
0.7–0.8
0.8–0.9
0.9–1.0
0.1 0 0.1 0.2 0.3 km
Map by: Mojca Foški
Source: GURS, 2015
© 2018, UL, FGG


Legend
0.00–0.25
0.25–0.50
0.50–0.75
0.75–1.00
0.1 0 0.1 0.2 0.3 km
Map by: Mojca Foški
Source: GURS, 2015
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3 IOP results in the selected test cases

IOP was calculated for 22 selected fields (Table 2, Figure 1) in irregular blocks, furlongs, continuous strips, and enclosures. For each test field we calculated the indicators of descriptive statistics for IOP, while the distribution of IOP values was shown on histograms (Table 2) and box-and-whiskers plots (Figure 7). The statistical values were compared and it was determined whether IOP reflected the actual characteristics of a parcel shape and if the parcel shape was, in fact, characteristic for the various types of arable land division according to Ilešič. Using the hierarchical clustering method, the fields were clustered into groups, and the results were depicted using a dendrogram (Figure 8).

We used descriptive statistics, histograms (Table 2), a comparison of box-and-whiskers plots (Figure 7), and depiction of hierarchical clustering (Figure 8) to try to establish similarities between parcel shapes and the patterns formed by the parcels. The IOP distribution in fields as furlongs and fields as irregular blocks is very similar (with the exceptions of Vinjole and Trška gora), where two modes are observed (0.35 and 0.75). This was also confirmed by the classification into the same group using the hierarchical clustering method.

The parcel shapes in areas of continuous strips also show great similarity. The mode class is 0.3-0.4 or 0.4-0.5. The narrowest is the second quartile (maximum densification of parcels), while the asymmetry coefficient (y_2) is positive in all test fields (asymmetry to the right). The fields are classified as continuous strips, except for Kleče and Podgora. The fields of Buje and Žerovnica also belong to this group, even though Ilešič classified them as furlongs (belt-like furlongs), while their parcel shape was distinctly belt-like, which is characteristic for parcels in continuous strips.

The analysed fields as furlongs can be classified into two groups (Figure 8). The first group is Arja vas, Predoslje, Kleče, and Podgora, and the second group is Trška gora, Stržišče, Sovjak, Sedlarjevo, and Vinjole. The groups are combined in the next aggregation. Ilešič classified Vinjole and Trška gora as winegrowing blocks, while in terms of parcel shape (rectangular with a small side ratio) the fields are comparable to furlongs.

Table 2: Descriptive statistics and IOP histograms for all fields considered.

		IOP									
		N	*AVG*	*MIN*	*MAX*	*Me*	*Mo*	σ	γ_1	γ_2	*histogram*
IRREGULAR BLOCKS	Gorenje	722	0.60	0.09	0.98	0.49	0.36	0.22	0.38	-1.16	
	Zatolmin	517	0.56	0.12	0.98	0.58	0.35; 0.74	0.24	-0.02	-1.29	
	Vinjole	422	0.69	0.13	0.98	0.76	0.75	0.19	-0.86	-0.05	
	Lanišče	272	0.54	0.20	0.97	0.52	0.36	0.19	0.31	-1.11	
	Trška gora	388	0.66	0.24	0.98	0.72	0.75	0.19	-0.43	-1.00	
	Hlebce	622	0.56	0.12	0.98	0.58	0.35	0.24	-0.02	-1.29	
FURLONGS	Žerovnica	1247	0.47	0.18	0.98	0.42	0.37	0.13	1.25	2.17	
	Buje	332	0.52	0.14	0.98	0.42	0.38	0.23	0.72	-0.91	
	Predoslje	389	0.65	0.24	0.98	0.66	0.75	0.19	-0.05	-1.11	
	Arja vas	761	0.61	0.21	0.98	0.58	0.42	0.21	0.31	-1.27	
	Stržišče	282	0.66	0.19	0.98	0.73	0.75	0.22	-0.44	-1.03	
	Sovjak	1009	0.70	0.18	0.98	0.77	0.71	0.20	-0.53	-0.79	
	Sedlarjevo	206	0.67	0.24	0.98	0.72	0.75	0.19	-0.47	-0.76	
CONTINUOUS STRIPS	Jama and Praše	338	0.51	0.21	0.98	0.44	0.37	0.19	0.86	-0.20	
	Kleče and Podgora	368	0.60	0.31	0.98	0.53	0.41	0.22	0.51	-1.24	
	Suhadole and Moste	705	0.52	0.22	0.98	0.41	0.37	0.21	1.08	-0.30	
	Bitnje and Žabnica	2861	0.52	0.11	0.98	0.46	0.44	0.19	0.59	-0.44	
	Župečja vas	624	0.51	0.19	0.98	0.44	0.38	0.18	0.99	0.09	
ENCLOSURES	Pernice	222	0.55	0.10	0.98	0.55	0.35; 074	0.22	0.00	-1.24	
	Bele vode	1010	0.55	0.07	0.98	0.52	0.35; 0.75	0.23	0.16	-1.28	
	Kokra	212	0.59	0.10	0.97	0.59	0.35; 0.75	0.23	0,12	-1.24	
	Strojna	216	0.52	0.06	0.98	0.49	0.32; 0.75	0.24	0.24	-1.26	

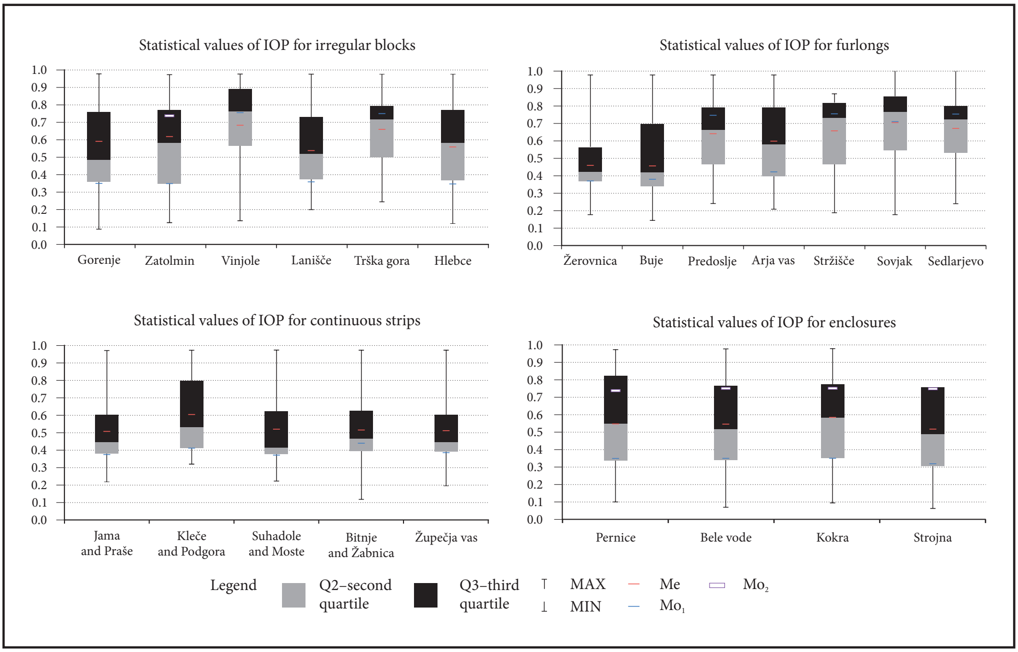

Figure 7: Box-and-whiskers plots for IOPs for all selected test fields shown on the same graph for fields as irregular blocks, furlongs, continuous strips, and enclosures.

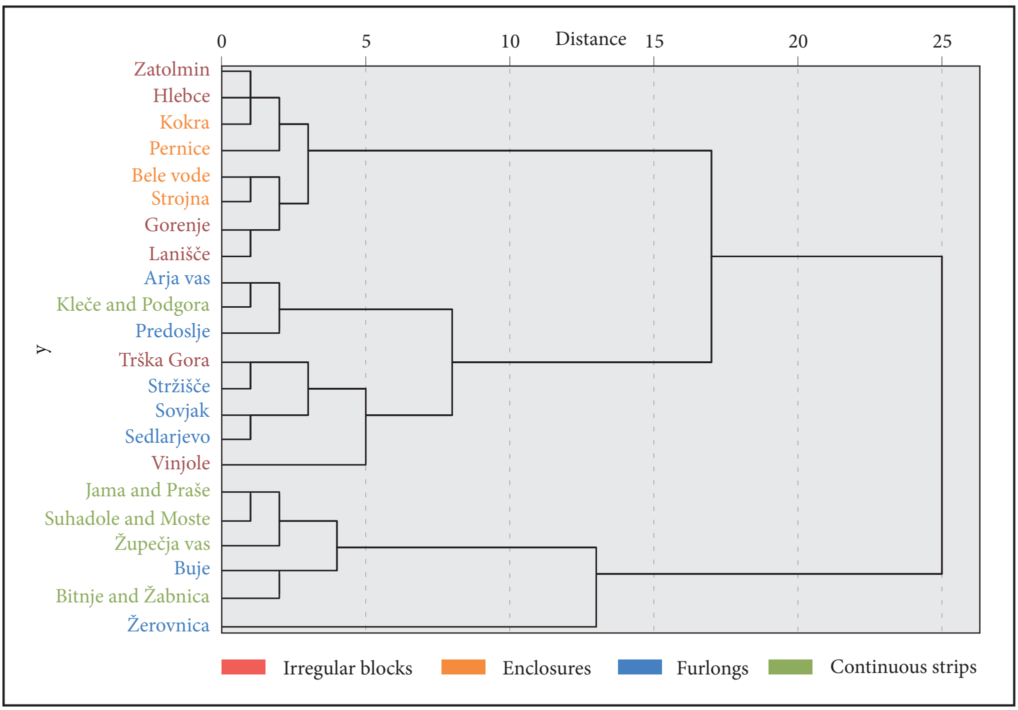

Figure 8: Dendrogram of the hierarchical clustering of fields into groups using Ward's method.

4 Discussion

IOP is the arithmetic mean of four mutually independent single-parameter indices that also consider the holes in parcels, which was not found with other authors (Tourino et al. 2003; Aslan, Gundogdu and Arici 2007; Amiama, Bueno and Alvarez 2008; Zondonadi et al. 2013; Demetriou 2014; Bielecka and Gasiorowski 2014). In Slovenia, parcels with holes are the consequence of natural geographic features and specifics of the Franciscan Cadastre, where for each type of land use a separate parcel was determined, even though neighbouring parcels belonged to the same proprietor (Ferlan 2005). In cases where a field was in the middle of a meadow or a at the bottom of a sink hole there are holes in parcels preserved to the present day. In Slovenia, holes are present mostly in irregular blocks and enclosures, and exceptionally also in areas of continuous strips (Bitnje), so we feel that this feature should be taken into account in IOP. A hole in a parcel decreases IOP, while the proportion of parcels with lower IOP increases in the pattern, which is characteristic for irregular blocks and enclosures.

Some authors determined parcel shape only by using the compactness index (Bielecka and Gasiorowski 2014; Oksanen 2013; Zondonadi et al. 2013), which has several shortcomings (Demetriou, See, and Stillwell 2013). The values were standardised to a reference parcel shape only by Demetriou (2014). This standardisation to a reference parcel shape is necessary, even though the determination of a reference parcel varies depending on the study purpose. Using this standardisation we delineated the rectangles with a more favourable side ratio (up to 1 : 8) from distinctly elongated rectangles (belts).

The IOP calculation for the Gorenje test area demonstrated (Figure 6) that parcels in the individual classes are visually similar. But then over a larger sample (all 22 fields, 13,725 parcels) it became evident that the IOP value for long and narrow parcels in the area of continuous strips was similar to the values of irregular parcels in the areas of irregular blocks, i.e. between 0.30 and 0.45 (Figure 10). Future work should include an index to improve the determination of the characteristics of very long and narrow parcels (e.g. ratio between the shortest and the longest diagonal of a parcel).

Despite this deficiency, the statistical data analysis of various types of arable land division (Figure 7) and hierarchical clustering (Figure 8) demonstrated that IOP allows for distinguishing between fields as continuous strips from other types of fields mostly because these two types of parcel shapes usually do not occur together. In Slovenia, continuous strips are more frequent in plains, in particular in Sorško polje (Ilešič 1950), and are a reflection of systematic settlement (Blaznik 1970), while irregular blocks are characteristic of a more diverse terrain and are classified as the oldest type of arable field division (Blaznik 1970).

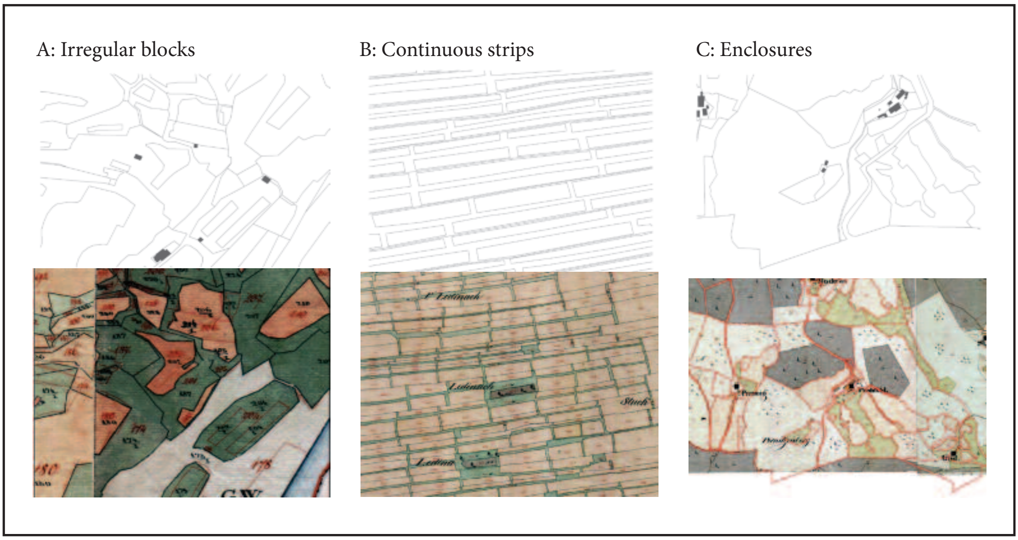

Figure 9: Sections from the land cadastre depiction (Geodetska uprava RS 2015; above) and sections from the Franciscan Cadastre (Arhiv RS; below) with cases of holes in irregular blocks (Zatolmin, A), continuous strips (Bitnje, B), and enclosures (Pernice, C).

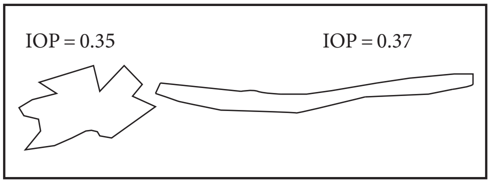

Figure 10: The case of similar IOP values for two parcels different in shape.

This arable land division analysis is mostly based on the study results by Ilešič from 1950. His study remains the only study for the area of the entire Slovenia and to date has not been systematically revised. This is why there are deviations between Ilešič's definition of the individual arable land types and the results indicated by the IOP analysis in parcels from 2015.

IOP allows for the classification of fields and even the exclusion and aggregation of fields that stand out according to their parcel shape characteristics. The fields with a proportion of IOP above 0.7 (Vinjole, Sedlarjevo, Sovjak, Stržišče and Trška gora), which were classified either as irregular blocks or furlongs according to Ilešič, should be classified into a new group.

We noticed deviations in the classification of fields based on parcel shapes with furlongs and continuous strips. Ilešič classified the fields of Kleče and Podgora as continuous strips, while according to IOP they were classified as furlongs due to the shorter strips. Buje and Žerovnica were classified as furlongs because of short strips.

Based on the statistical differences between fields we can identify some new groups and propose improvements upon Ilešič's field classification. This is the case with winegrowing areas, which are either considered irregular blocks or furlongs. This way we confirmed the working hypothesis about the possibility of producing a numerical index for describing parcel shapes to be used to determine and classify fields.

The use of the Parcel Shape Index has a wide ranging applicability. Parcel shape is important in agriculture in terms of the rational use of individual parcels (Zondonadi et al. 2013), while in Slovenia parcel shape should be included in identifying protected farmsteads and used in the analysis of GERK (Graphical Unit of Agricultural Land) and RABA (Register of Existing Agricultural and Forest Land Use) data kept by the ministry responsible for agriculture.

The parcel shape is, of course, not the only criterion for determining arable land division types, so it would be advisable to determine indices for other field characteristics, such as land distribution (Simmons 1964; Januszewski 1968; Igbozurike 1974; Gosar 1978; Razpotnik Visković 2012) and land use diversity (McGarigal in Marks 1995; McGarigal 2013, 2015).

5 Conclusions

The paper shows that IOP values and statistical indicators vary among fields as irregular blocks, enclosures, continuous strips, and furlongs. Ilešič's classification of fields in the selected test fields was mostly confirmed. Out of 22 fields 17 were classified in line with Ilešič's system. But because Ilešič also included other indicators in the determination of arable land division types, such as land fragmentation, the number of indices considered should be increased. Using the hierarchical clustering method and based on IOP fields can be classified into classes, which allows for confirmation and improvement upon the existing typification. Even though it is very difficult to describe all the visual characteristics of a spatial object using shape indices (Williams and Wentz 2008), doing so nonetheless limits an individual's subjectivity. Furthermore the transformation of a shape's characteristics to numerical values allows for easier processing and comparison of data. IOP could help us to observe the changing of parcel shapes (e.g. in a field). This would be particularly applicable where agricultural and built-up land meet, where the transformation of the shape of a parcel into (as a rule) a square indicates the purpose of transforming agricultural land into built-up land.

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CHRONOLOGY OF HETEROGENEOUS DEPOSITS IN THE SIDE ENTRANCE OF POSTOJNA CAVE, SLOVENIA

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The trail cut into cave deposits.

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Chronology of heterogeneous deposits in the side entrance of Postojna Cave, Slovenia

ABSTRACT: The development of the tourist trail in the side passage Rov Novih Podpisov of Postojna Cave in 2002 exposed an over four metres thick sedimentary succession characterised by horizontal flowstone layers intercalated between fine-grained fluvial sediments, and gravel deposits that record past environmental changes. The time of the flowstone deposition was determined by radiocarbon and uranium-thorium dating techniques. The results yielded three distinctive age groups of flowstone facies of 33 ka BP, 103 ka BP and 153 ka BP. These results also indicate that flowstone deposition has not been limited solely to periods of warm climate, which suggests that environmental conditions during glacial periods in south-western Slovenia supported flowstone deposition.

KEY WORDS: Geography, geoscience, geology, karst, stratigraphy, dating, ^{14}C, U/Th

Časovna interpretacija raznovrstnih sedimentov v stranskem vhodnem rovu Postojnske jame, Slovenija

POVZETEK: Pri modernizaciji turistične poti v Rovu novih podpisov, ki je stranski rov Postojnske jame, leta 2002 je bilo v več kot štiri metre globokem vkopu odkrito zaporedje menjajočih se plasti sige, fluvialnih sedimentov in grušča. Te plasti so pomemben pokazatelj preteklih okoljskih sprememb. Starost sige med plastmi je bila določena z radioogljikovo in uran-torijevo metodo. Siga se je odlagala v treh obdobjih, in sicer okoli 33 ka BP, 103 ka BP in 153 ka BP. Odlaganje sige ni bilo omejeno zgolj na topla obdobja, ampak se je siga odlagala tudi v hladnejših obdobjih. Rezultati kažejo, da je bilo na območju jugozahodne Slovenije vsaj v nekaterih hladnih obdobjih Pleistocena podnebje primerno za rast sige.

KLJUČNE BESEDE: Geografija, geoznanost, geologija, kras, stratigrafija, datiranje, ^{14}C, U/Th

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1 Introduction

Postojna Cave is a 24 km long system of underground passages with multiple entrances (Cave Register 2018, Figure 1). It is located in south-west Slovenia, which is famous for its high diversity (Perko, Hrvatin, and Ciglič 2015; Perko, Ciglič and Hrvatin 2017). Since 1819 the cave has been managed as a show cave (Shaw and Čuk 2015). During the last two centuries different parts of the cave were sequentially arranged and equipped for public access. It has a long tradition of cave exploration and scientific research (Valvasor 1689; Hohenwart 1830; Schmidl 1854; Perko 1910; Gams 1968; Gospodarič 1969; 1971; Ikeya, Miki and Gospodarič 1983; Šebela 1998; Šebela and Sasowsky 1999; Mihevc 2002; Stepišnik 2004; Šebela and Turk 2011; Ferk 2016; Domínguez-Villar et al. 2018; Pipan et al. 2018). It is a ponor cave of the Pivka River in the contact karst area where the surface streams (e.g., Lekinka River) from impermeable Eocene flysch rock sink into the karstified Upper Cretaceous limestone (Buser, Grad and Pleničar 1967; Šebela 1998; Pleničar, Ogorelec and Novak 2009; Stepišnik 2017).

The cave passages were formed at two main levels. The lower, several meters wide passages, are in the epiphreatic zone and periodically flooded on a yearly basis. The walls and ceiling contain solutional rock features (e.g. scallops), whilst the floor is mostly covered by fluvial sediments (i.e. flysch gravel) (Gospodarič and Habič 1966). Passages on the higher level have diameters mostly around 10 m and are hydrologically inactive. However, they preserve remnants of solution (e.g., scallops) and numerous interchanging fluvial and chemogenic sediments that were deposited in changing conditions, revealing a hydrologically dynamic evolution during their speleogenesis. Cave sediments indicate repeated fluvial deposition and successive erosion (Gams 1966; Gospodarič 1976). Palaeomagnetic analyses show that the oldest sediments are up to 2.15 Ma old, revealing that the cave system has evolved over a long period of time (Šebela and Sasowsky 1999; Zupan Hajna et al. 2008). The fluvial deposits and layers of flowstone close to the cave entrances are intersected by sequences of slope-derived gravel, remnants of Pleistocene large mammals and stone tools of Palaeolithic hunters (Rakovec 1954; Brodar 1966; 1969; Bavdek 2003).

About 50 m east of the main entrance to Postojna Cave is the entrance to one of its side passages called *Rov Novih Podpisov* that joins the main channel *Stare Jame* after about 150 m. The passage belongs to the higher and hydrologically inactive level. The passage floor at the entrance is on the elevation of 530 m a.s.l. which is from 10 to 19 m above the present ponor of Pivka River (from 511 to 520 m a.s.l.) depending on the water level. The shallow cave passage, from 2 to 4 m high and in average 10 m wide, was equipped as a biospeleological laboratory in 1931. At present it operates as the Vivarium with a research facility and an exhibition section where basic concepts of karstology and speleobiology are presented to the visitors. Recent slope-derived gravel covering the entrance was removed during construction works in the 1930s. In 2002 the entrance part was modified to ease access to the Vivarium for tourists. An over four metres deep trench was cut into the floor exposing a flowstone covered sedimentary succession composed of various cave sediments.

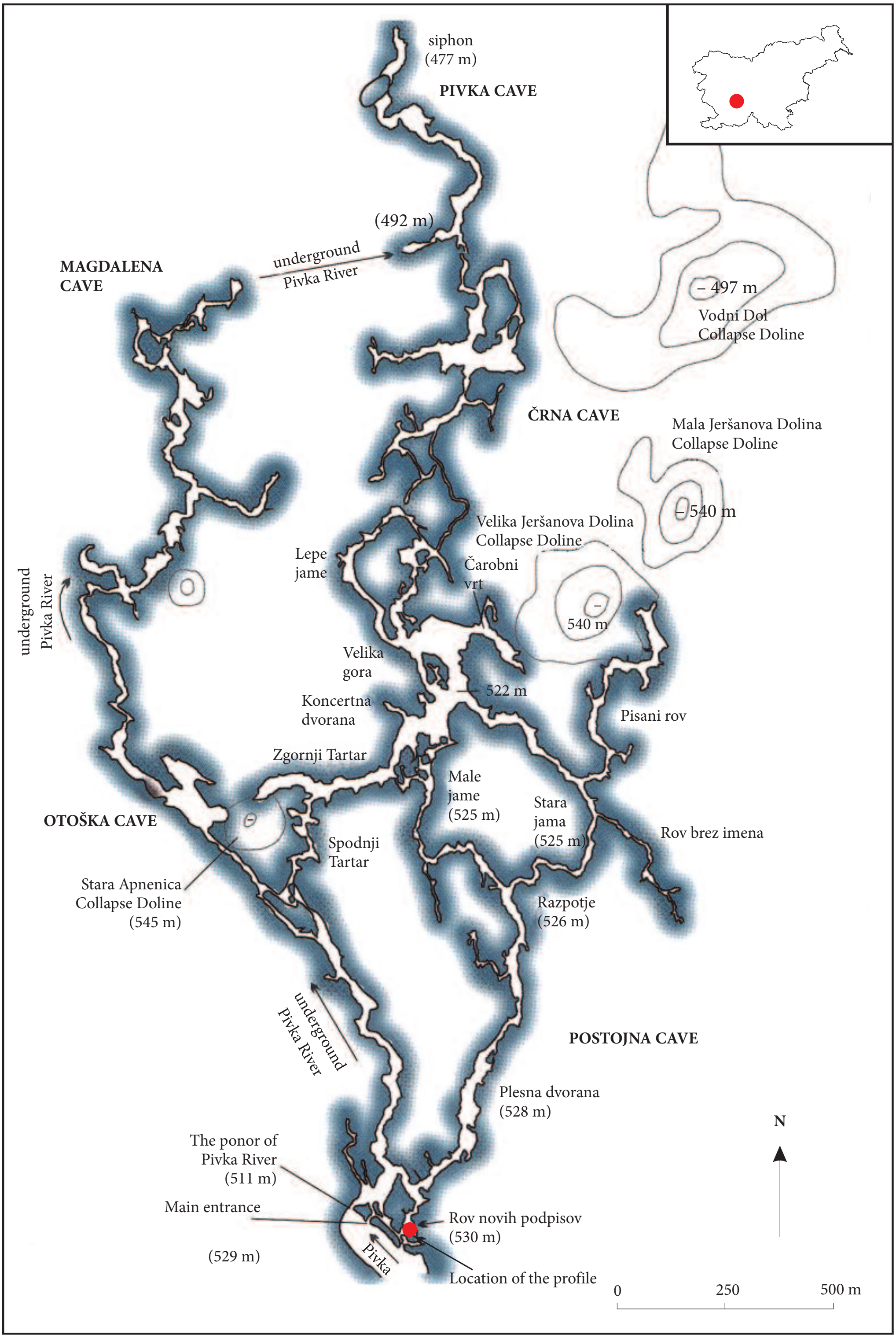
Palaeomagnetic research on the exposed sediments showed only N polarized magnetisation corresponding to the Brunhes Chron indicating the sediment was deposited within the last 780 ka (Zupan Hajna et al. 2008). Despite lacking any data of numerical dating the profile vas interpreted as »very young« (Zupan Hajna et al. 2008, 176). Based on Mousterian artefacts found in a nearby cave channel also filled with various sediments (Brodar 1966; Bavdek 2003), the middle and upper part of the profile was interpreted to be less than 40 ka old and the flowstone layer covering the profile to be of Holocene age (Mihevc and Zupan Hajna 2004; Gabrovšek and Mihevc 2009; Mihevc and Gabrovšek 2012). However, results of the first numerical dating of the uppermost flowstone revealed it was deposited 36 ka BP (Ferk 2016) strongly implying the previous chronological interpretations of the profile were inaccurate.

The aim of the paper is to present results of two different dating techniques coupled with additional mineralogical and grain size analyses to provide the robust chronological timeline of the exposed heterogeneous deposits, which will be beneficial for further palaeoenvironmental studies.

2 Methods

The 4.16 m thick profile was recorded in resolution bed-to bed using standard sedimentological log in 1:10 scale. Six stratigraphic levels were identified (Figure 2). From the succession five flowstone samples were

Figure 1: Location of the Postojna Cave System and the analysed cave sediments. ➤ p. 106


siphon
(477 m)
PIVKA CAVE
(492 m)
underground
Pivka River
MAGDALENA
CAVE
– 497 m
Vodni Dol
Collapse Doline
ČRNA CAVE
Mala Jeršanova Dolina
Collapse Doline
– 540 m
Velika Jeršanova Dolina
Collapse Doline
Čarobni
vrt
Lepe
jame
underground
Pivka River
540 m
Velika
gora
522 m
Koncertna
dvorana
Pisani rov
Zgornji Tartar
Male
jame
(525 m)
Stara
jama
(525 m)
OTOŠKA CAVE
Rov brez imena
Spodnji
Tartar
Stara Apnenica
Collapse Doline
(545 m)
Razpotje
(526 m)
underground
Pivka River
POSTOJNA CAVE
Plesna dvorana
(528 m)
N
The ponor of
Pivka River
(511 m)
Main entrance
Rov novih podpisov
(530 m)
(529 m)
Pivka
Location of the profile
0
250
500 m

acquired for age and geochemical analysis and one fine-grained clastic sediment sample was collected for mineralogical and grain size analyses.

2.1 Laboratory analyses for chemically precipitated sediment layers (flowstone)

Two stratigraphically older samples of flowstone were dated by the uranium-thorium (U/Th) method at the University of Queensland (Brisbane, Australia). To assure that samples have enough U/Th for dating, they were first sampled to provide ICP-MS trace element data. Ages were corrected for non-radiogenic ^{230}Th incorporated at the time of deposition. Full details of the method are provided in Hellstrom (2003; 2006). Age errors are reported as 2σ uncertainties.

In addition, the flowstone samples were analysed for both $\delta^{13}C$ and $\delta^{18}O$ isotopes at the stable isotope laboratory at the University of Melbourne (Australia), alongside with four samples of present-forming flowstone to compare the results for basic interpretation of climatic differences between the times of older flowstone deposition and present. Analyses were performed on CO_2 produced by reaction of the sample with 100% H_3PO_4 at 70 °C using continuous-flow isotope ratio mass spectrometry (CF-IRMS), following the method previously described in Drysdale et al. (2009) and employing an AP2003 instrument. Results are reported using the standard δ notation (‰) relative to the VPDB scale. Based on the following working standards, the uncertainty was 0.05‰ for $\delta^{13}C$ and 0.07‰ for $\delta^{18}O$ based on the NEW 1 standard.

Three stratigraphically higher deposited samples of flowstone were dated by the radiocarbon technique at the Beta Analytic Laboratory in Miami, USA. All samples provided enough carbon for accurate measurements. The ages are reported as RCYBP (radiocarbon years before present (AD 1950)). The modern reference standard was 95% the ^{14}C activity of the National Institute of Standards and Technoloy (NIST) Oxallic Acid (SRM 4990C) and calculated using the Libby ^{14}C half-life (5568 years). The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the $\delta^{13}C$ relative to the Vienna Peedee Belemnite (VPDB) scale. The Calendar Calibrated results are calculated from the Conventional Radiocarbon Age and listed as 2σ calibrated results.

2.2 Laboratory analyses for clastic sediment sample

The qualitative and quantitative mineral composition of the stratigraphically highest and youngest loamy sediment (facies B, see chapter 3) was determined by X-ray powder diffraction (XRD) analysis, which, in turn, indicates the source of the sediment (Haldorsen et al. 1989; Stanley, Nil and Galili 1998). We used the Faculty of Natural Sciences and Engineering, University of Ljubljana (Slovenia) Philips PW3710 diffractometer equipped with a Cu Kα radiation and a graphite monochromator, operating at 40kV and 30mA in continual scan mode with a speed of 0.5 °/min from 2° to 70° 2Θ. The Rietveld Method was used for semiquantitative mineralogical analysis.

To determine the deposition dynamics of the same sediment the grain size analysis using a Malvern Mastersizer 2000 particle analyser at La Trobe University (Melbourne, Australia) was carried out; full details of the latter analytical procedure are provided in Sperazza, Moore and Hendrix (2004).

3 Results and discussion

The maximum thickness of the exposed profile is 416 cm. We divided it into six stratigraphic levels of various horizontal facies (Figure 2). From bottom to top, these are:

- 416 to 370 cm, subangular gravel mixed with fine-grained sediment (facies F);
- 370 to 210 cm, very angular gravel mixed with fine-grained sediment and partly cemented with calcite (facies E);
- 210 to190 cm, white flowstone layers intercalated by two up to 1 cm thick black layers (facies D);
- 190 to 90 cm, angular gravel mixed with fine-grained sediment containing bones in the lower part (facies C);
- 90 to 45 cm, fine-grained sediment with indistinctive horizontal parallel lamination (facies B);
- 45 to 0 cm, white flowstone layers intercalated by millimetre thin layers of fine-grained sediment towards the lowest part (facies A).

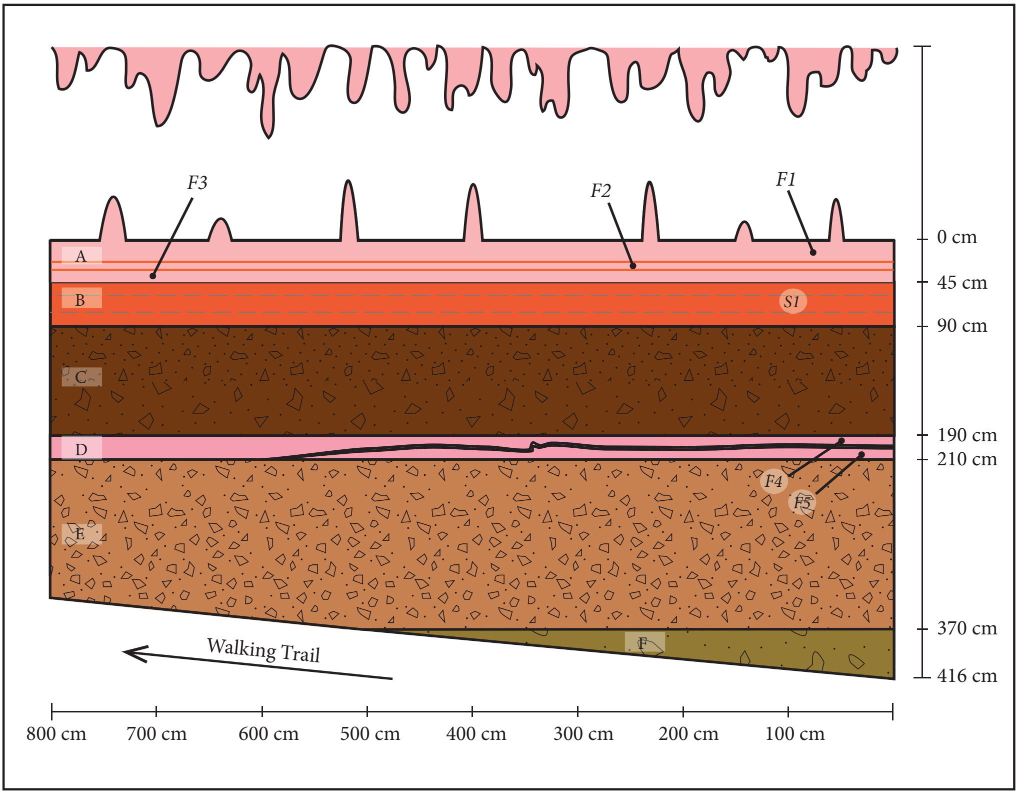


Figure 2: Stratigraphic levels of horizontal facies identified in the analysed sediment profile in the side passage *Rov Novih Podpisov* of Postojna Cave.

3.1 Facies F

Facies F is the oldest recognised facies in the succession (Figure 2). The total thickness cannot be determined due to the limited exposure but is at least 46 cm thick. The facies consists of subangular limestone gravel with clast size mostly around 5–10 cm and some larger pieces with diameters up to 20 cm. The gravel is poorly sorted and mixed with grey to yellow fine-grained sediments presumably originating from the flysch rocks in the Pivka Basin (Zupan Hajna et al. 2008). Mihevc and Zupan Hajna (2004) describe the facies F as the oldest sediment deposited in the cave by the Pivka River which was partly eroded away in the upper part.

3.2 Facies E

The facies E is 160 cm thick and is the thickest facies in the succession (Figure 2). It consists of very angular well sorted limestone gravel with clast size around 5 cm. The gravel originates from the local limestone which builds cave walls and ceiling. It is partly cemented with calcite in the upper part. The amount of calcite cement decreases towards the lower part of the facies. The gravel is mixed with light brown fine-grained sediment.

Mihevc and Zupan Hajna (2004) assumed the layer was deposited at the beginning of the last glacial period (Würm glaciation; Marine Isotope Stage (MIS) 5-2) in climate similar to the present one (Mihevc and Gabrovšek 2012) although no numerical datations were published. Results of the current study revealed an older age of the deposits, since the deposition of the facies E ended more than 150 ka BP (see chapter 3.3).

3.3 Facies D

The facies F is covered by a 30 cm thick layer of white flowstone (facies D; Figure 2). The flowstone includes two up to 1 cm thick black layers that resemble charcoal. Two samples of flowstone from facies D were analysed; sample F4 was taken from the upper part of the facies, from above the black layer, and sample F5 was taken from the lower part of the facies, from beneath the black layer.

The results of the ICP-MS trace element data (Table 1) revealed that both samples have U/Th levels high enough for dating. The U/Th dating results yielded an age of 103.2 ka (MIS 5c) for the stratigraphically younger flowstone (F4) and 153.1 ka (MIS 6) for the older flowstone (F5) (Table 2).

Table 1: ICP-MS trace element data for the flowstone of facies D. Concentration results in ppb or ng/g. Note: ^{6}He (i.e. enriched ^{6}Li), ^{61}Ni, ^{103}Rh, ^{115}In, ^{187}Re and ^{235}Np (i.e. enriched ^{235}U) are internal standards added to the sample solutions.

Sample	F4	F5		F4	F5		F4	F5
^{6}He	0	0	^{86}Sr	24994	30598	^{165}Ho	2.8	2.8
^{7}Li	72.2	27.7	^{89}Y	106.7	108.8	^{166}Er	7.7	7.8
^{9}Be	28.2	12.8	^{90}Zr	96.2	70.4	^{169}Tm	1.1	1.1
^{25}Mg	102191	104147	^{93}Nb	9	4.8	^{172}Yb	6.5	6.7
^{31}P	341172	162150	^{98}Mo	4.3	2.1	^{175}Lu	0.9	0.9
^{43}Ca	427280107	411705358	^{103}Rh	0	0	^{178}Hf	1.6	1.2
^{45}Sc	112.9	111.8	^{111}Cd	35	47.8	^{181}Ta	–0.4	–0.5
^{49}Ti	1702.1	1291.9	^{115}In	0	0	^{184}W	4.7	4
^{51}V	326.8	236.1	^{120}Sn	2.3	–3.9	^{187}Re	0	0
^{53}Cr	265.1	340.9	^{121}Sb	2.2	2.2	^{202}Hg	46	45.7
^{55}Mn	1097.7	1525.3	^{133}Cs	17	9.3	^{205}Tl	12.5	12.7
^{57}Fe	807828	776202	^{137}Ba	2569.5	12116	^{206}Pb	83.8	69.3
^{59}Co	256.4	312.3	^{139}La	84.2	79.5	^{207}Pb	76.1	62.6
^{60}Ni	42550	3658	^{140}Ce	167.5	134.8	^{208}Pb	79.1	64
^{61}Ni	0	0	^{141}Pr	22.3	19.9	^{209}Bi	2.3	1.4
^{65}Cu	687.3	411.9	^{146}Nd	84.7	82.1	^{220}Bkg	0	0
^{66}Zn	1170.7	550	^{149}Sm	18.7	17.8	^{232}Th	13	9.7
^{69}Ga	15.2	–57.8	^{151}Eu	4.1	4.2	^{235}Np	0	0
^{71}Ga	26.4	14.8	^{159}Tb	2.8	2.4	^{238}U	362.4	215.3
^{74}Ge	1.6	0.2	^{160}Gd	17.8	16.5	U/Th	28.0	22.2
^{85}Rb	187.5	100.2	^{161}Dy	14.8	12.8			

Table 2: U-Th isotope data for the flowstone of facies D. Two laboratory standards included: YB-1 is an ANU speleothem standard with an age of 30.2±0.6 ka. SRM-960 U is a metal standard manufactured during the World War II (~1936).

Sample	F4	F5	SRM-960 standard	YB-1 speleothem std
Sample wt. (g)	0.103	0.103	0.1057	0.10214
U (ppm)	0.35038	0.23732	5.53963	0.12525
±2σ	0.00015	0.00010	0.0046	0.00004
^{232}Th (ppb)	51.442	46.151	0.008	0.486
±2σ	0.083	0.062	0.000	0.001
(^{230}Th/ 232Th)	13.091	12.044	1484.971	339.829
±2σ	0.039	0.034	28.251	1.229
(^{230}Th/238U)	0.6334	0.7719	0.0007	0.4343
±2σ	0.0016	0.0020	0.00001	0.0015
(^{234}U/ 238U)	1.0095	1.0055	0.9636	1.7492
±2σ	0.0011	0.0009	0.0007	0.0013
Uncorr. Age (ka)	107.59	159.0	0.0805	30.53
±2σ	0.51	1.0	0.0009	0.12
Corr. Age (ka)	103.2	153.1	0.0805	30.46
±2σ	2.3	3.1	0.0009	0.12
Corr. Initial (^{234}U/ ^{238}U)	1.0132	1.0090	0.9636	1.8174
±2σ	0.0015	0.0015	0.0007	0.0014

The up to 1 cm thick black layers resembling charcoal deposits in the middle part of the flowstone has not been examined. According to the presence of a Palaeolithic site in the close vicinity where artefacts of Mousterian stone tools were discovered (Brodar 1966) it is likely the layer is a cultural deposit. Based on the measured ages of the flowstone underlying and covering the black layer it should be attributed to the presence of Neanderthals, which is in accordance with the Mousterian stone tools found nearby (Brodar 1966; Bavdek 2003).

According to the general palaeoclimatic curve for that time frame (Friedrich et al. 2016), the flowstone was deposited during the MIS 6 glacial period with generally colder temperatures and the MIS 5c interstadial with generally warmer temperatures. In addition, the flowstone layers have heavier oxygen isotopic values (–6.45‰ (F4) and –6.20‰ (F5)) than the present-forming flowstone (~ –6.83), which may reflect a reduced plant activity and thus lower levels of soil CO_2 production, or a higher proportion of plants adopted to the climate with less effective rainfall during the time of flowstone deposition (103.2 ka and 153.1 ka BP; Figure 3). This could be especially valid for the MIS 6 glacial period (and the heaviest value of the F5 sample) when global water circulation was reduced due to lower evaporation.

3.4 Facies C

Facies C is a 1 m thick layer of moderately sorted gravel composed of angular limestone clasts. In the lowermost part the clasts are up to 10 cm large and animal bones are present between them, while the clasts are smaller (up to 5 cm) in the middle and upper part of the facies. The gravel is mixed with brown fine-grained sediment. The clasts are composed of the same rock as the cave walls and ceiling. Mihevc and Gabrovšek (2012) interpreted the gravel slided from the entrance deeper into the cave by cryoturbation. Based on archaeological findings of Mousterian stone tools at the nearby Palaeolithic site, few tens of metres away (Brodar 1966), Mihevc and Zupan Hajna (2004) assumed the facies C was deposited between 40 and 20 ka BP and during the Last Glacial Maximum. However, results of the numerical dating methods show the time of gravel deposition in the cave is constrained by the lower lying 103.2 ka old horizontal layer of flowstone (facies D) and the 36.8 ka old flowstone toping the profile (facies A). Therefore, the facies C is older than previously believed and was deposited between MIS 5c and MIS 3. The gravel production may have intensified at the transition between MIS 5a and the glacial maximum during MIS 4 when the general average temperatures were lower than the present one (Friedrich et al. 2016).

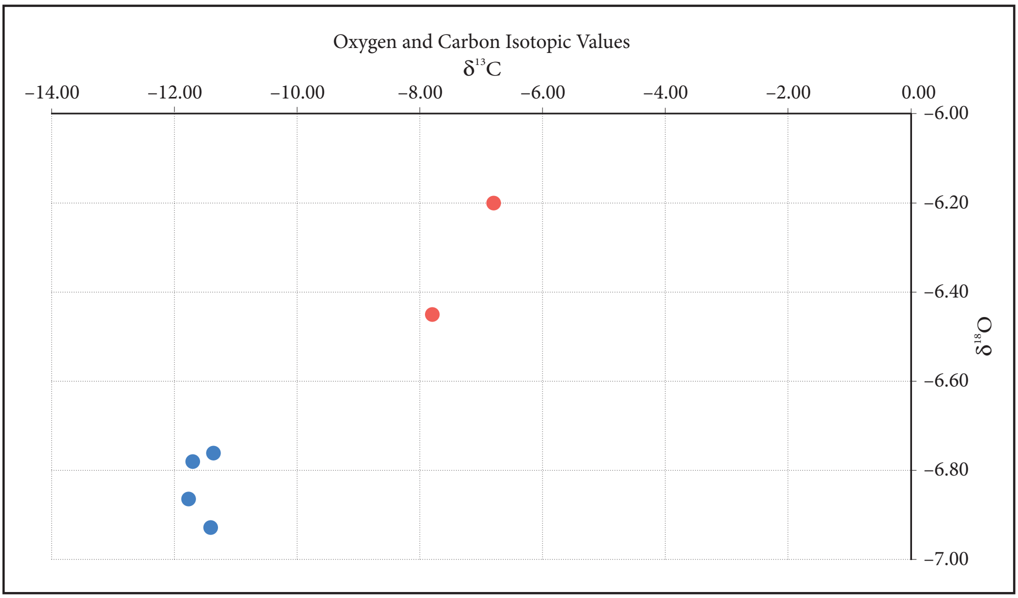


Figure 3: Diagram of oxygen and carbon isotope values of the flowstone (facies D). Orange colour: flowstone samples F4 and F5; blue colour: present-day samples of flowstone.

3.5 Facies B

Facies B is a 45 cm thick layer of homogenous red fine-grained sediment with partially preserved horizontal and parallel lamination which was sampled for mineral and grain size analyses. The X-ray powder diffraction (XRD) analysis showed that the sediment consists of quartz (47%), muscovite/illite (24%), chlorite (18%), K-Na feldspar (7%) and kaolinite (4%) (Ferk 2016). Based on the mineral composition the provenance of this sediments are flysch rocks (Orehek 1970) present in the Pivka River catchment (Buser, Grad and Pleničar 1976; Pleničar, Ogorelec and Novak 2009). The grain size analysis showed the sediment is silt loam according to the Soil Bulk Density Calculator (Wentworth 1922; Plaster 1992), consisting of 68.61% silt, 21.9% clay, and 9.49% sand (Table 3; Figure 4).

Table 3: Grain size characteristics of the facies B sediment (sample S1).

Grain size (mm)	Classification		Percentage (%)	
	Major	Minor		
2-1	Sand	Very coarse sand	0.59	9.49
1-0.5		Coarse sand	2.21	
0.5-0.25		Medium sand	2.18	
0.25-0.125		Fine sand	1.27	
0.125-0.062		Very fine sand	3.24	
0.062-0.031	Silt	Very coarse silt	10.15	68.61
0.031-0.016		Coarse silt	18.43	
0.016-0.008		Fine silt	21.07	
0.008-0.004		Very fine silt	18.96	
< 0.004	Clay	Clay	21.9	21.9

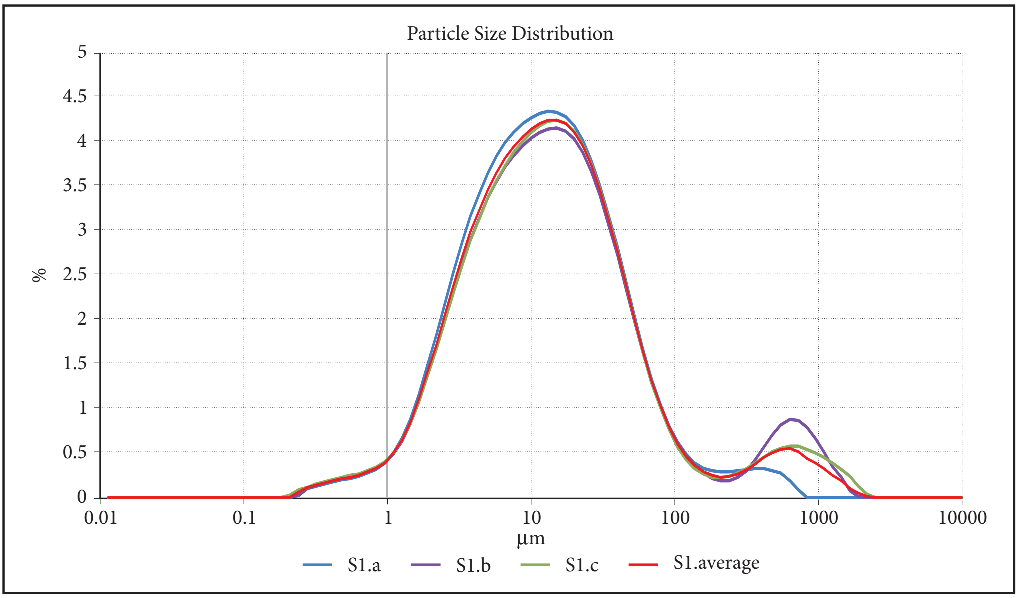


Figure 4: Grain size characteristics of the facies B sediment (sample S1).

Supposedly, these sediments were washed into the cave from the Pivka Basin during episodic flooding and sedimentation from suspension in a standing or slow-moving water as suggested by parallel horizontal lamination and silt loam texture of the sediment (cf. Farrant and Smart 2011; Ferk 2016). Considering that the laminas are less than 1 mm thick, the 45 cm thickness of the sediment would suggest a long time-scale of periodical flooding and not a single extreme event. However, laminated silt loam deposits can derive from aeolian material redeposited by overland flow (Mücher and De Ploey 1984) which is in accordance with Zupan Hajna et al. (2008) who suggested that the sediment of facies B was washed into the cave from the surface. Nevertheless, the age of the flowstone (facies A) above the silt loam sediment shows that the sedimentation of facies B ceased around 36.8 ka BP.

3.6 Facies A

The top layer of the profile, facies A, is a 45 cm thick white flowstone. In the lower half the flowstone is intercalated with thin layers of red fine-grained sediment. Three flowstone samples from facies A were dated using radiocarbon technique (Table 4). The micro location of the samples within the flowstone was chosen based on their stratigraphic location (Figure 2): sample F1 was taken from the top of the facies A, sample F2 was taken from the middle of the facies A underlying an up to 5 cm thick layer of fine-grained sediment, and sample F3 was taken from the lowest part of the facies underlying an up to 1 cm thick layer of intercalated fine-grained sediment. The calibrated radiocarbon ages of flowstone F1, F2 and F3 yielded ages of 33.2 ka, 34.9 ka and 36.8 ka BP, respectively. Their accordance with the stratigraphical position strengthens the reliability of the results and suggests the deposition of the facies A between 33.2 and 36.8 ka (Ferk 2016). The age of the facies A is older than previously thought when it was linked to the Holocene (Mihevc and Zupan Hajna 2004; Zupan Hajna et al. 2008).

The deposition of flowstone occurred during MIS 3 which is characterised by high variation of average temperature amplitudes, although the stage in general is part of the last glacial period (Lisiecki and Raymo 2005). During the MIS 3 the temperatures were globally slightly higher than during the MIS 2 and MIS 4 periods. The cave entrance at that time must have been blocked as flowstone deposition requires absence of frost weathering. This is strongly indicated also by the absence of broken speleothems or frost weathering affected speleothems during the Last Glacial Maximum (e.g. MIS 2). The end of flowstone deposition towards the final stage of MIS 3 marks the beginning of a still ongoing hiatus in deposition at the location of the analysed profile.

The carbon isotopic values of the flowstone are heavier than the present values (see Section 3.3) and suggest a reduced plant activity compared to a modern vegetation above the cave or a higher proportion of plants more adapted to drought (Gillies 2011), which could be a result of colder climate with less effective precipitation.

Table 4: Results of radiocarbon dating of the topmost flowstone (facies A).

Sample	Measured Radiocarbon Age (BP)	±1RSD	Conventional Radiocarbon Age (BP)	±1RSD	δ13C (‰ PDB)	Calibrated Radiocarbon Age (BP)	±2σ
F1	28410	140	28720	140	–5.9	33165	275
F2	30060	160	30330	160	–8.4	34860	180
F3	32080	180	32360	180	–7.8	36800	240

4 Conclusion

Construction works for touristic purposes in the Postojna Cave led to the exposure of an over 4 metres deep sedimentary succession composed of various cave sediments in the side passage *Rov Novih Podpisov of the Postojna Cave*. Six horizontal stratigraphic levels of depositional facies were identified (bottom to top); subangular gravel (facies F), very angular gravel (facies E), flowstone (facies D), angular gravel (facies C), red silt loam (facies B), and flowstone (facies A).

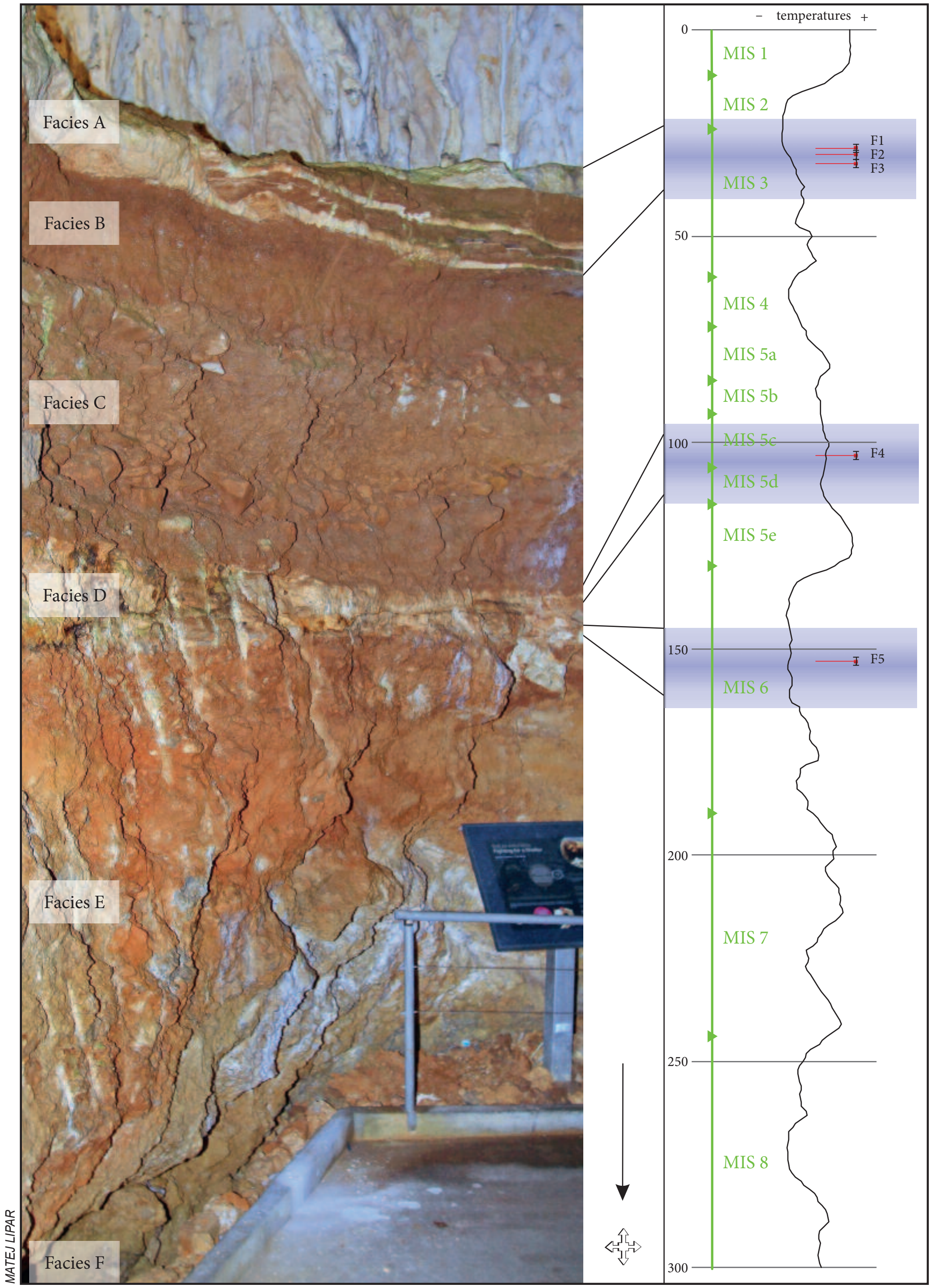


Figure 5: The profile of deposits at the side entrance of the Postojna Cave with the timeline of sediment deposition. The temperature curve is based on data by Friedrich et al. (2016).

Flowstone from two stratigraphic levels (facies A and D) was collected for radiocarbon (3 samples) and uranium-thorium (2 samples) dating, respectively. The dating results show the deposits are older than previously thought. The stratigraphically higher and younger flowstone was deposited in the second half of MIS 3 (33,2–36,8 ka BP), and the stratigraphically lower flowstone was deposited in the second half of MIS 6 (153,1 ka BP) and in MIS 5c (103,2 ka BP). The numerical dates of the flowstone age show its deposition during periods of low average temperatures. Consequently, we argue that despite lower temperatures in these periods the amount of precipitation was probably lower, but still sufficient to allow flowstone deposition.

During MIS 6 and MIS 5c the flowstone deposition was probably occasionally interrupted which is indicated by two distinctive up to 1 cm thick black layers resembling charcoal, stretching throughout the side passage. The black layers could be a cultural deposit attributed to the Neanderthal activities and related to the nearby Palaeolithic site where Mousterian stone tools were found.

The dated facies of flowstone are separated by a 1 m thick layer of gravel (facies C) and a 45 cm thick layer of red silt loam (facies B). The silt loam was sampled for mineral and grainsize analyses, proving the sediments origin in flysch rocks from where it was transported into the cave and deposited whether from calm water during floods or overland flow redeposition of aeolian sediment. Both facies between the flowstone layers were deposited between MIS 5c and MIS 3.

Based on the flowstone age, the stratigraphically lowermost layers of gravel (facies F and E) were deposited earlier than 153.1 ka BP. Especially the lowermost subangular gravel (facies F) could reach a significant age, since the upper boundary of the facies shows traces of an erosion phase during which at least some of the gravel was removed before the next depositional phase of gravel deposition begun (facies E).

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Green creative environments

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GREEN CREATIVE ENVIRONMENTS: CONTRIBUTION TO SUSTAINABLE URBAN AND REGIONAL DEVELOPMENT

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Greenery in the Chinese city of Chongqing.

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Green creative environments: Contribution to sustainable urban and regional development

ABSTRACT: The aim of this paper is to provide a theoretical and conceptual introduction for the Special Issue on the role of green creative environments in sustainable urban and regional development. The idea is based on the assumption that concepts of creativity mostly address economic issues and to a lesser extent social issues, while green concepts predominantly deal with environmental aspects. Therefore, we lack a deeper insight into the interrelations between creative and green environments in urban and regional development. This special issue addresses this research gap through investigating 1) the residential preferences of the creative class in city-regional, urban and rural settings, 2) participatory urbanism as a tool for creative interventions in urban planning, and 3) the importance of green amenities as spatial attraction factors for small creative actors. We argue that green creative environments can contribute to sustainable urban and regional development.

KEY WORDS: creativity, innovation, sustainability, nature, creative city, green city, creative industries, natural amenities

Zelena ustvarjalna okolja: prispevek k trajnostnemu urbanemu in regionalnemu razvoju

Namen tega prispevka je prispevati teoretski in konceptualni uvod v posebno izdajo o vlogi zelenih ustvarjalnih okolij v trajnostnem urbanem in regionalnem razvoju. Ideja temelji na predpostavki, da koncepti ustvarjalnosti večinoma obravnavajo ekonomska vprašanja in v manjši meri socialna vprašanja, zeleni koncepti pa se pretežno ukvarjajo z okoljskimi vidiki. Zato v urbanem in regionalnem razvoju nimamo globljega vpogleda v medsebojne povezave med ustvarjalnimi in zelenimi okolji. Posebna izdaja revije obravnava to raziskovalno vrzel s preučevanjem 1) bivanjskih preferenc ustvarjalnega razreda v regionalnih, mestnih in podeželskih okoljih, 2) participativnega urbanizma kot orodja za ustvarjalne posege v urbanistično načrtovanje in 3) pomena zelenih dobrin kot dejavnika prostorske privlačnosti za male ustvarjalne akterje. Trdimo, da zelena ustvarjalna okolja lahko prispevajo k trajnostnemu urbanemu in regionalnemu razvoju.

KLJUČNE BESEDE: ustvarjalnost, inovacije, trajnostnost, narava, ustvarjalna mesta, zelena mesta, ustvarjalne dejavnosti, naravne dobrine

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1 Introduction

This special issue is taking into consideration two distinct, but interrelated fields in urban and regional development. The first issue refers to creativity and related concepts such as creative industries, creative economy, and the creative class. The second issue pertains to the natural environment, which can be associated with concepts such as green infrastructure, green economy, greenery, ecosystem services, and nature-based solutions. Both are heavily cited as significant factors of sustainable urban and regional development (Ravbar, Bole and Nared 2005; Bole 2008; Ravbar 2011; Mell et al. 2013; Clifton, Comunian and Chapain 2015; Smrekar, Šmid Hribar and Erhartič 2015; Uršič 2016; Bowen and Lynch 2017; Kozina and Bole 2017; Kozina 2018; Lazzeretti, Capone and Innocenti 2018), but from different aspects and in different manners. Whereas the »creative city« mostly addresses economic and to a minor degree social issues (Pratt and Hutton 2013), the »green city« predominantly deals with environmental features (Brilhante and Klaas 2018). However, the line between them is subtle. The creative economy and creative jobs are not easily identified and measured (Boggs 2009) and the same is true of green economy and green jobs (Muro, Rothwell and Saha 2011). Cooke (2013) reports that »eco-innovation« on the one hand and creative industries analysis on the other have largely operated in sealed containers or intellectual »silos«. Stolarick and Smirnova (2015) argue that clean, green, creative, and smart cities have all been separately identified, measured, ranked, and evaluated. So there is a need to take these concepts and their potential interrelations into deeper consideration.

The roots of the creative city movement can be sought in a discourse of a post-industrial society that has seen a shift from traditional manufacturing to new agents of growth such as knowledge, creativity, and innovation (Bell 1973; Scott and Storper 2015; Florida 2002; 2005; 2008). In the 1980s, the »cultural turn« moved attention away from the Marxist tradition towards culture by favouring cultural industries (Garnham 2005) that refer to the traditional cultural economics and to forms of cultural production characterised by symbolic elements (Lazzeretti, Capone and Innocenti 2018). Since the 1990s, the »creative turn« has denoted the dawn of a new era in political and academic domains by constructing creative industries and later the creative economy as a policy object that can be managed to secure primarily economic, but also occasionally social outcomes so as to increase competitiveness (Schlesinger 2017; Kozina and Bole 2018). The focus of cities, regions, and countries across the world has thus been redirected to the importance of creativity and innovation in fostering development with the emergence of highly interrelated concepts such as creative industries, creative economy, and the creative class (Chapain, Clifton and Comunian 2013).

The origins of the green city movement can be associated with rapid urbanisation, industrialisation, and the deterioration of urban environmental performance in the 20th century (Brilhante and Klaas 2018). As a response to pressing challenges in the 1980s, strong voices emerged to reconcile economic growth, environmental preservation, and social development (WCED 1987). The new millennium has seen the »green turn« as a response to the global ecological crises and the accumulating evidence of rising inequality (Bina and La Camera 2011). It signifies a new privileging of listening to consumer demand for more usable, less over-engineered, more sustainable goods and services (Cooke 2010). To address these issues, modern cities apply collective approaches to the use and management of green spaces in urban social-ecological systems. This form of social-ecological innovation provides a valuable resource in the production and adaptive management of local ecosystem services (Dennis and James 2018).

At the moment, we lack more detailed theoretical and empirical contributions about the interrelations between creativity and natural environment in urban and regional development. This special issue addresses this challenge by focusing on selected examples of:

1) residential preferences of the creative class in city-regional, urban, and rural settings,
2) participatory urbanism as a tool for creative interventions in urban planning,
3) the importance of green amenities as spatial attraction factors for small creative actors.

However, the aim of the special issue and the following contributions is not to comprehensively address the role of green creative environments in urban and regional development. Instead, it wants to reveal some hidden aspects in analysing the connection between creativity and the natural environment and unveil the potential spatial implications of their synergies. A shift is needed in how we mutually reflect the creativity and the environment. The changing nature of the society, the economy, and the environment demands new solutions for governance and communication. We argue that by focusing on green creative environments, we can begin to near sustainable urban and regional development and a high quality of life.

2 Natural environments: a missing aspect in studying the impact of creativity on urban and regional development?

The impact of the natural environment on creative and knowledge-intensive processes has been analysed by various disciplines such as psychology, interior design, education and health studies, landscape architecture, etc. A large body of evidence shows that interaction with greenery can be beneficial for reducing stress and improving emotional states and cognitive function (Van Den Bogerd et al. 2018). The environment, including green areas discussed here, influences creativity, because a connection to nature enhances creative performance (van Rompay and Tineke 2016) and is associated with innovative and holistic cognitive styles (Leong, Fischer and McClure 2014). Nature plays a role especially in the preparation phase and the incubation phase of the creative process (Plambech and Konijnendijk van den Bosch 2015).

The impact of greenery has a significant impact on creativity within indoor physical environments (Dul and Ceylan 2011; Caple 2019) and also when it is exposed to outdoor natural environments (Plambech and Konijnendijk van den Bosch 2015). For this reason, connectedness with nature should be promoted in schools, workplaces, and at home (Leong, Fischer and McClure 2014). Green areas can contribute to new ways of understanding modern environmental issues such as noise, pollution, and other hazards in urban and rural areas where new creative and innovative solutions are constantly being pursued.

In spite of abundant evidence of the highly positive impact natural environment has on creativity, the research in urban and regional science offers only limited proof to support such relations. Proximity to the natural environment as part of the so-called »soft« factors such as diversity, openness, amenities, and tolerance plays only a marginal role in attracting creative and high-skilled workers to a particular place. However, these factors play a more important role in retaining the creative capital in a given area, which justifies policies aimed at retaining people rather than attracting them (Martin-Brellot et al. 2010). Professional and social relations, other types of local social connections related to people's life courses, and so-called »hard« conditions, especially job availability, seem to be the more relevant drivers of creative urban and regional development (Musterd and Gritsai 2012). The reasons for such outcomes are at least twofold. First, recent studies on regional creative capacity often focus on the urban context without taking into account the rural settings (Gülümser, Baycan-Levent and Nijkamp 2010), which exhibit a more prominent role of the natural environment. As reported by some authors, attraction to rural areas might be significantly attributed to an access to outdoor amenities and activities (McGranahan and Wojan 2007; White 2010). Second, creativity in urban and regional development has been mostly applied through the »culture-centric« and »econo-centric« approach (Andres and Chapain 2013), which has neglected the ecological perspective of sustainability.

This brings us back to the initial question: what is the relation between green and creative environments? Are these two different concepts in their own right or do they share some commonalities? Cooke (2013; 2015) tried to merge the two central themes of this special issue through »eco-innovation« and »eco-art«. These two conceptualizations imply that synergies between creativity and greenery are relevant to promoting sustainability. However, the connection between them is undermined by Stolarick and Smirnova (2015), who offer a rare example of statistical comparative analysis of green, sustainable, creative, and smart cities. Their findings suggest that these concepts are different and measured differently. While each may have its own importance and value to many regions for various reasons, they are different dimensions that are quite independent of each other – at least currently and by using the available measures. This kind of argumentation calls for additional in-depth research into the connection between creativity and the natural environment in urban and regional development.

3 Ljubljana as an example of a green creative city

One of the starting points for preparing this special issue was the conference »Creative Green Ljubljana: From Theory to Practice«, organized in 2016 by the Research Centre of the Slovenian Academy of Sciences and Arts and Poligon Creative Centre. Its aim was to accelerate the flow of knowledge and information in the field of creative industries, but with the focus on green aspects, since Ljubljana at that time celebrated and promoted its European Green Capital 2016 Award. Ten researchers from diverse disciplines discussed how developed the cultural and creative industries in Slovenia are and what is their role in a sustainable economy. They also analysed which socio-cultural projects and initiatives creatively support a sustainable and participatory development of Ljubljana and indicated how such activities can contribute to social innovation while preserving the environment.

Ljubljana proved a good point of departure for discussions; besides promoting its green qualities (being a European Green Capital 2016, Global Top 100 Sustainable Destination, World's Best Sustainable Destination etc.), it has been heavily branded with its »culture« and »creativity« (e.g. as the 2010 World Book Capital and the 2015 UNESCO City of Literature). This reflects the city's strategy to intertwine cultural and green measures, which has proved particularly successful for its current development. The common denominator of both concepts is a notion of the »quality of life«: the goal cities are striving for in order to attract inhabitants, tourists, companies, and investment bringing in new revenues of economic and human capital (Poljak Istenič 2016). However, the quality of life always depends on sustainability, as the cities must maintain the capacity to meet its residents' future needs in relation to just ecological, economic, and social systems (Evans 2002). Yet, the link between creativity, sustainability (or green urban policies and measures ensuring it), and the quality of life is often unclear or even contested, thus, it calls for further elaboration.

4 Filling the gaps: papers of the special issue

The special issue fills some gaps in studying the interrelations between creativity and the natural environment in urban and regional development. The selected examples encompass 1) the residential preferences of the creative class in city-regional, urban, and rural settings, 2) participatory urbanism as a tool for creative interventions in urban planning, and 3) the importance of green amenities as spatial attraction factors for small creative actors.

The first paper by Kozina and Clifton (2019) addresses the question on what matters more in understanding the residential location of the creative class in Slovenia: the city-region or the urban-rural framework? Their analysis shows that differences in residential concentrations of the creative class vary more within city-regions (on an urban-rural framework) than between city-regions. Moreover, the creative class is moving out of densely populated urban areas to more sparsely populated suburban and rural areas within all city-regions. Their research indicate that the new models of living promote dispersion. Subsequently, the authors contest the claim that creative-knowledge activities are fundamentally a predominantly urban-centric phenomenon. In the long run, they seem to become impregnated by a mixture of rurality and suburbanity with a more prominent role of the natural environment.

Shifting the focus of the analysis from rural to urban settings, the paper by Poljak Istenič (2019) presents the concept of participatory urbanism as a tool for creative interventions in urban planning and analyses its practical implications in the context of the City of Ljubljana. It assesses the potential of participatory methodology for physical and social interventions in public spaces through the case-studies of two creative spatial practices: the *Onkraj gradbišča / Beyond the construction* site urban community garden and the community-led renovation of the *Savsko naselje* neighbourhood. The cases show how bottom-up initiatives can contribute to the sustainable development of an urban area, especially to its environmental and social features. The paper concludes with ideas on how cities might engage with bottom-up spatial practices to increase the effectiveness of urban spatial planning, management, and administration and to boost their green creative image.

Closing this special issue, the paper by Uršič and Tamano (2019) investigates the importance of green amenities for small creative actors in Tokyo. In the last decade, the Japanese authorities have invested considerable effort and economic resources into constructing developmental models that can help build a friendlier environment for the domestic creative economy. Based on an analysis of spatial attraction factors for individuals of various creative occupations, the authors identify how important green or natural amenities are in comparison with other sociocultural characteristics regarding small creative groups. The analysis of data acquired through semi-structured interviews indicates that green amenities do not play a primary role in the spatial distribution of small creative groups, but they do play a very important secondary role in cases when creative workers consider places with similar spatial attraction characteristics in Tokyo's specific areas.

5 Conclusion

The aim of the special issue is to contribute new evidence to the studies of urban and regional development by unveiling the connections between creativity and nature. The idea is based on the assumption that the concepts of creativity mostly address economic and to a lesser extent social issues (Pratt and Hutton 2013), while green concepts predominantly deal with environmental features (Brilhante and Klaas 2018). The »creative city«, the »green city«, and other similar paradigms are all useful when addressing the challenges caused by the (de)industrialisation and urbanisation of recent decades. These are related to the transformed post-industrial way of production and consumption and associated environmental pressures. Although the link between creativity and the natural environment seems quite obvious in this regard, the literature offers quite a limited set of theoretical and practical contributions. For this reason, the authors of this special issue have cross-pollinated the two fields of interest by searching for their interrelations.

The main findings suggest that agglomeration logics do not necessarily apply when studying the relationship between urban hierarchy and the distribution of the creative economy. Thus, urban and regional planners should also invest in rural/suburban localities with a significant extent of natural amenities and the increasing amount of creative and knowledge workers. However, green infrastructure should also be promoted in urban areas, especially when trying to retain talent in certain districts. Merging green environments and practices with participatory and collective actions can then boost urban development. Cities should simultaneously invest in physical and social green infrastructure in order to reach their ultimate goal: a high quality of life of its citizens.

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PARTICIPATORY URBANISM: CREATIVE INTERVENTIONS FOR SUSTAINABLE DEVELOPMENT

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Participatory urbanism builds communities, contributes to sustainable development and boosts a creative city image.

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Participatory urbanism: creative interventions for sustainable development

ABSTRACT: The paper presents the concept of participatory urbanism and analyses its practical implications in the context of the City of Ljubljana. It assesses the potential of participatory methodology for physical and social interventions in public spaces through the case-studies of two creative spatial practices: urban community garden *Onkraj gradbišča / Beyond the construction site* and community-led renovation of *Savsko naselje* neighbourhood. It indicates how bottom-up initiatives can contribute to sustainable development of an urban area, especially to its environmental and social features. It concludes with the ideas of how cities might engage with bottom-up spatial practices to increase the effectiveness of urban spatial planning, management and administration, and to boost their green creative image.

KEY WORDS: participatory urbanism, grassroots creativity, spatial policy, creative city, European Green Capital, Ljubljana, Slovenia

Participativni urbanizem: ustvarjalni posegi za trajnostni razvoj

POVZETEK: Prispevek predstavi koncept participativnega urbanizma in analizira njegove praktične učinke v Mestni občini Ljubljana. Na primeru dveh ustvarjalnih prostorskih praks, urbanega skupnostnega vrta Onkraj gradbišča in skupnostne prenove Savskega naselja, avtorica vrednoti potencial participativne metodologije za fizične in družbene posege v javni prostor. Nakaže, kako lahko iniciative od spodaj navzgor prispevajo k vzdržnemu razvoju urbanega okolja, še posebej v okoljskem in družbenem smislu. Prispevek se sklene z idejami, kako lahko mesta upoštevajo prostorske prakse svojih prebivalcev, da bi povečala učinkovitost urbanega prostorskega načrtovanja, vodenja in upravljanja ter okrepila svojo zeleno ustvarjalno podobo.

KLJUČNE BESEDE: participativni urbanizem, samonikla ustvarjalnost, prostorska politika, ustvarjalno mesto, Zelena prestolnica Evrope, Ljubljana, Slovenija

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1 Introduction

Green cities have become a norm, but also a trend. However, being green does not only denote providing green areas such as parks and gardens, planting trees, arranging green roofs and some other actions directly linked to nature. Green cities are also pursuing sustainable development bearing in mind not only environmental, but social, cultural and economic features as well (Nurse 2006). They can choose to brand themselves as a green destination or a green city (Poljak Istenič 2016), which positively affects their reputation and income from tourism, investments and other venues, as is proved by Ljubljana when gaining the *European Green Capital* award and being included among the top hundred sustainable destinations. And finally yet importantly, being green could as well mean having efficient urban management which strives to develop ecosystem services, include all citizens in decision-making and share responsibility for functioning of urban areas.

Academics and practitioners increasingly advocate participatory and inclusive practices in local planning, management and decision-making (Bond and Thompson-Fawcett 2007). Cities as well are becoming keener to embrace urban interventions »from below«, not only because they struggle with complex management and administration, excessive bureaucracy and the lack of funds for investing into and managing urban infrastructure, but also because such interventions, joined under the term participatory, do-it-yourself (DIY), tactical or any other urbanism (see below), have become »*a brand in itself*« and »*the latest political vernacular of the Creative City*« (Mould 2014, 529). Although many such practices are initiated by local activists, anarchist groups or some internet communities, one can indeed link most of them to the desires and struggles of the »creative class« (Florida 2002) to make a city and urban living more »*tailored to the individual needs of its citizens*« (Ljubljana European … 2016, 51). In Slovenia, these new forms of collective urban engagement range from (collaborative) community practices, co-working, community-led renovations, temporary use of space and urban gardening to local economies, housing communities and co-mobility (Internet 1) – commonly in various combinations. Despite coming into public limelight only recently, media, policymakers and public administration increasingly recognize their potential and appropriate them for their own agendas.

The aim of the article is to introduce the concept of participatory urbanism, to present local people's visions and interpretations of top-down (authoritarian) as well as bottom-up (participatory) urbanism, and analyse practical implications of the latter in the context of the City of Ljubljana. Ljubljana is the capital city of the Republic of Slovenia, situated on a crossroads of Central Europe, the Mediterranean, Balkan Peninsula and the Pannonian Plain (Ciglič and Perko 2013). It is the political, administrative, cultural and

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Figure 1: A map with marked locations of analysed practices of participatory urbanism, *Onkraj gradbišča / Beyond the construction site* community garden and *Savsko naselje* neighbourhood.

economic centre of the country while it also hosts many international institutions and organizations. Giving the name to the Ljubljana urban region, by far the most developed region in the country, it mainly relies on its service sector. It covers 275 square kilometres and has a population of 288.919 (SURS 2017). In my ethnographic argumentation, I will focus on two case studies of creative (i.e. artistic or cultural) spatial practices on the brinks of the Ljubljana's core city centre, on the south and north-east of the central train station. Both were initiated by NGOs, which have successfully implemented participatory methodology when intervening in public spaces and have been acknowledged by the city.

The first case is a community gardening project in *Tabor*, a former industrial and working-class neighbourhood in the inner-city district of Ljubljana, located between the town hall, the main railway and bus station and the University Medical Centre Ljubljana. The neighbourhood comprises different residential and other buildings as a heritage of the past (e.g. old power plant, railway station, former military barracks) and places of present activities (i.e. a retirement home, students hall of residence, church, schools, offices, shops, museums, cinemas, mixed-use housing, etc.). Until 2009, it was under pressure of property market development and experienced a loss of residential and social life as well as a degradation of public spaces, especially a lack of green areas and non-commercial public spaces (Pichler-Milanović 2012). Due to its residency in the former construction pit, the analysed garden, named *Onkraj gradbišča / Beyond the construction site*, materialized in the framework of the cultural festival *Mladi levi / Young Lions* in summer 2010 and was initially financed from the *Interreg* project *Sostenuto* (Internet 2), dedicated to the revitalization of the *Tabor* neighbourhood. In the seven years of operating, the community has changed several times from the initial one, but regularly around one hundred persons take care of forty plots of land in the garden and participate in numerous public and community-based events that take place there or in other public spaces of the local community. The initiator and supervisor of the garden is cultural association *Obrat*, and the city supports the practice by giving the annual permission for the temporary use of land and occasionally financing minor interventions (when the association successfully applies for funds).

The second example of participatory urbanism I analyse is a community-led renovation in *Savsko naselje*, Ljubljana's oldest post-second-world-war neighbourhood lying on the opposite side of Ljubljana's central railway station than *Tabor* neighbourhood, away from the centre towards the north. The first apartments were built in 1946–1947 and the housing stock had been increasing until the 1970s when they built several skyscrapers. Consequently, the neighbourhood experienced a sudden influx of socially and ethnically diverse populations and soon became notorious for a gang of youngsters, which fought with groups from other neighbourhoods (Mehle 2017). The delinquents later became associated with drug users, and, at least according to the conversations with more recent inhabitants, the settlement became one of the most disreputable in Ljubljana, especially so due to relatively old and deteriorating housing stock. A decade ago, people seeking accommodation were therefore advised not to move there, let alone buy a flat (see, e.g., Internet 3), and the neighbouring school was, in the words of one of the parents, *»on the brinks of closure«* (Interviewee 1) due to decrease of younger population and children switching schools due to the neighbourhood's low reputation. The first push-up for a change came from a famous musician who has lived there from his birth. In 2010, when releasing a rap album dedicated to the neighbourhood, he organized a promotional event in the local schoolyard (Cerar 2010). Later this so-called *Blok-party* developed into the main annual neighbourhood gathering. According to my interviewees, this was the start of the revival of social life in the community, and in a few years, several cultural and social associations and interest groups started positively interfering with local life, what had not gone unnoticed by the City. Since the neighbourhood – currently counting around 8.000 people – is on a prime location, the city decided to fund a minor project of community-led urban renewal in 2013 and engaged cultural association *Prostorož* to coordinate the activities. The association – previously also active in the *Tabor* neighbourhood – needed to combine funds from different sources to make more profound changes in the neighbourhood, and today the area can boost with renovated playgrounds, tidy green spaces, managed community place and improved minor infrastructure.

Through described case studies, I will test the hypothesis that participatory urbanism fruitfully complements top-down spatial interventions, especially in contributing to the pillars of sustainable development that are often overlooked by urban planners, i.e. its social and cultural dimension. In conclusion, I will also provide some ideas on how cities might engage with such practices to increase the effectiveness of their spatial planning, management and administration as well as boost its image of a green creative city.

2 Methods

The article is derived from a research on creativity as an interactive social process that reflects the livelihood strategies of various individuals and communities mostly active in the field of (urban) culture, who challenge the prevailing notions of importance of financial in favour of human (social, cultural, symbolic) capital. In this way, it complements recent research on creativity in Slovenia, which understands it in more economic terms (Bole 2008; Kozina 2016; Uršič 2016; Kozina and Bole 2017a, 2017b; Kozina 2018; for critical qualitative assessment of creativity's economic dimension see Bajič 2015, 2017; Poljak Istenič 2015, 2016, 2017, 2018; Uršič 2017; Vodopivec 2017). During my two and a half year long fieldwork, I followed cultural initiatives in Ljubljana that significantly contribute to the perceived »creativity« of the city, but have not been always recognized as creative (at least not in the sense of the creative economy). This paper interprets their practices in the theoretical framework of participatory urbanism, focusing on described case studies.

To be able to grasp the phenomena of participatory urbanism in practice, I used qualitative methods of research. I engaged in a participant observation of community gardening and took an informal tour around *Savsko naselje*, guided by one of its inhabitants. I carried out conversations with passers-by, local inhabitants, participants as well as initiators of both presented cases of participatory urbanism. Additionally, I conducted thorough narrative interviews with two representatives of the mentioned initiatives. Finally, I contextualised the data with information gained through previously done interviews with people active in Ljubljana's public places and with employees of the local and state administrations. I recorded the majority of interviews (29 altogether) and transcribed most of them as well as wrote down the key comments from coincidental talks. The article is based on my interlocutors' visions and interpretations of top-down as well as bottom-up urbanism, and presents the views gained through conversations. However, as I was not observing described actions consistently and did not aim to gather a representative sample of informants for analysis, the article only has a modest ambition to disclose the multiplicity of views on participatory urbanism and to offer such insights into practices in Ljubljana that are often overlooked by more representative, quantitatively oriented studies.

3 Participatory urbanism

In 2015, 54% of the world's population lived in urban areas, and urban population is continuing to grow with unfathomable speed (Internet 4). This makes cities hard to manage and govern, and one of the greatest challenges that urban administrations face today is motivating people to participate in their governance – i.e. in urban planning, design and management – and in this way share responsibility for the quality of urban living (Silver, Scott and Kazepov 2010). On the other hand, some cities avoid participation, either due to the conflicting interests of the communities and city administration, or because the experiments with participatory planning have »*turned out to be an opportunity for loud and dissatisfied citizens to communicate with the municipal representatives face-to-face [where] the debates quickly escalated into non-topic related mess*« (Kozina et al. 2017, 73).

If the late 1990s and early 2000s have been characterized by the »creative turn« (see, e.g., Landry 2000; Florida 2002) and the cities that had used culture have been »*celebrated and looked to as successful proponents not only of culture-led regeneration, but also of urban regeneration generally*« (Evans 2002, 213; for Ljubljana see Žaucer et al. 2012), then the last decade was identified with the »participatory turn« – first within the fine arts, then also in urban planning, urban design and architecture (Krivý and Kaminer 2013). Informal, grassroots initiatives in public spaces, cultural as well as physical – embodying what Kurt Iveson (2013) calls »micro-spatial urban practices« – have been labelled with numerous and diverse (not always or completely synonymous) terms, such as guerrilla, hacktivism, acupuncture, subversive, minor, wiki, open-source, insurgent, pop-up, DIY, hands-on, tactical, bottom-up, grassroots, participatory (and probably some else) urbanism, even the New Urbanism (when referring to the movement in the USA) (Courage 2013; Wortham-Galvin 2013; Finn 2014a). Although Emily Talen (2012) traces such movements (particularly DIY urbanism) to the mid-to-late 1800s (when municipal arts and civic improvement actions had swept the USA), direct historical connection is usually made to user-centric visions for architecture in 1960s, in which the ideal was empowering the user to act in space by means of physical engagement without the mediation of the architect (Chernyakova et al. 2012). The first more thorough ethnographic as well as theoretical accounts on participation also originate in this decade (e.g. Gans 1962; Arnstein 1969; Reynolds 1969). In Slovenia, however, participation as a concept was defined in the 1970s (Mlinar 1973). The majority of authors conceptually exploring participation differentiate between formal (structural, legally defined) and informal (grassroots) participation and/or vertical (link between institutions and participants) and horizontal participation (relationship among communities, individuals and groups), whereas ladder-based approaches define it as an evolution from manipulation to citizen control (for more on this topic see Cerar 2015).

Membership of ex-socialist countries in the European Union has opened up new perspectives for their urban policies that demand citizen participation in initiatives for the improvement of urban issues (Keresztély and Scott 2012). Participatory planning – at least in Western Europe – has been long integrated into planning policies »*in diluted forms*« (Krivý and Kaminer 2013, 1), such as public consultations and similar practices of public cooperation; it is increasingly so also in Slovenia (see Mežnarič, Rep and Mizori Zupan 2008). However, these practices tend to be more individual-centred, while participatory urbanism relies on the idea of community – be it that it can generate a sense of community through specific design principles or through residents' involvement in the whole development process. Urbanism becomes participatory only when it is understood as flexible, temporal, in a state of evolution and equated with the community on individual as well as collective level (Chernyakova et al. 2012). It tends to be grassroots and bottom-up, most of the time with anti-authoritarian characteristics and aiming to enhance urban living experience through incremental strategies of urban fabric improvement (Courage 2013). Broadly defined, it can be any action taken by citizens that impacts urban space, by the rule without government involvement or even in opposition to government policies and regulations (Finn 2014b). It can be also understood as »*a specific mode of informal space production*« (Jabareen 2014, 414) or »*tactics in which groups of citizens and architects/designers/activists appropriate and transform private or public space into temporary urban commons*« (Bradley 2015, 91). In this sense, the initiatives are often seen as the »right to the city« movements (Lefebvre 1996), as resistance practices against neoliberal interventions into a city (Poljak Istenič 2018).

However, »*[i]n many cases [the phrase] seems to mean just the right to a more 'human' life in the context of the capitalist city and on the basis of a ('reformed') representative 'democracy'*« (de Souza 2010, 315). The same applies to Ljubljana's initiatives, which strive to »*take back public spaces we forgot about*« (Interviewee 2), as expressed by one of the initiatives' spokesperson. They usually act in the belief that change is possible and offer (or try to develop) alternatives for the use of space or urban living in general. Giving a social commentary to urban neoliberal policies in an artistic (or cultural) form, they »*propose alternative lifestyles, reinvent our daily lives, and reoccupy urban space with new uses*« (Zardini 2008, 16). Gathering people together to work for a common cause, such initiatives often refer to the nostalgic feelings of community, authentic experience and going »*back to basics*« (Forkert 2016, 11). As pointed out by Boris Buden (in Krivý and Kaminer 2013), a concern for »community« and »culture« has replaced »society« as the horizon of contemporary politics. However, establishing a link between physical design of cities and social goals like »sense of community«, »social equity« and »common good« proved to be difficult, and attaching normative town planning to these social goals very problematic (Talen 2002). Participatory urbanism, with its focus on common good, informality and temporality, thus often fills this gap, inefficiently (or unsuccessfully) addressed by the »top-down« urban administration – and in this way contributes to the »least popular pillars« of sustainable development, social and (when involving artists and cultural producers and/or implying a specific identity formation) also cultural.

The spread of such practices is especially noticeable after the 2008 crisis, which caused diminishing of many mechanisms for funding and managing urban infrastructure and public spaces. As pointed out by Karin Bradley (2015; see also Forkert 2016), urban interventions »from below« in a way actually legitimize public withdrawal, which is the opposite of what these spatial practices try to achieve. As a reaction to under-efficient public spatial management – its rigid formality, unsuccessful regulation of private and individual interests, non-transparent funding – they strive to develop alternative production, management and economic models which would (and already are) successfully solve(-ing) some of the less pleasant matters of living in a city. These models show that »*changes in space for the better are possible and within reach, which often estranged and long-lasting processes of spatial planning do not enable*« (Skupnostne prakse 2014) – i.e. that it is possible to make a positive change only with minor interventions and low funds, especially when relying on (whichever) community participation in all phases: planning, implementation and management.

On the other hand, such practices have also been increasingly embraced by the cities and appropriated for city branding or other promotional strategies (Poljak Istenič 2016), as is the case of *Onkraj gradbišča / Beyond the construction site* garden. As a role model of community urban garden, it has been promoted on some of the city's websites, and although it could be argued that the city has promotionally supported the garden, one cannot deny this has (also) benefited the city, as Ljubljana heavily promotes its green and creative orientation (and was specifically advertising its *European Green Capital* award in 2016).

In the last three years, the phenomenon of »bottom-up« initiatives transformed from marginal spatial practices into more and more obvious »mainstream« mode of spatial action, in Slovenia and globally (Peterlin 2015). However, as a »mainstream« practice (increasingly – although unsystematically – funded by local authorities, as they recognize them as improving the quality of urban life and the city's image), the initiatives lack decisive oppositional or explicitly political aspects. Thus they have not been able to achieve any profound change in spatial policy, »proposed« to the cities in the form of alternative models or/and modes of spatial interventions, as I will show below.

4 Ljubljana – a green creative city

In the last decade, Ljubljana's promotion mainly revolves around two global brands: »the city of culture« or »the creative city« and »green« or »sustainable« city (cf. Internet 5). It was recently listed among the *Global Top 100 Sustainable Destinations 2014, 2016* and *2017* (Internet 6) and won the *European Green Capital 2016* award in 2014 (Internet 7) as well as the *UNESCO City of Literature* title in 2015, which granted the city an inclusion into the *Creative Cities Network* (Internet 8). In its promotional and development strategies, culture (also as an element of a creative economy) is seen as an integral part of environmental design (Trajnostna … 2015). Ljubljana thus often supports (at least on paper) grassroots creativity – especially such that addresses as wide participation of diverse inhabitants as possible and leaves visible traces in space – to show the diversity of its urban culture. In this way, however, it also tries to fill in the gaps in cultural production, caused by austerity measures as well as the shrinking of cultural and spatial budgets. Additionally, it occasionally promotes it to gain a competitive advantage in the interurban rivalry or to appeal to the European Union's demands and trends (Poljak Istenič 2016; 2018). Although there are numerous green creative initiatives in Ljubljana, I will point out two examples of distinctively spatial practices that have been acknowledged and – financially, morally and/or promotionally – supported by the city.

4.1 Community garden *Onkraj gradbišča / Beyond the construction site*

One of the most successful – proved by its long run – participatory spatial practice in Ljubljana is the community garden *Onkraj gradbišča / Beyond the construction site*. Invited to the project for revitalization of the neighbourhood, the cultural and artistic association *Obrat* decided to experiment with gardening as a temporary use of space as well as one of the »*alternative modes of action*« (Interviewee 3). Its main motives were to make a compound and degraded place accessible to people and to redesign it into a community place, »*i.e. place which would be planned, redesigned and managed by included individuals. We wanted to show what kind of charge and potential can community actions in space have, and simultaneously test where the practice of tactical urbanism, which can respond quicker to actual spatial and social needs than regular long-term planning, will take us*« (Lovšin et al. 2015, 2). They succeeded to get an official permission from the city for a temporary use of land, and rearranged an abandoned construction site into a community urban garden, which is still thriving. During the years of operating, the garden has become the site for establishing informal contacts and exchanging information, services and goods. In this way, it »formed« a community, which the initiators understood as a prerequisite for a positive social change: »*Let's look concretely at what that [garden] has brought about, what happened, did it really influence community cohesion, did it influence the safety of the neighbourhood, are the people more connected,*« argued one of the association's founders (Interviewee 3). »*It did a little, but I don't know if it had a great impact.*«

Although association *Obrat* has been taking care of the legal issues (i.e. annual renewal of permission for the temporary use of land), it managed to transfer the management of the gardening activities to a self-organized coordination committee in 2015, as »*this is sustainable. To make a project sustainable means that you provide people who will continue this [activity]*« (Interviewee 3). In this way, they co-created a community capable of self-organizing and collaborating despite different social, ethnic and educational backgrounds of its members; association only mediates in solving regular issues and coordinates community meetings if needed. The garden thus operates as a space for sensibilization to differences as well as for practicing active co-designing and sharing urban space. As such, it has been a popular location for various artistic and environmental projects, initiatives, events, for mass media coverage as well as for the local community. The City of Ljubljana also promotes it on its website dedicated to the *European Green Capital 2016* program.

NGOs are often the key link between the city and urban communities (Cernea 1988, cf. Abbott 1996), and the same applies to Ljubljana's cases. With a desire to gain public support, encourage people's participation and diversify socializing possibilities, the garden community – under the association's guidance – established various communication channels with the neighbourhood and city authorities as well. Besides updating a fanzine, notice board and website, they also organize public events and workshops to revive local public life. There is more interest to join a community than available plots of land, so the association maintains a waiting list of all who would like to participate. By proving that an increasing number of people want to have a more active role in the co-creation of the city, the garden therefore serves as a practical critique of the city's rigid, unifying policy of organizing and leasing small garden plots. It draws attention to the shortcomings of prevailing urban management of already scarce public spaces, which are also insufficiently supported by the proper mechanisms. By gaining local, academic and media support, the garden initiative has strived to convince the city to ensure more places in its area that are not earmarked for consumption and capital. But despite their efforts, the project still »*did not bring about what we wished for. First, the city did not loosen the rules for temporary use of places in such a way that people would have access to the land that is on hold. It is sick that we only have this project. I see this as bad, not as good. In fact, such projects should have developed all around Ljubljana,*« advocates the association's representative (Interviewee 3). The so-called *Network for Space*, a network of various NGOs under the umbrella of the Institute for Spatial Policies (non-governmental, consulting and research organization in the field of sustainable spatial and urban development), now continues association's efforts to loosen the rules for temporary use of land.

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Figure 2: Gardening in degraded areas, such as in *Onkraj gradbišča / Beyond the construction site* garden, offers an opportunity to grow one's own food, be in touch with nature and socialize.

4.2 Community-led renovation of *Savsko naselje*

When in 2013 the city decided to fund the first project of community-led urban renewal in its area, it engaged cultural association *Prostorož*, which already had a decade of experience with revival and renewal of public space in Ljubljana, including the *Tabor* neighbourhood where presented community garden operates. The area chosen for a test bottom-up renewal was *Savsko naselje* neighbourhood, the oldest post-second-world-war settlement with a bad reputation and on a prime location within the city. The association invited three other non-profit organizations, active in the neighbourhood, to cooperate in a »*renovation of the urban neighbourhood which considers the community as much as space*« (Internet 9). Under the slogan »Who helps, (that) wins!«, they employed different participatory techniques to outline integral urban renovation program.

Associations managed to gain the initial attention of inhabitants with picnics between buildings. They asked a local musician to rap on the lawn under balconies, made pancakes and invited people to come by shouting through megaphones. At such informal gatherings, they chatted with participants over 3-D models of the neighbourhood and wrote down their aspirations for changes. They also sporadically interviewed coincidental inhabitants about the most burning local issues, which crystallized to be traffic arrangement, green places, street furniture and the lack of events. They organized the so-called *Assembly for Savsko naselje* and established a working group for each issue to discuss what to do, and then used local newsletters and local renewal office as well as announcement boards, social media and e-mails to further communicate with inhabitants about the progression of their proposed interventions and upcoming actions or events. Until 2016, when the project finished – besides the City of Ljubljana the funds also came from the *Creative Europe* project *Artizen* – they managed to propose a traffic strategy, renovated a local sports field and a children's playground, cleaned overgrown local hill and planted fruit trees.

A local inhabitant, who took me on a tour through the neighbourhood when asked to explain recent changes and his view of a place, pointed out marked paths to school, renovated school playgrounds, children's playground and sports field, fruit trees and cleaned hill, renovated city library and the *Knjižnica reči / Library of things*. The latter is a place established to encourage ethical sharing economy, as its members

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Figure 3: The renovated children's playground and freshly planted fruit trees, as seen from the cleaned local hill.

(and non-members for a symbolic fee) can borrow useful items, namely those that one uses only a few times a year because they are too expensive to buy or too big to store. My tour guide also pointed out recently renovated buildings and stressed that bottom-up interventions in space in his opinion also encouraged the residents of certain apartment buildings to finally start renovating their immediate dwelling surroundings, e.g. facades, entrances, common inner spaces, courtyards, or auxiliary facilities. Some residents now also organize regular picnics in front of their building to socialize with their neighbours and meet more often. Young families started moving back into the neighbourhood and the school currently has enough pupils as well as a good reputation.

When asked how the city reacted to their suggestions and actual spatial interventions, one of the project coordinators admitted the importance of initial financial support, but regretted that their proposals were insufficiently considered and the implementation of proposed interventions lacking: »*We pointed out too many things, we reported frankly to the city about everything the inhabitants wished, however, their initiatives fell into domains of more departments, not just the urbanistic one* [so the implementation should have been planned, financed and executed by several municipal offices, e.g. spatial, environmental, traffic, cultural]. *The urbanistic department didn't anticipate that we'll make a whole traffic strategy but only expected us to hang some nice street lights. That is why our cooperation then finished. We found it unfair to hang some lights around Savsko naselje if the problems are a thousand cars too many, empty spaces, many unemployed people, unmown grass, unremoved snow, unknown land ownership – why would we hang the lights then? […] We categorized the problems and people's initiatives according to some criteria, and defined which of them are prioritized by the inhabitants and which could already be implemented by them alone. And we handed that over to the city as a final report. We did a lot more work than ordered, but there was no willingness to grab that and work further*« (Interviewee 4). Local inhabitants also admit that an enormous work has been done and that the neighbourhood is now much more pleasant to live in than before, but also fear that without further support by the city, and especially without a formal coordinator, nothing more will happen and infrastructure will be again left to decay. On the other hand, they also complained over some »*unsatisfied*« individuals who opposed the changes, claiming that they in a way drove the initiators away, as »*that kills you; in whose honour one would do it if the local community whacks you on the head?*« (Interviewee 1).

5 Conclusion: Implications for cities

The aim of the article was to present initiators' and local people's visions and interpretations of top-down (authoritarian) and bottom-up (participatory) urbanism as well as to analyse practical implications of the latter in the City of Ljubljana. Spontaneous, informal, bottom-up interventions into urban space – termed participatory (or any other) urbanism – may be a torn in a city's side, because they're unorthodox, avoid getting official permissions, they do not follow formal procedures for spatial interventions and disregard power relations embedded in urban policies. However, they can still achieve what cities are striving for, e.g. a wide participation of citizens, social inclusion and equity, public safety etc., and on top of it – as also shown in the article – with much less resources, in a shorter time and with longer-lasting effects than official, top-down spatial projects. We can assume that such expected results were the reason why the City of Ljubljana ensured some funds for the test bottom-up neighbourhood renewal in 2013, and some other Slovenian cities (e.g. Kranj, see Internet 10) are already following its example. Due to the popularity and effectiveness of participatory urbanism, and bearing in mind cities' diminishing budget, local authorities might start considering how to better utilize bottom-up participatory urbanism for more efficient urban spatial policies, i.e. planning and governance.

Despite its critical, sometimes even rebellious nature, participatory urbanism embodies many aspects central to the official spatial policies. It addresses burning spatial issues and makes efforts to resolve them, encourages private investments or establishes private-public partnerships for improvements of public infrastructure, strives to share responsibility for management of public space with local people, and makes development more sustainable, since it builds a community with strong local identity which helps to achieve the set goals. If people feel connected to a place and to their neighbours, they care about what happens in their area and are more willing or motivated to participate in solving spatial and environmental, economic as well as social problems. I can thus confirm my hypothesis that participatory urbanism fruitfully complements top-down spatial interventions, especially in contributing to the pillars of sustainable development that are often overlooked by urban planners, i.e. social and cultural sustainability.

Network for Space recently prepared recommendations for municipalities on how to include bottom-up spatial practices into public spatial policies, as they also believe that such practices do not substitute spatial planning and other formal procedures, but only supplement them (Peterlin 2015). They make small, quick and low-cost changes in line with official regulations, but can on the other hand – as a testing ground for new models of spatial production, management and governance – also serve to illustrate how institutionalized planning could be reorganized. The municipalities shall thus actively support bottom-up spatial practices with funds, information and coordination; include them in development plans and use their participative methods in spatial interventions as well as support pilot projects in this domain; make information about municipal housing stock and land publicly available and transparent; and use economically the municipal property (Od skupnostnih praks … 2015).

Participatory urbanism also discloses creativity – as well as an entrepreneurial potential – of certain individuals and groups that are crucial for keeping cities lively, evolving and interesting places to live and work in (Finn 2014a) – which are the features of a »creative city« image. The recent economic crisis has again aroused a growing interest in the creative economy as a means to revive economic development (Florida 2010; Indergaard, Pratt and Hutton 2013), and urban policies focusing on creativity have become one of the main strategies in solving economic and increasingly social issues in cities – in as much sustainable way as possible. As I tried to show, a contribution of creative individuals to urban spatial interventions and governance is not negligible, at least in Ljubljana. Furthermore, researchers from the global South, most severely hit by the austerity measures, pointed out that grassroots creativity as an alternative is worth pursuing »*because of the opportunities offered for a way out of the crisis and into the development of a new and better society*« (Leontidou 2015, 72). Despite the fact that the demise of economic crisis usually encourages new investments, which lead to less under- or unused urban spaces and thus endanger DIY practices, it is to be hoped that an increase of financial capital will motivate cities to take a step further and properly support creative participative initiatives. In such a way, cities could boost their green creative image, soothe citizens' dissatisfaction with slow, rigid and occasionally »misfired« spatial interventions, and maybe find a suitable model for more efficient urbanism and spatial policy as well as for urban sustainable development.

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CITY-REGION OR URBAN-RURAL FRAMEWORK: WHAT MATTERS MORE IN UNDERSTANDING THE RESIDENTIAL LOCATION OF THE CREATIVE CLASS?

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Direction of creativity

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City-region or urban-rural framework: what matters more in understanding the residential location of the creative class?

ABSTRACT: This paper addresses the key question as to what matters more in understanding the residential location of the creative class in Slovenia: the city-region or the urban-rural framework? Our analysis shows that differences in residential concentrations of the creative class vary more within city-regions (on an urban-rural framework) than between city-regions. Moreover, the creative class is moving out of densely populated urban areas to more sparsely populated suburban / rural areas within all city-regions. There also are significant differences between more developed western Slovenia (denser settlement structures) and less developed eastern Slovenia (sparser settlement structures). We conclude that new models of living promote dispersion.

KEY WORDS: creative class, knowledge economy, regionalisation, urbanisation, suburbanisation, dispersion, residential preferences, economic geography

Delitev na regije ali mesto in podeželje: kaj je pomembneje za razumevanje razporeditve ustvarjalnih ljudi po kraju bivanja?

POVZETEK: Namen prispevka je odgovoriti na vprašanje, kaj je pomembneje za razumevanje razporeditve ustvarjalnih ljudi po kraju bivanja v Sloveniji: delitev na regije ali mesto in podeželje? Analize kažejo, da se razlike v koncentraciji ustvarjalnih ljudi po kraju bivanja bolj razlikujejo znotraj regij (med mesti in podeželjem) kot med regijami. Poleg tega se ustvarjalni ljudje pomikajo iz gosteje poseljenih mestnih območij v redkeje naseljena primestna / podeželska območja v vseh regijah. Obstajajo tudi velike razlike med bolj razvito zahodno Slovenijo (gostejša poselitev) in manj razvito vzhodno Slovenijo (bolj razpršena poselitev). Sklepamo, da novi modeli življenja spodbujajo razpršenost.

KLJUČNE BESEDE: ustvarjalni ljudje, ekonomija znanja, regionalizacija, urbanizacija, suburbanizacija, disperzija, bivanjske preference, ekonomska geografija

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1 Introduction

The key question addressed by this paper is what matters more in understanding the residential location of the creative class: city-region or urban-rural framework? A detailed investigation aims to get a deeper insight into residential characteristics of the creative class within city-regions in Slovenia from the perspective of their level of urbanisation. By doing this, we seek to set the frame for studying intraregional relations in attracting, retaining or releasing the creative-knowledge potential in specific territorial contexts. The hypothesis is that differences in residential concentration of the creative class between urban and rural areas are bigger than between city-regions. In this way the paper intends to add weight to an urban-rural framework for studying and planning creative-knowledge city-regions.

In addition, much of the theoretical work on city-regions is firmly located in the urban experience of North America and Western Europe (Roy 2009), so the contribution of this paper may also be understood as an extension of the research agenda to other European territories and as a mode to reconfigure the theoretical heartland of urban, rural and regional analysis by presenting new evidences from Slovenia.

Although we can trace the origins of the city-region paradigm back to the 1909 Plan of Chicago (Geddes 1915; McKenzie 1933; Dickinson 1947), the concept of the city-region does still not enjoy a common definition in present times (Parr 2005; Harrison 2007; Davoudi 2008; Rodríguez-Pose 2008). However, the need for a spatial definition of the city-region is imperative when concern is with such matters as the analysis of structural change, the design, implementation, and evaluation of policy, spatial and temporal comparisons (Parr 2008). Investigating city-region's structure and nature is an ongoing and relevant task since city-regions form a network of supranational economic systems (Scott and Storper 2003; Jonas and Ward 2007; Harrison and Heley 2015). In global competition, those city-regions that are able to capture eminent positions and to gain economic advantages can create favourable conditions for both their cities and wider regions (Egedy, Kovács and Kondor 2016). To this end we need a better insight about the relationship of a city-region's material-physical structure to its economic performance (Storper 2013).

The minimum common denominator of virtually all definitions of a city-region is the presence of a core city linked by functional ties to a hinterland (Rodríguez-Pose 2008). The core city possesses some specified set of functions or economic activities; thus it may account for a substantial proportion of the population of the city-region (sometimes in excess of 50%) and is invariably the dominant urban centre. The hinterland contains a rural population and (in advanced economies) a much larger urban population, arranged within a hierarchy of centres, the core city representing the highest level of the hierarchy (Parr 2005; 2008). As exposed by Davoudi (2008), multifaceted definitions of a city-region share two common features. Firstly, they portray an urban-centric conception of the city-region that puts emphasis on the core city, sometimes at the expense of neglecting the region and rural areas. Secondly, they represent an economically driven approach to city-region definition in which the dominant economic flows determine the extent of the city-region.

Despite the variations among nations of the developed world, it was generally the case that well into the 20th century there was a continuing trend toward concentration of the spatial structure, with the core city increasing its share of the city-region's population, employment and income. This was prompted in no small degree by the rise of manufacturing that, because of the importance of agglomeration economies, favoured development in the core city. In more recent decades, however, the spatial structure of city-regions in the developed world had undergone something of a transformation and was evolving differently. Due to technical change, developments in transport and communication, changing patterns of work, mobility and lifestyle in rural areas, steadily rising levels of income, and negative externalities of the core city, population (first) and employment (later) gradually began to shift to the hinterland, the overall outcome representing a trend toward deconcentration within the city-region (Parr 2005).

Thus the city-region is not a static construct (Parr 2008) and as Harrison and Heley (2015) emphasize there is a need for taking into consideration the hitherto neglected temporal dimension into sharper focus. The recent trends of spatial organization of city-regions clearly imply dispersion – territorial aspect and diversification – sectorial aspect. However, in recent times the focus is on the creative-knowledge economy (Bontje, Musterd and Pelzer 2011) that is sharply different from the past. Thus it is similarly expected to produce its own space through reshaping the industrial city and region to a new form that would suit the new conditions for economic production and their associated social habits and institutions (Madanipour 2011).

1.1 Urban-rural framework: an underutilized aspect of a city-region concept

When discussing the structure and nature of city-regions the accent is clearly on urban areas or super-agglomerations and their development (Scott and Storper 2003). This is problematic from two perspectives. First, it seems that the prevailing literature on city-regionalism is more interested in comparisons between than within city-regions, typically emphasising narrow definitions of competitiveness at the expense of more holistic considerations of internal cohesion and resilience (as per Bristow 2010). Since city-regions may contain greater variations in economic characteristics within them (e.g., urban vs. rural) than between them, comparisons between city-regions can potentially be misleading (Bakhshi et al. 2015). Second, a debate remains concerning the extent to which rural localities are incorporated within city-region boundaries (Healey 2009) and development policies (Harrison and Heley 2015). Subsequently, there is the view that city-region approaches to economic development are having a detrimental impact on the competitiveness of rural areas (Gülümser, Baycan-Levent and Nijkamp 2010; Huggins and Clifton 2011) and can reinforce rather than resolve the problems of uneven development and socio-spatial inequalities (Etherington and Jones 2009).

The first ideas of combining urban and rural aspects in planning dates at least back to Ebenezer Howard and his book Garden Cities of Tomorrow (first published in 1898 under the title To-morrow, and republished under its better-known title in 1902) in which he argued that both cities and countryside had an indissoluble mixture of advantages and disadvantages (Hall and Tewdwr-Jones 2011). However, it was only in the 1960s when the spatial linkages between urban and rural areas became a common concern that urban analysts turned their attention away from the city and towards the city-region (Davoudi and Stead 2002). Proponents on the one hand argue that the city-region model provides a potential link between urban and rural areas in a way that the competitive and complementary aspects of urban-rural relations become more transparent, and this is particularly so for labour and housing markets, as well as for shopping and leisure patterns (Parr 2005; 2008; Davoudi 2008). Conceptualized as such, city-regions are increasingly regarded as the appropriate sub-regional scale for the implementation of development policies (Rodríguez-Pose 2008).

However, opponents on the other hand argue that there is a limit to how far city-regionalism – as currently constructed – can represent the interests of the population at large (Harrison and Heley 2015). As stated by Woods (2009), it carries the risk of addressing rural localities solely in terms of their relation to the urban, of disregarding any sense of an overarching, interregional rural condition, and of marginalizing rural concerns within structures dominated economically and demographically by cities. Furthermore, it establishes and reinforces out-of-date notions of geographical centrality and hierarchies, and it actively marginalises places, consigning them to the periphery, dividing and polarising (Ward 2006). This can also increase differences in values and political orientation between urban and rural dwellers (Tiran 2011; 2015). Pemberton and Shaw (2012) added that whilst significant attention has been placed on the impact of new sub-regional governance arrangements on urban areas, there has been little consideration of the nature and effectiveness of such arrangements on rural areas.

Because economic activities are territorialized (Storper 1997), there is a need for more integrated, locally specific, place development agendas (Healey 2009; Bontje et al. 2011). Nevertheless, there remains a noticeable silence in city-region debates concerning how rural spaces are conceptualised, governed and represented (Harrison and Heley 2015), despite the fact that they are important spaces that cannot be ignored (Pemberton and Shaw 2012). Research that explicitly interrogates the role of rural areas within a city-region framework is therefore important and welcome (Woods 2009). However, whilst there is considerable literature on both rural and urban development issues, there is much less concerning the linkages between them (Davoudi and Stead 2002).

1.2 Creative-knowledge economy and a city-region

The literature on the emerging creative-knowledge economy often suggests that city-regions are the focal points of this economy. Hence, it is hard to imagine an alternative economic growth path for city-regions in advanced capitalist countries that would replace the current focus on creativity, knowledge and innovation (Bontje, Musterd and Pelzer 2011).

However, to understand the geography of the creativity, and to formulate supportive policies for both urban and rural areas, it is necessary to analyse it at a sub-regional or even neighbourhood level (Clifton 2008).

Analysis at a high degree of spatial resolution allows concentrations of a particular activity to be more accurately identified; to this end, in this paper we employ an occupational, residence-based operationalisation of creative activity – aka the creative class (Clifton 2008; Boschma and Fritsch 2009; see the section below for a full discussion of this methodology). Concentrations of such activity may also occur at small spatial scales, so it is desirable to analyse the data at the smallest possible scale for which official statistics are available (Bakhshi et al. 2015).

Nevertheless, most of the previous mappings concerned with the creative economy addressed regional or metropolitan scale (e.g. Florida 2002; Marlet and van Woerkens 2007; Clifton 2008; Rutten and Gelissen 2008; Boschma and Fritsch 2009; Andersen et al. 2010). They revealed that creative-knowledge workers are more intensively located in predominantly urban regions. There have been rare attempts to unveil intraregional disparities by simultaneously examining urban and rural areas, despite sub-regional scales of working increasingly being promoted as means of securing greater spatial equity and economic competitiveness (Harrison and Heley 2015). The reasons for this can be ascribed to a historical focus on the benefits of urban areas on the account of their creative capacity and the limited availability of secondary data on rural areas, plus the difficulty in collecting accurate primary data and the lack of comparable data (Gülümser, Baycan-Levent and Nijkamp 2010). However, as investigated in selected European metropolitan areas of Amsterdam, Birmingham, Helsinki, Poznan, Riga, and Toulouse, creative-knowledge workers are concentrated not only in traditional core cities, but also in new centres on the city edges and beyond. More specifically, city centres may mainly attract the »creative core« (scientists and engineers, architects and designers, academics and teaching professionals), while city edges and beyond may be more attractive for »creative professionals« (associated professional and technical occupations of the creative core, managers, financial and legal professionals) (Bontje and Kepsu 2013).

Recent theories on regional creativity often focus on urban areas without taking into account rural localities. In addition, the application of such analyses to rural areas may lead to misrepresentation or misunderstanding of rural creative capacity. Thus, there is a need to combine the current knowledge on innovation and rural areas in order to conduct more effective research (and policies) for achieving sustainable rural development (Gülümser, Baycan-Levent and Nijkamp 2010). Although conditions for creating or stimulating creative-knowledge economies in the context of a global world certainly depend on urban history (Pareja-Eastaway and Pradel i Miquel 2015), they also play a significant role in the development of rural areas (McGranahan and Wojan 2007). As suggested by Madanipour (2011), the creative workers can be found and developed not only in elite centres, but also in the peripheries, smaller cities and towns, and in the »less-favoured« parts of larger cities. However, little, if any, locality-specific qualitative or quantitative research has been undertaken to assess the residential preferences of creative-knowledge workers in a regional context (Verdich 2010).

2 Methods

The aim of this paper is to measure the (re)distribution of the creative class across and within the city-regions of Slovenia in the period 2000–2011. To this end, it employs microdata from the Statistical Register of Employment by the Statistical Office of the Republic of Slovenia. The fine-grained data allows distinction between different types of urbanisation as residential places of the creative class.

The investigated **city-regions** are functional regions. Their boundaries correspond to a large extent to travel-to work areas (see Bole 2004). In size they are similar to NUTS 3 regions. The latter are twelve, whereas we distinguish between eight city-regions in Slovenia. Such regionalization is often mentioned as one of the most appropriate as the second level of local self-government (Ravbar 1997; Plut 1999; Kozina 2010) but is officially not established yet. The largest city-region is the Osrednja Slovenija (core city: Ljubljana), with a population of almost a third of the country's population (2m in total). The Podravska (core city: Maribor) and Savinjsko-Koroška (core city: Celje) city-regions represent half of its size, while other city-regions are even smaller. Central and western city-regions are more successful than the eastern ones, which lag behind (Ravbar 2009). The differences are greater with regard to economic issues and smaller with regard to social and environmental issues (Vintar Mally 2018).

The **urban-rural typology** used in this paper is based on the work of Ravbar (1997). The data were later revised by Krevs et al. (2005) and the number of types were simplified and diminished from seven to four. The types were estimated on the basis of a set of sociogeographic, physiognomic, structural, and functional criteria. The urban-rural typology consists of four residential types as follows:

- urban settlements (degree of urbanisation = 100%);
- suburbanised settlements (75% < degree of urbanisation < 100%);
- urbanised rural settlements (55% < degree of urbanisation < 75%);
- rural settlements (degree of urbanisation < 55%).

Altogether, there are around 6,000 settlements in Slovenia. Overall, 43% of the population reside in »urban areas«, 22% in »suburbanised areas«, 15% in »urbanised rural areas«, and 20% in »rural areas«.

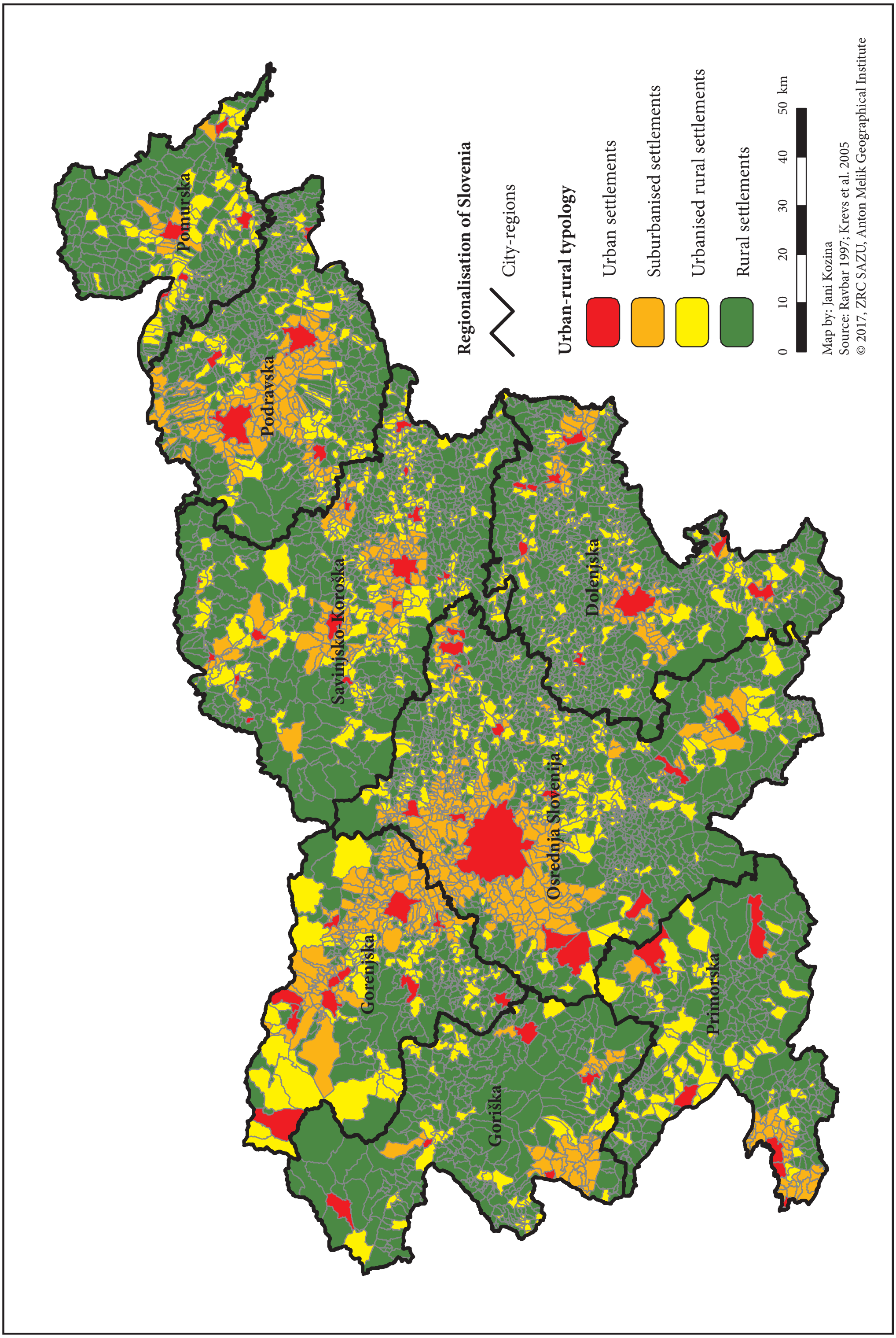
The definition of the **creative class** is adopted from the works of Florida (2002; 2005; 2008), which separates the creative class from others based on their occupation, while additionally differentiating between members of the creative core, creative professionals, and bohemians. The fundamental idea is that of the secondary data that is available, occupation is the best proxy of how an individual uses knowledge and creativity in the work. In the technical sense, we used the example of the *Technology, Talent and Tolerance in European Cities: A Comparative Analysis* European research project's methodology (e.g. Fritsch and Stützer 2007; Marlet and van Woerkens 2007; Clifton 2008; Boschma and Fritsch 2009; Andersen et al. 2010) and the Slovenian Standard Occupational Classification (SKP-V2), which is based on the International Standard Occupational Classification (ISCO-88). Creative core (A) consists of workers who create new knowledge. These are mostly engineers of a technical profile, natural scientists, doctors, teachers, and researchers in the fields of economy, social sciences, and humanities. These highly creative social groups are said to run the social and economic development (SKP-V2 codes: 211–214, 221, 222, 231–235, 243, 244, 247, 344). Creative professionals (B) are made up of experts in labour intense occupations. These are managers, high-ranking state officials, experts in various technical, educational, medical fields, lawyers, and other occupations that support the social and economic development (SKP-V2 codes: 1, 223, 241, 242, 31, 32, 341–343, 345, 346). Bohemians (C) are creative workers in the narrowest sense of the word. These include musicians, publicists, writers, painters, sculptors, and others (SKP-V2 codes: 245, 347, 521).

The differences in residential concentration of the creative class between city-regions on the one hand and between urban-rural types on the other hand were calculated by location quotient (LQ). The LQ itself is a measure of spatial concentration, expressed as a proportion such that the average for Slovenia is 1. The differences in residential concentration of the creative class within city-regions on the one hand and within urban-rural types on the other hand were calculated by locational Gini coefficient (Krugman 1991). It can take values between 0 (even distribution across settlements) and 1 (extreme concentration in one settlement). Finally, the dataset for the creative class location quotient (LQ) was constructed for every settlement. Based on it statistical differences between city-regions on the one hand and between urban-rural types on the other hand were examined by the Kruskal-Wallis test which is a non-parametric counterpart of the one-way independent ANOVA (Field 2009).

3 Spatial distribution of creative-knowledge economy in Slovenia

Slovenia as a country and Ljubljana as its capital and a middle-sized city can compete with their comparable European counterparts in terms of concentration of the creative class, i.e. in Slovenia being around one third of the workforce. Previous analyses have shown that creative economy is a growing sector in the post-socialist context, similarly to tendencies observed in Western Europe (Kozina and Bole 2017a; 2017b). Creativity as such is strengthening its societal position, which is manifested in the spatial expansion and dispersion of the creative class. The background for such spatial development in Slovenia and Ljubljana can be found in the post-independence European-style culture- and creativity-driven urban policy that was introduced into Slovenian development policies as well as in concrete spatial projects that are visible in Ljubljana in particular and the further shifting of attention towards Ljubljana as the main creative and innovative centre of Slovenia (Ehrlich, Kriszan and Lang 2012; Poljak Istenič 2015; 2016). In the following section we present the results of the empirical analysis to answer the question what matters more in understanding the residential location of the creative class: city-region or urban-rural framework?

Figure 1: City-regions and urban-rural typology in Slovenia. ➤


Pomurska
Podravska
Savinjsko-Koroška
Dolenjska
Osrednja Slovenija
Gorenjska
Goriška
Primorska
Regionalisation of Slovenia
City-regions
Urban-rural typology
Urban settlements
Suburbanised settlements
Urbanised rural settlements
Rural settlements
0 10 20 30 40 50 km
Map by: Jani Kozina
Source: Ravbar 1997; Krevs et al. 2005
© 2017, ZRC SAZU, Anton Melik Geographical Institute

3.1 City-regional differences

Slovenia can be divided into three relatively homogeneous areas according to the residential distribution of the creative class (Figure 1). The first is the area of eastern Slovenia (Dolenjska, Savinjsko-Koroška, Podravska, and Pomurska), where the concentration of all three creative sub-groups is below the national average, most notably in the case of the bohemians. Compared to western Slovenia, the east is economically less developed. The second area is Osrednja Slovenija with the capital of Ljubljana as its core city. This is the only region where members of the creative class are highly overrepresented. The third area is denoted by other regions of western Slovenia (Primorska, Goriška, and Gorenjska), where location quotients range around the average.

Between 2000 and 2011, the volume of the creative class increased by 27% in Slovenia. During the same period, the labour force in manufacturing shrank by 30%, while the number of workers in services (+1%) and agriculture (–2%) stagnated. Sectoral changes in the economic base clearly signify the transition to the »creative-knowledge society«, mostly on the account of deindustrialization. From the regional perspective, the increase was the largest in Dolenjska (37%) and the two economically most developed regions: Primorska (33%) and Osrednja Slovenija (31%). On the contrary, the increase was the smallest in Pomurska (15%) as economically the most deprived region.

According to Gini coefficients, the creative class (G = 0.836) in Slovenian settlements reflects higher concentrations than the working population generally (G = 0.773) and the total population (G = 0.760). Among city-regions, the residential concentration is the highest in Osrednja Slovenija, Primorska, and Podravska, where the largest university centres are located (Ljubljana, Maribor, and Koper). Between 2000 and 2011, the spatial distribution of the creative class in all city-regions dispersed and became more even. This process has been stronger in the city-regions of eastern Slovenia (Dolenjska, Savinjsko-Koroška, Podravska, and Pomurska) than in the city-regions of western Slovenia (Primorska, Goriška, Gorenjska, and Osrednja Slovenija) (Table 1). The reasons for this may be twofold. The first reason could be prescribed to economically more developed urban centres of western Slovenia that attract the creative class to a greater extent than economically less developed urban centres of eastern Slovenia. The second reason could be identified in settlement structure which is in western Slovenia generally denser and more compact than in eastern Slovenia.

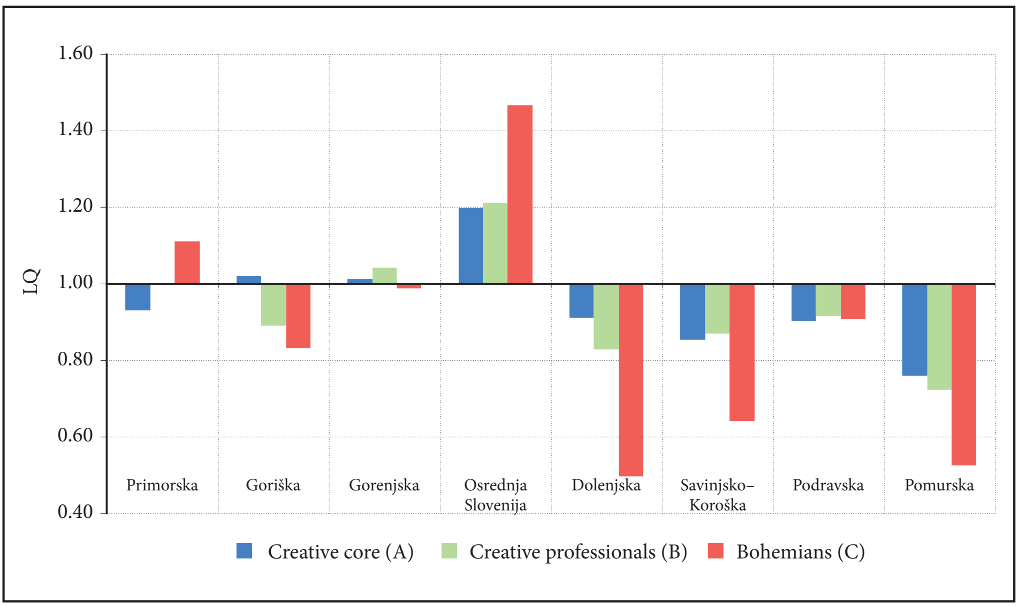


Figure 2: Spatial distribution of the creative class in city-regions of Slovenia in 2011 (own calculations from the Statistical Register of Employment database).

In order to verify whether there are statistically significant differences in the settlement concentration of the creative class between city-regions, we used the Kruskal-Wallis test. The results showed that residential concentrations of the creative class ($H(7) = 371.4$, $p < .001$), creative core ($H(7) = 163.0$, $p < .001$), creative professionals ($H(7) = 267.4$, $p < .001$), and bohemians ($H(7) = 164.6$, $p < .001$) statistically significantly vary between city-regions. In order to gain insight into the differences between exact city-regions, the post hoc testing by using the Mann-Whitney test and Bonferroni correction was applied. In this case, the significance was accepted at a .008 level (for detailed instructions see Field 2009, 565 and 566). The results are summarized and illustrated in the error bar charts, where the red arrows connect city-regions with no statistically significant differences in residential concentration of the creative class and its subgroups (Figure 3).

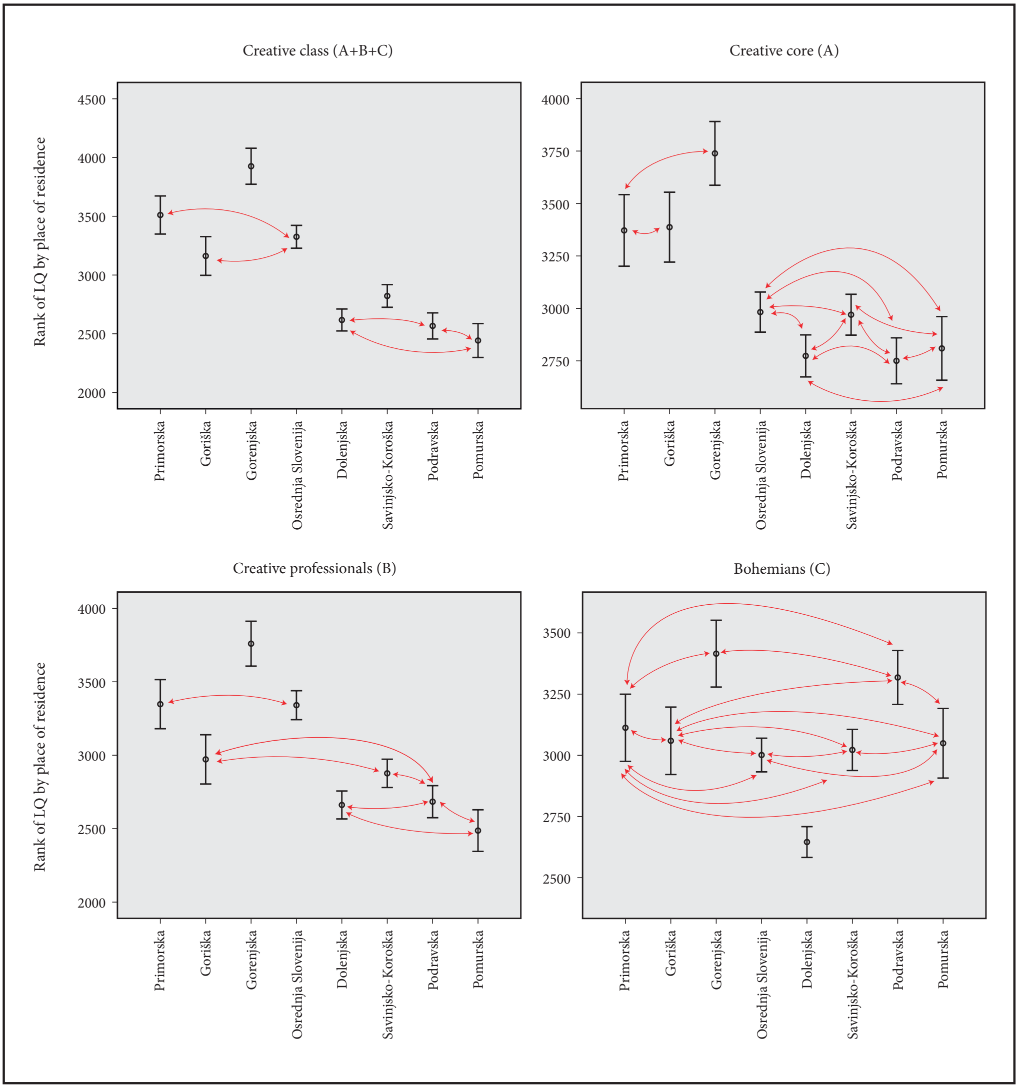


Figure 3: The results of post hoc testing by using the Mann-Whitney test and Bonferroni correction. Error bar charts present the spatial distribution of the creative class across city-regions in Slovenia. The red arrows connect city-regions with no statistically significant differences in residential concentrations of the creative class (own calculations from the Statistical Register of Employment database).

Table 1: Gini coefficient of residential concentration of the creative class in Slovenian city-regions (own calculations from the Statistical Register of Employment database).

City-regions	Creative class (A + B + C)			Creative core (A)			Creative professionals (B)			Bohemians (C)		
	Year 2000	Year 2011	Difference 2000 in 2011	Year 2000	Year 2011	Difference 2000 in 2011	Year 2000	Year 2011	Difference 2000 in 2011	Year 2000	Year 2011	Difference 2000 in 2011
Primorska	0.840	0.816	–0.024	0.858	0.817	–0.041	0.838	0.819	–0.019	0.942	0.925	–0.017
Goriška	0.804	0.769	–0.035	0.829	0.785	–0.044	0.796	0.766	–0.030	0.935	0.899	–0.036
Gorenjska	0.813	0.781	–0.032	0.834	0.783	–0.051	0.806	0.782	–0.024	0.910	0.869	–0.041
Osrednja Slovenija	0.931	0.906	–0.025	0.945	0.918	–0.027	0.926	0.900	–0.026	0.984	0.965	–0.019
Dolenjska	0.828	0.764	–0.064	0.881	0.809	–0.072	0.818	0.754	–0.064	0.980	0.940	–0.040
Savinjsko-Koroška	0.819	0.764	–0.055	0.851	0.787	–0.064	0.812	0.759	–0.053	0.949	0.905	–0.044
Podravska	0.847	0.798	–0.049	0.871	0.823	–0.048	0.840	0.790	–0.050	0.958	0.897	–0.061
Pomurska	0.744	0.681	–0.063	0.780	0.718	–0.062	0.733	0.673	–0.060	0.937	0.864	–0.073
Slovenia	0.871	0.836	–0.035	0.893	0.851	–0.042	0.865	0.831	–0.034	0.970	0.939	–0.031

Table 2: Gini coefficient of residential concentration of the creative class in urban-rural types in Slovenia (own calculations from the Statistical Register of Employment database).

Urban-rural types	Creative class (A + B + C)			Creative core (A)			Creative professionals (B)			Bohemians (C)		
	Year 2000	Year 2011	Difference 2000 in 2011	Year 2000	Year 2011	Difference 2000 in 2011	Year 2000	Year 2011	Difference 2000 in 2011	Year 2000	Year 2011	Difference 2000 in 2011
Urban settlements	0.690	0.690	0.000	0.683	0.686	0.003	0.689	0.688	–0.001	0.815	0.775	–0.040
Suburbanised settlements	0.606	0.579	–0.027	0.635	0.588	–0.047	0.598	0.580	–0.018	0.794	0.696	–0.098
Urbanised rural settlements	0.607	0.572	–0.035	0.650	0.595	–0.055	0.601	0.570	–0.031	0.864	0.792	–0.072
Rural settlements	0.615	0.564	–0.051	0.695	0.620	–0.075	0.624	0.573	–0.051	0.946	0.878	–0.068
Slovenia	0.871	0.836	–0.035	0.893	0.851	–0.042	0.865	0.831	–0.034	0.970	0.939	–0.031

Again, we can see a sharp division between the area of eastern Slovenia (Dolenjska, Savinjsko-Koroška, Podravska, and Pomurska) and the area of central and western Slovenia (Osrednja Slovenija, Primorska, Goriška, and Gorenjska) at an aggregate level of the creative class. A divide is more significant when we compare spatial distribution of the creative core and less notable when it comes to the creative professionals and the bohemians. Especially the last group reflects quite similar proportions of spatial distribution within most of the city-regions in Slovenia.

3.2 Urban-rural differences

The spatial distribution of the creative class in Slovenia is highly and positively correlated with the degree of urbanisation; i.e. members of the creative class predominantly reside in urban settlements. The differences are the biggest in case of the bohemians and the smallest in case of the creative professionals. The latter, however, are also overrepresented in suburbanised settlements (Figure 4).

Between 2000 and 2011, the volume of the creative class increased in all types of urbanisation. However, the increase was the smallest in urban settlements (15%), moderate in suburbanised and urbanised rural settlements (41%, respectively), and the biggest in rural settlements (67%). The urban settlements have grown above the average in most of central and western Slovenia (Osrednja Slovenija, Primorska, and Gorenjska) and Dolenjska. In Goriška and most of eastern Slovenia (Savinjsko-Koroška and Podravska) the increase was recorded as below average, while it was in Pomurska even negative. Suburbanised settlements have grown above the average only in Osrednja Slovenija and Primorska. Both types of rural settlements have increased the most in Osrednja Slovenija and Dolenjska, and moderately in Primorska and Podravska. In other city-regions, these two types have shrunk.

According to Gini coefficients, the residential concentration of the creative class is the highest in urban settlements and lower in other types of urbanisation. However, between 2000 and 2011, the ratio between urban settlements has not changed much, while the other types recorded dispersion (Table 2). In other words, all aspects of the creative class are becoming more evenly distributed within all types of area, other than urban.

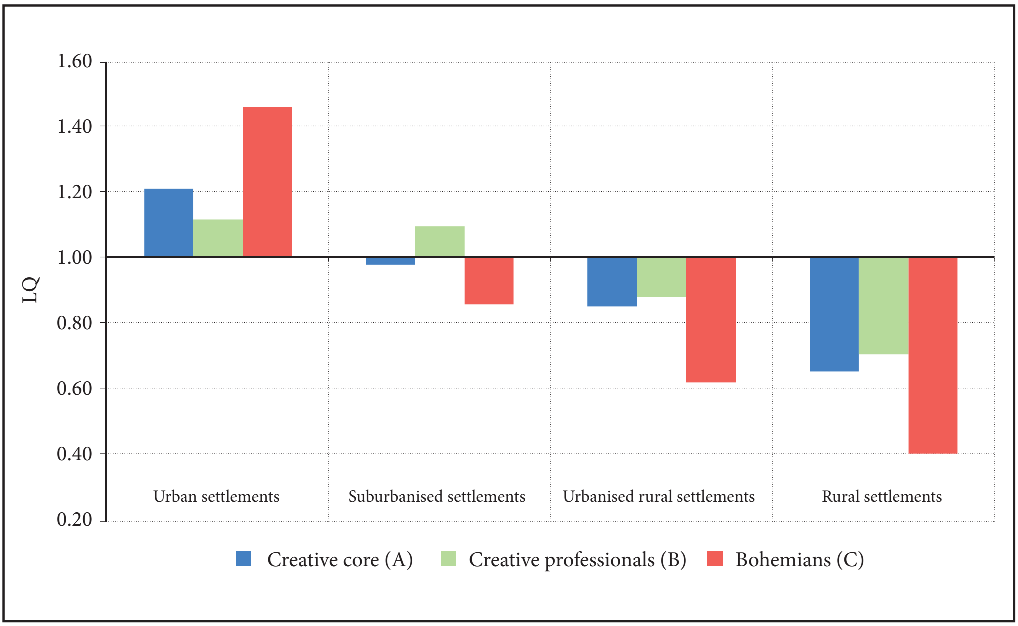


Figure 4: Spatial distribution of the creative class in different types of urbanisation in Slovenia in 2011 (own calculations from the Statistical Register of Employment database).

In order to verify whether there are statistically significant differences in the settlement concentration of the creative class between urban-rural types, we used the Kruskal-Wallis test. The results showed that residential concentrations of the creative class ($H(3) = 47.8$, $p < .001$), creative core ($H(3) = 62.4$, $p < .001$), creative professionals ($H(3) = 40.4$, $p < .001$), and bohemians ($H(7) = 30.1$, $p < .001$) statistically significantly vary also between urban-rural types. In order to gain insight into the differences between exact urban-rural types, the post hoc testing by using the Mann-Whitney test and Bonferroni correction was applied. In this case, the significance was accepted at a .002 level (for detailed instructions see Field 2009, 565 and 566). The results are summarized and illustrated in the error bar charts, where the red arrows connect urban-rural types with no statistically significant differences in residential concentration of the creative class and its subgroups (Figure 5).

Here, we can see a sharp division between most of the urban-rural types. The only exception is a similarity between urban and suburbanised type, mainly on the account of creative professionals.

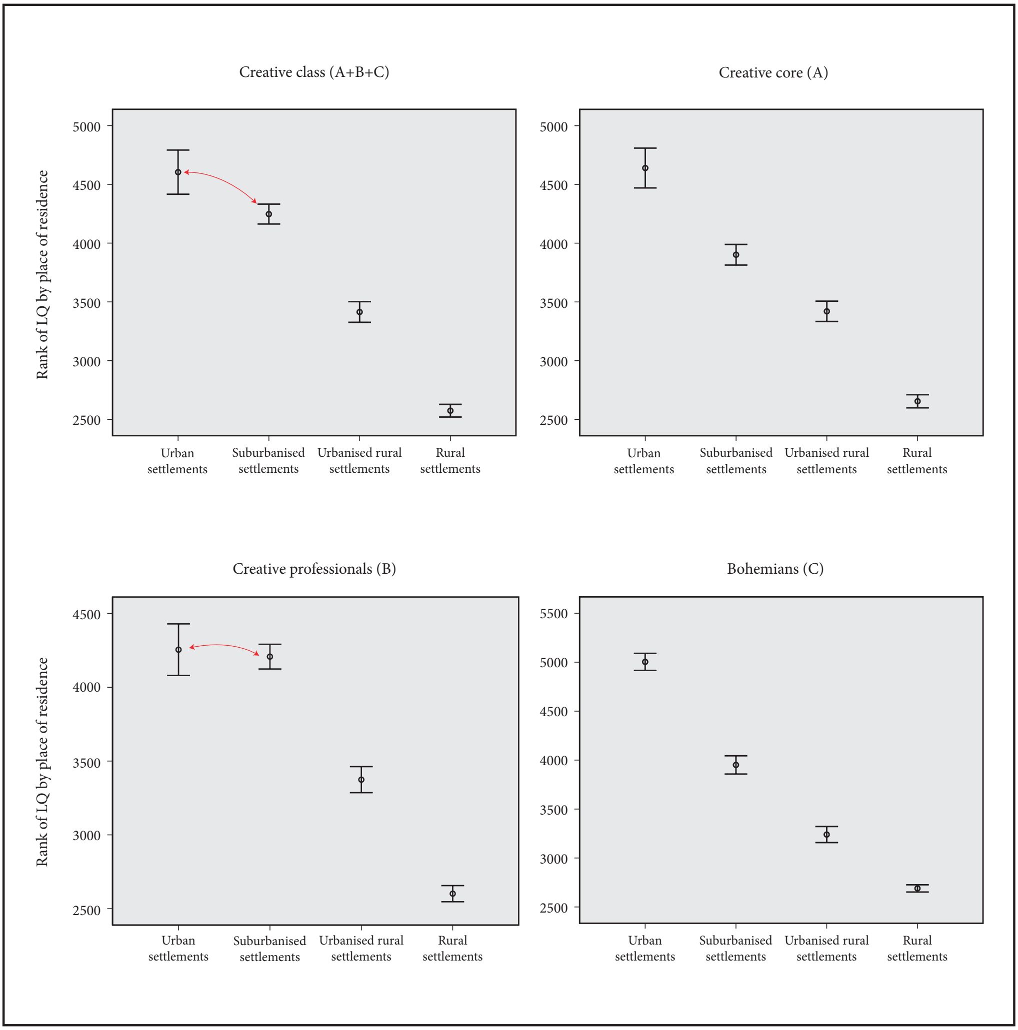


Figure 5: The results of post hoc testing by using the Mann-Whitney test and Bonferroni correction. Error bar charts present spatial distribution of the creative class across urban-rural types in Slovenia. The red arrows connect urban-rural types with no statistically significant differences in residential concentration of the creative class (own calculations from the Statistical Register of Employment database).

4 Discussion

The key question addressed by this paper is what matters more in understanding the location of the creative class: city-region or urban-rural framework? By analysing microdata from the Statistical Register of Employment by the Statistical Office of the Republic of Slovenia we tested the hypothesis that differences in residential concentration of the creative class between urban and rural areas are bigger than between city-regions.

We found that members of the creative class in Slovenia predominantly reside in urban areas. A further analysis confirmed the findings of Markusen (2006) and Bontje and Kepsu (2013) about the higher attraction of urban areas for all of the creative subgroups, while the creative professionals are also more attracted to suburbanised areas. As expected, these findings suggest that creative-knowledge activities are predominantly urban-centric phenomenon.

More significantly, a temporal analysis exposed a dispersion of residencies of the creative class as the main spatial trends in the period 2000–2011. When deciding where to live, the creative class is moving out of densely populated urban areas to more sparsely populated suburban and rural areas within all Slovenian city-regions. The average change in locational Gini coefficient in the investigated period was –0.035. These trends are generally in line with the spatial processes in other city-regions (Parr 2005). As claimed by Ravbar (2002; 2011), this would suggest that the urban system is gradually transforming from a hierarchical structure of settlements to a more balanced network of nodes. It is based on modern principles of weak hierarchical relations and dispersed development poles at infrastructural nodes. According to him, changes in the socio-economic structure of the population, associated with the rise in living standards, decisively motivate people when deciding on where to live. New living conditions promote dispersion encompassing processes such as suburbanisation, peri-urbanisation, and counter-urbanisation.

However, in comparison to other occupational groups and the total population the observed residential de-concentration of the creative class is stronger. Subsequently, we may contest the claim that the creative-knowledge economy is fundamentally a predominantly urban-centric phenomenon. In the long run, it appears to be gaining a mixture of rurality and suburbanity. As reported by some authors, attraction to rural areas might be attributed to quality of life, access to outdoor amenities and activities, the quality of local schools, and social and cultural interaction (McGranahan and Wojan 2007; White 2010). For those moving from urban to rural areas, the attraction factors are usually not related to employment opportunities. However, many newcomers are torn between »city-businesses« oriented towards the city market and »local business« oriented towards customers in their local area. In order to avoid long commuting time to the city and to continue creative career in sectors new to the rural areas, they adapt their business to a wider regional context (Herslund 2012).

At this point, several questions arise. What is happening with the Slovenian urban system? Why are urban areas becoming (relatively) less attractive to live in? Why do some cities shrink? Conversely, what is happening within the Slovenian countryside that attracts new creative capital? From our spatial analyses, we can conclude that cities in more developed western Slovenia are more attractive to live in than cities in less developed eastern Slovenia. However, the statistical tests (see Figures 3 and 5) showed that significance is stronger when comparing urban vs. rural than when comparing city-regions per se. By taking a closer look at the city-regions it seems that there are significant differences between western and eastern Slovenia (NUTS 2 level). Interestingly, NUTS 2 level serves as a basis to allocate European funding (Cohesion fund, European regional development fund, European social fund). Eastern Slovenia as less developed (GDP is significantly below the average of EU) and is thus eligible to receive higher funding than more developed western Slovenia (some parts of western Slovenia are above the average of EU). Future research should focus on explaining these differences. In addition, more attention should be put on critical evaluation of urban development and revitalisation strategies. As indicated by our results, they have not done their work adequately so far.

The statistical analysis confirmed the hypothesis that differences in residential concentration of the creative class between urban and rural areas are bigger than between city-regions. It could be hypothesised that the creative class in urban areas reflects different residential preferences than the creative class in rural areas. Herein, we agree with Gülümser, Baycan-Levent and Nijkamp (2010) that in terms of abilities and capabilities, urban and rural areas are quite different and that comparing »apples« and »pears« with the same parameters can cause problems. Following from these finding, Regional Development

Programmes, that try to address regional development in Slovenia, should put more focus into distinguishing between the supply of and demand for urban, suburbanized, urbanized rural, and rural areas. The fact is that different contextual localities request different approaches and methodologies which bring different outcomes.

From the methodological limitations standpoint, our research should be upgraded in the future by a more distinctive urban-rural typology. We agree with Parr (2005) that juxtaposing of the aggregate categories of urban and rural is of very limited value without the introduction of a more specific spatial context. This is because there is such a wide variation within each category. An urban centre of say 250,000 population is inherently different from one of 2.5 million population, while a remote rural area is not to be compared with a rural area in the immediate vicinity of a major metropolitan area. By virtue of this variability, any generalization of urban-rural relations is beset with difficulties (Parr 2005).

Furthermore, the paper only partly addresses the call of Harvey (1985) and Jonas and Ward (2007) to explore the city-region as both a living and as a working place. To this end, analysis by place of work (i.e. as opposed to residence) would be a valuable next research step – particularly with this data also revealing industry of employment; as we know from previous research (e.g. Clifton 2008) occupation is a useful but imperfect capturing of economic activity, which could usefully be augmented by sector data at the individual level as per the »creative trident« approach of Higgs and Cunningham (2008). While it is easy to argue that for city-regions place of residence and place of work are effectively the same thing (city-regions being more or less functional labour markets) this argumentation is less clear when looking at degree of urbanisation – i.e. it is perfectly conceivable to live in a rural area (and certainly a suburban one) while working in an urban one. However, this data is presently not available at the micro level, at least from secondary sources.

In our view, future research should not be limited only to residential locations but correspondingly take into account a deeper investigation of basic human activities such as housing and environment as well as educational, health, supply and social services, and employment opportunities. As claimed by Collinge and Musterd (2009), a holistic approach is indispensable in an effort to attract or retain creative-knowledge workers to certain areas.

Although space constraints preclude it here, our findings suggest that an interesting exercise could be to undertake a »cross-sectional« analysis of the two frameworks employed and look at urban-rural distribution *within* city-regions; this could potentially reveal intraregional disparities and help add insight to what is happening within city-regions.

From the findings presented here we can also conclude that it would be a useful exercise to undertake similar city-region vs. urbanisation analyses in other European contexts, not least ones in which the urban hierarchy is different (Clifton, Cooke and Hansen 2013). With a larger cross-national sample of city-regions other controls could be introduced into the analysis, regional dummies for example to deal with spatially uneven development. More generally with regional policy-making moving towards a city-region agenda (as per the recent »city deals« in the UK) it is imperative that these dynamics are better understood.

5 Conclusion

In this paper we sought to analyse what matters more in understanding the residential location of the creative class in Slovenia: city-region or urban-rural framework. Our analysis revealed that differences in residential concentrations of the creative class vary more within city-regions (on an urban-rural framework) than between city-regions. Although members of the creative class predominantly reside in urban areas, they are moving out of densely populated urban areas to more sparsely populated suburban / rural areas within all city-regions. There are also significant differences found between more developed western Slovenia (denser settlement structures) and less developed eastern Slovenia (sparser settlement structures). We conclude that new models of living are promoting dispersion. Subsequently, we may contest the claim that creative-knowledge activities are fundamentally a predominantly urban-centric phenomenon. In the long run, it appears to be gaining a mixture of rurality and suburbanity.

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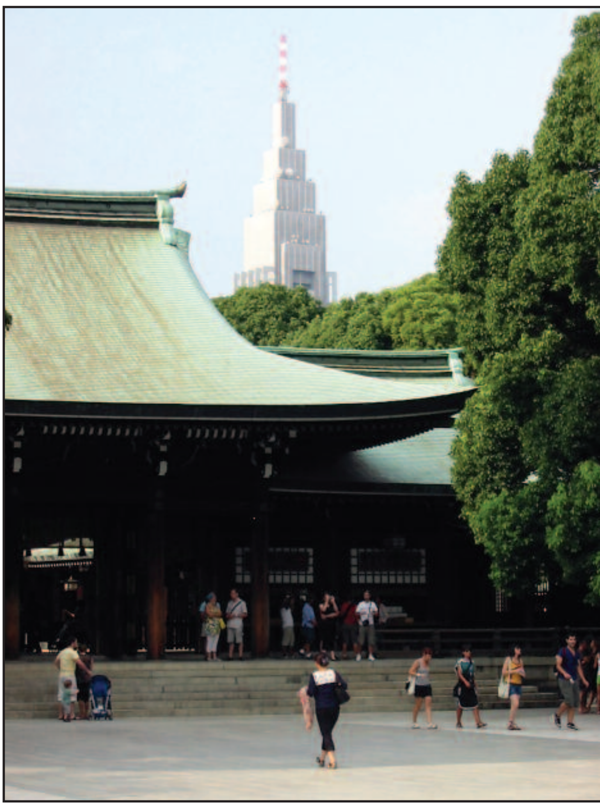
THE IMPORTANCE OF GREEN AMENITIES FOR SMALL CREATIVE ACTORS IN TOKYO: COMPARING NATURAL AND SOCIOCULTURAL SPATIAL ATTRACTION CHARACTERISTICS

Matjaž Uršič, Kazushi Tamano


MATJAŽ URŠIČ

In intensely urbanized Tokyo, green areas are of great importance.

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The importance of green amenities for small creative actors in Tokyo: Comparing natural and sociocultural spatial attraction characteristics

ABSTRACT: In the last decade, the Japanese authorities have invested considerable effort and economic resources into constructing developmental models that can help build a friendlier environment for the domestic creative economy. Due to Tokyo's specific natural and sociocultural characteristics, these efforts have had mixed effects on small creative groups. Based on an analysis of spatial attraction factors for individuals from various creative occupations, this article identifies how important green or natural amenities are in comparison with other sociocultural characteristics for small creative groups. The analysis of data acquired through semi-structured interviews indicates that green amenities do not play a primary role in the spatial distribution of small creative groups, but they do play a very important secondary role in cases when creative workers balance similar spatial attraction characteristics in specific areas in Tokyo.

KEY WORDS: spatial attraction factors, natural amenities, green amenities, creative sectors, creative ecosystem, small creative actors, Tokyo

Pomen zelenih dobrin za male kreativne akterje v Tokiu – Primerjava naravnih in družbeno-kulturnih značilnosti prostorske privlačnosti

POVZETEK: V zadnjem desetletju so japonske oblasti vložile veliko truda in ekonomskih virov v izdelavo razvojnih modelov, ki bi pomagali zgraditi prijaznejše okolje za domačo kreativno ekonomijo. Ta prizadevanja so zaradi specifičnih naravnih in družbeno-kulturnih značilnosti Tokija različno vplivala na majhne ustvarjalne skupine. Na podlagi analize faktorjev prostorske privlačnosti za posameznike iz različnih kreativnih poklicev smo v članku ugotovili, kako pomembne so zelene, tj. naravne dobrine v primerjavi z drugimi socialno-kulturnimi značilnostmi, ko gre za majhne ustvarjalne skupine. Analiza podatkov, pridobljenih prek polstrukturiranih intervjujev, razkriva, da zelene dobrine nimajo primarne vloge za prostorsko distribucijo majhnih kreativnih skupin, vendar imajo zelo pomembno sekundarno vlogo v primerih, ko kreativni delavci primerjajo podobne značilnosti prostorske privlačnosti na določenih območjih Tokija.

KLJUČNE BESEDE: faktorji prostorske privlačnosti, naravne dobrine, zelene dobrine, kreativni sektorji, kreativni ekosistem, mali kreativni akterji, Tokio

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1 Introduction

Global structural changes in trade and industrial production have affected the Japanese economy, which, due to its relative dependence on the domestic market (Kenkyujo 2007; Miyazaki 2008), is increasingly investing in innovative technologies and production, which are intended to open new markets and generate economic growth. In this view, creative industries, often referred to as the creative economies, are increasingly seen as a valuable tool for diversifying the local economic base and replacing jobs lost in traditional industrial and service sectors (Rausch and Negray 2006; Bole 2008; Chapain, Clifton and Comunian 2013; Gielen 2013; Kozina 2016). Creative industries are becoming a more important segment of urban economies, but the share of creative employees in Japan is increasing slowly in comparison to other economically developed countries (Sasaki 2003; Yoshimoto 2009).

Although Japan cannot be identified as a typical liberal market, but rather as a special form of »coordinated market economy« (Hall and Soskice 2001, 8), the transformation of global markets and production chains, the rise of digitalization, and informatization have radically changed the position of the employed in small creative firms that were traditionally embedded in manufacturing (Fujita and Hill 2005; Karatsu 2001). New types of production that intensified in the 1990s and demanded greater flexibiliation, internationalization, quicker production, and fast transferability of knowledge were less favorable for Japanese creative groups embedded in very specific historical, cultural, and political circumstances. In this regard, Clifton, Cooke, and Hansen (2013, 204) state that »varieties of capitalism« depending on specific national environments differently influence the location dynamics of the creative class. Similarly, Godina (2015) mentions the case of Japan, which shifted into the capitalist system while being strongly embedded and path-dependent on place-specific traditions, rituals, and cultural practices. Due to these specific contextual and spatial characteristics, the Japanese creative economy was better prepared for »incremental« or coordinated innovation rather than the »radical« (i.e., disruptive) innovation model typical for liberal markets (Nemet 2009, 702). The circumstances described were favorable for powerful large companies supported by government institutions and banks, which attracted the majority of the creative workforce.

Today, the main economic power and creative employment still resides within large companies, but in the last decade a trend in an increase in small creative groups and individuals has been noticed; that is, small creative firms that try to establish themselves in a very competitive market (Sasaki 2003; Hanzawa 2009; Kon 2010; Goto 2014). Japanese policymakers often neglected the significance of smaller firms, which is of huge importance in the case of highly economically vulnerable, grassroots creative activities. From this perspective, establishing conditions to better empower small creative groups to create (self-)employment and thrive in the context dominated by large firms is of extreme importance.

This article analyzes specific social-physical elements of the economic environment in which creative groups are embedded. Namely, we explore what kind of working environment and conditions are expected from the perspective of these groups. For this purpose, we pay particular attention to how these groups perceive the importance of »soft and hard location factors« (Musterd and Murie 2010; Martin-Brelot et al. 2010; Alfken, Broekel and Sternberg 2015) in their working and living environment. Whereas hard location factors mainly apply to the availability of certain resources, soft location factors apply to improvements in one's general quality of life or lifestyle. In this relation, we compare whether natural or green spatial attraction factors such as parks, open recreational areas, and other environmental factors are of higher importance for the new bottom-up emerging creative firms in comparison to other sociocultural attraction characteristics of Tokyo. On the basis of interviews, a questionnaire, and official statistics, we analyze whether existing places and urban conditions provide optimal circumstances for the long-term formation of small (bottom-up) creative actors.

2 Conceptualization: spatial attraction characteristics and the Tokyo creative ecosystem

As the importance of the innovation sector and creative economies rises, Tokyo and other Japanese cities are increasingly trying to improve their spatial advantages and create an environment of micro-locations that are better adapted for creative businesses (Tokyo Metropolitan Government 2014; Kim 2015). The advantages of individual locations for creative industries are reflected through various factors, ranging from green areas to the amount of rent for business premises, transport links, access to customers, lifestyle orientations of employees, extent of social networks, and proximity to sociocultural activities and leisure. All of these factors are an integral part of the creative ecosystem, defined as an environment that supports or is »*focused on creative-based activities*« (Rivas 2011, 4). It comprises places following the example of the creative city and economy in the form of creative industries, following specialized ways of exchanging, interacting, and communicating; people, (i.e., members of the creative class); and social and cultural capital, social networks, and so on (Scott 2006; Markusen 2006; Rivas 2011; Bell and Jayne 2004; Florida 2010).

It can be presumed that, when searching for appropriate working conditions, small innovative firms apply the system of progressive elimination or tapering of the most negative elements and pursuit of the most suitable options that meet their development needs. In doing so, they rely on what behavioral economics calls cost-benefit analysis, or CBA (Tevfik 1996), and decide on a suitable location only when they feel satisfied with the majority of conditions that minimize unnecessary costs (Giddens 1984). In accordance with their perception of contextual and spatial elements, potential users of a site for creative activities rigorously assess all possible costs and do not only pay attention to the economic price of rent or purchase cost of the premises. For example, the quality of natural amenities, transport accessibility, cost of access to the market (customers), mental/emotional effort required to operate at the location, level of cultural heterogeneity, access to various amenities, services, cooperation between similar companies, openness of the local community, and so on are all elements evaluated by potential users. For potential users, each of these elements can represent a significant cost, inappropriate effort, or, on the other hand, comfort and relief, which may significantly affect their work and either discourage or attract them to a location. These are the so-called push/pull factors in attracting creative groups (Gottlieb 1994; Musterd and Gritsai 2012; Krätke 2011).

Any suitable location for developing a creative milieu comprises a number of pull factors that successfully attract specific groups of people. In doing so, it is important to emphasize that specific pull factors heavily depend on the decisions of city or national authorities about how to intervene in space. Such is also the case of green areas, which are scarce in Tokyo's physical space. Although the central districts of Tokyo generally have some green areas such as the Imperial Palace and large private gardens, many of these spaces are not accessible to the public. Kobayashi (2015, 8) writes that in Tokyo »*spaces where forests and the natural environment can be experienced are actually very limited.*« A comparison of Tokyo with other global cities shows that Tokyo has an extremely low percentage of publicly accessible parks, gardens, squares, and cemeteries (Figure 1).

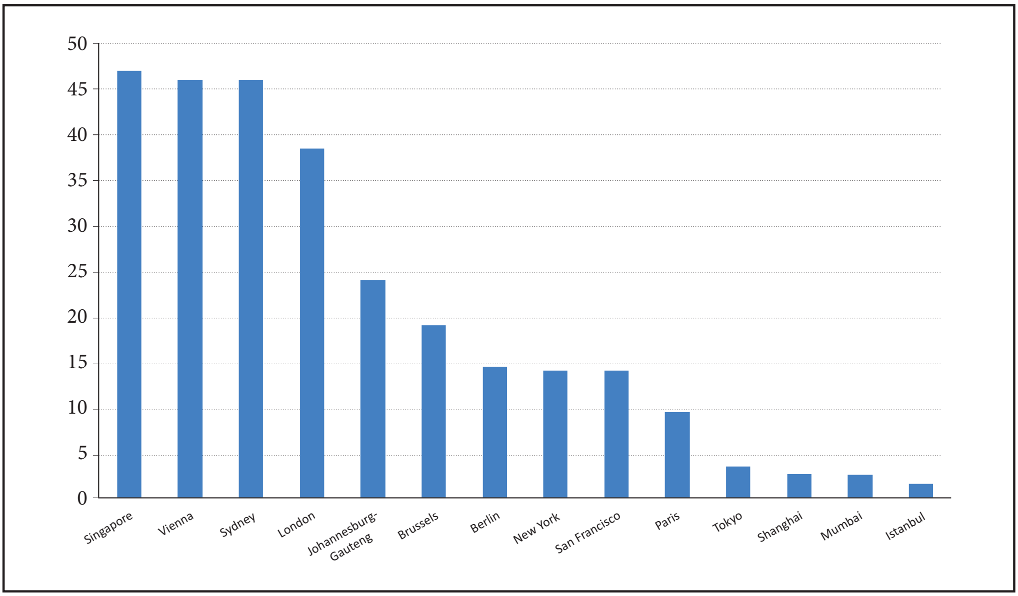


Figure 1: World cities' public green spaces (parks and gardens), percentage by proportion of area (Source: WCCF, World Cities Culture Report 2012, 2015).

From this perspective, it seems that the »Tokyo model« of a sustainable development strategy is not particularly concerned with the strategic integration of green spaces, but relies on the implementation of incremental (i.e., very particular) projects connected to the development of green areas. Past urban development in Tokyo considerably undermined many natural features and amenities that make other global cities attractive in the first place. The rapid growth of the urban population and increasing density have put pressure on the use of space for construction where natural amenities were barely integrated into public space.

Although at first glance the importance of nature for developing the local milieu and small creative groups for city development seems small, this does not mean that global cities cannot be affected by the availability of green spaces in the long term. For example, Florida (2005) asserts that specific factors that deeply affect the spatial distribution of creative sectors are at first glance more visible than other factors that may greatly influence the attraction potential of specific cities in the future. Such changes may occur at the micro or local level and are sometimes less noticeable but still have a deep and important impact. One such factor is described as »*urban sprawl and ecological decay*« (Florida 2005, 172) and could gradually significantly change the attraction hierarchy of global cities in the long term.

3 Methodology and research process

The major goal of the research was to accumulate various layers of data to make it possible to analyze the influence of place and environment on the organization of work for specific parts of Japanese creative sectors. In this regard, we approach small creative groups and individuals from the perspective of »creative occupations«; that is, by focusing »*more closely on what cultural workers do rather than what they make*« (Markusen et al. 2008, 25) and thus not taking into account the entire range of those employed in a particular sector of the creative industries. Relying on Florida's (2005) broad definition of the creative class, based on which we identified the creative fields of people included in the study, like DeNatale and Wassall (2006) we sought to narrow down the large occupational categories by identifying specific components of the creative cluster (e.g., defining enterprises and individuals that directly and indirectly produce cultural products in a specific area), the creative workforce (e.g., defining the thinkers and doers trained in specific cultural and artistic skills that drive the success of creative industries in specific areas), and the creative community (e.g., defining a geographic area with a concentration of creative workers, creative businesses, and cultural organizations in specific locations of Tokyo). The combination of specific components of the creative cluster, creative workforce, and creative community allowed us to filter out persons not directly engaged in creative tasks and at the same time to capture the creative employed and self-employed that are usually not considered part of the creative industries or creative workforce (e.g., general software, art crafts, etc.).

There were two stages in the research. The basic research model first included acquiring qualitative data through face-to-face interviews and then quantitative data through questionnaires. As such, in the first stage, key personnel (e.g., directors, managing directors, key developers, engineers, researchers, etc.) in institutions that provide jobs and attract a large number of self-employed creative individuals were interviewed. A total of twenty-three interviews in twenty different institutions were carried out from August to September 2014. Such institutions included co-working spaces, start-up incubators, and art and creative labs in Tokyo's central wards of Minato, Chuo, Shibuya, Shinjuku, Chiyoda, Sumida, Bunkyo, Taito, and Shinagawa (marked dark grey in Figure 2). After detailed interviews with key personnel in these institutions, the second stage of the research process addressed creative individuals from small firms (mainly ranging from one to five employees) that are associated with and directly use the services or working spaces in these institutions. As such, the key personnel in the institutions provided a sort of entry point for the second stage of the research process, which surveyed the creative individuals through a semi-structured questionnaire. Altogether, 102 respondents from thirty-five different institutions that spend their working time in Tokyo's central wards were surveyed from September to November 2014.

The data acquisition method used is a form of two-stage snowball sampling or chain (referral) sampling (Atkinson and Flint 2004; Morgan 2008; Voicu 2011). Such a non-probability sampling technique in which those interviewed (in our case, the key personnel in creative support institutions) in the first stage allow the researcher to access additional subjects (from among people that are part of institution's social network) for a questionnaire in the second stage of the research process is often used for populations that are difficult for researchers to access. In particular, independent creative workers that are highly mobile,

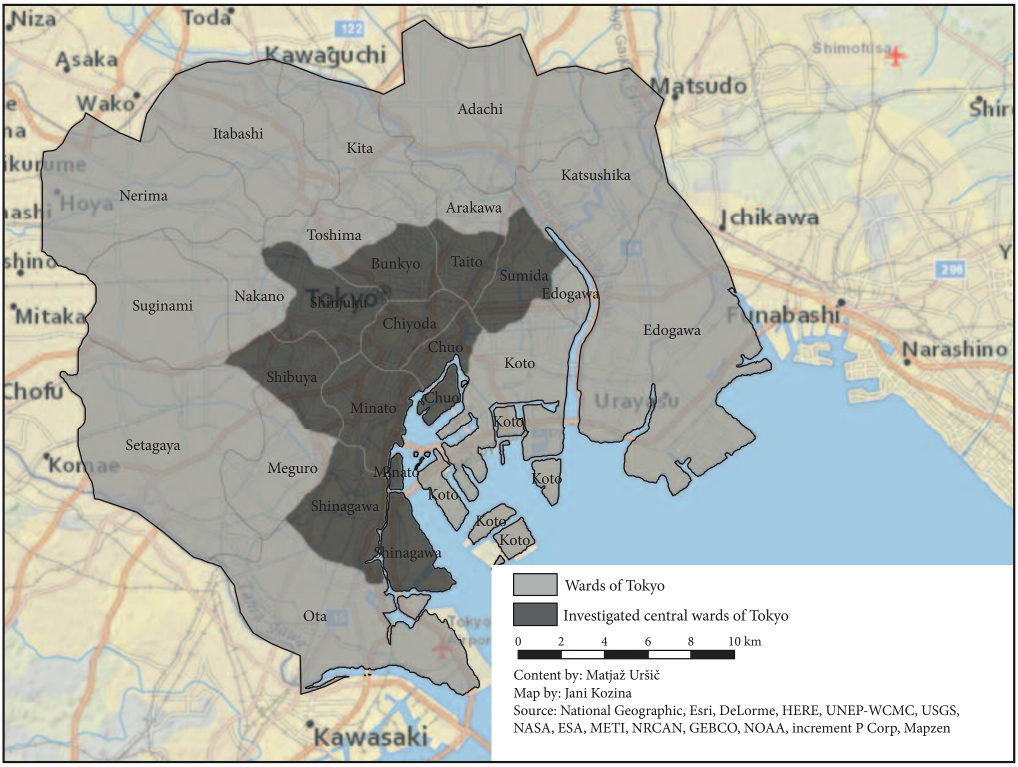


Figure 2: Tokyo's central wards included in the analysis.

non-sedentary, possess special skills or innovative approaches, and highly value privacy perfectly fit the description of a population that is difficult to access for researchers. In our sample, 70.6% of respondents from the questionnaire belonged to the 26–35 and 36–45 age groups, 58% were male, and in terms of social status they were middle class (40% earned ¥150,001 to ¥300,000 per month). Due to the snowball sampling technique, it was impossible to focus only on a specific creative occupation or concentrate on analyzing a very specific creative industry; instead, we used the »*occupation by-industry approach*« (Markusen et al. 2008, 37) to analyze specific occupations within larger creative industry fields. The research focuses on a general analysis of spatial factors in the creative ecosystem for small creative groups and individuals in Tokyo's central districts. The questionnaire was divided into various sections that included general questions regarding Tokyo's creative economy and details ranging from individuals' creative field, spatial factors, and value orientations to their relation toward urban development and demography. The individuals included in the questionnaire were based in very different creative occupations (27% arts and culture creation, 24% architecture, 15% general software and computer games, 12% crafts, 11% design, and 11% other groups). The open-question (qualitative) data were analyzed separately, and the quantifiable data were appropriately coded and inputted into the SPSS database for further analysis.

4 Analysis of results: the role of natural and sociocultural spatial attraction characteristics for small creative groups in Tokyo

The collected data confirm the importance of specific spatial factors for creative individuals that work in Tokyo's central districts. Undoubtedly, the most important spatial factor in the case of Tokyo is access to mobility infrastructures. In comparison to European cities, where personal networks are an important part of spatial attraction characteristics (Musterd and Gritsai 2012), their role does not seem so substantial in the case of Tokyo. Instead, the importance of mobility infrastructures was stressed on various occasions both in interviews and in quantitative data collected from the questionnaire. When asked: »How important are the following factors when you are choosing the location of work?« creative individual respondents put the location and its accessibility by public transport at the top of the list (see Figure 3).

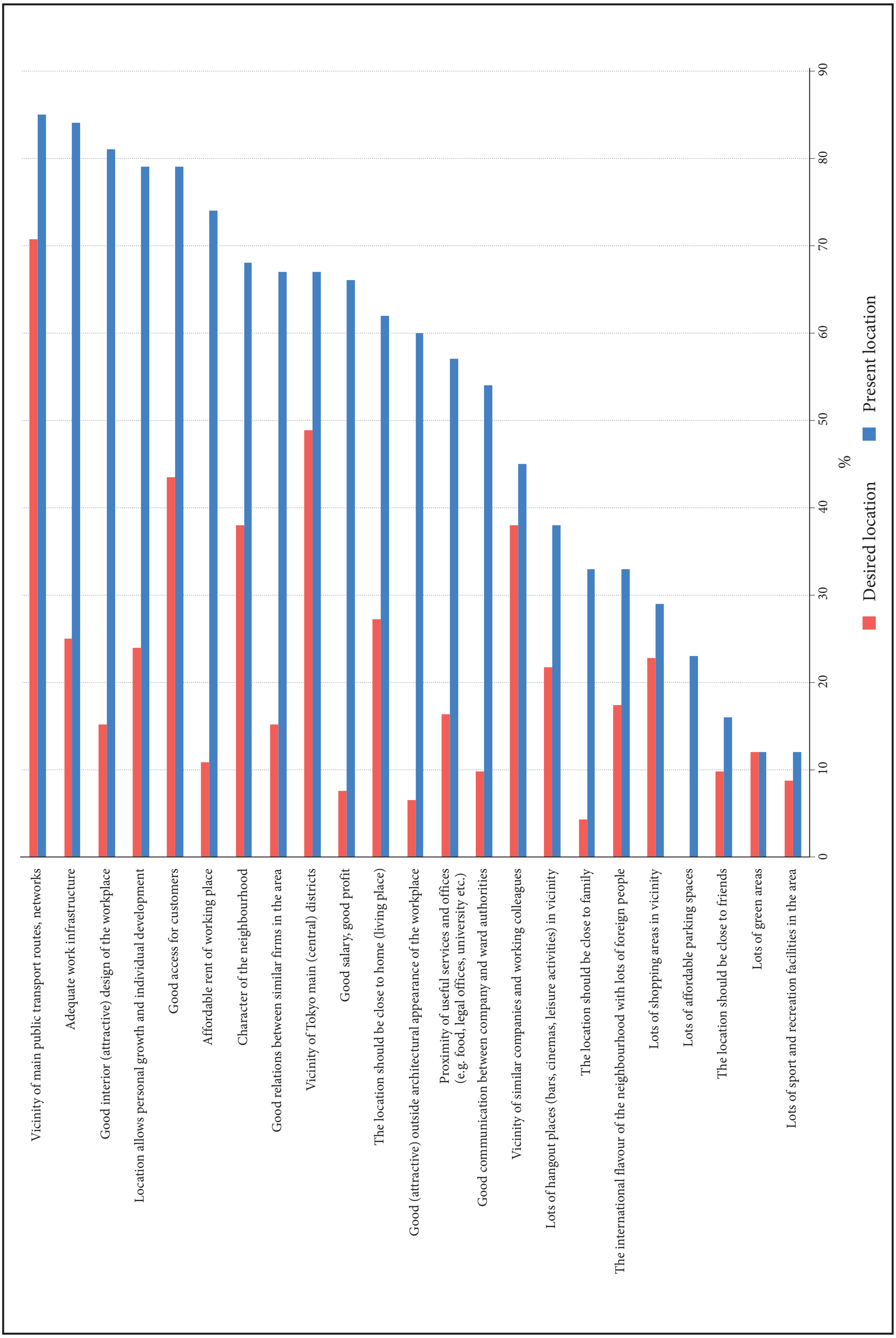
More than 85% of respondents replied that the vicinity of public transport routes and networks is a very important characteristic when choosing the present location of work. Similarly important is the need to have adequate work infrastructure (84%) and a good (attractive) interior design of the workplace (81%). The location of work must also have qualities that allow personal growth and individual development (79%). How important the location is in terms of mobility is further stressed by the need to be accessible to customers (79%) and indirectly through some other factors on the list (e.g., the vicinity of Tokyo's main districts, the proximity of useful services and offices, etc.). The importance of greenery, sports, and recreation facilities ranks at the very bottom of important factors because they are not perceived by creative groups as absolutely necessary for work. The importance of transport accessibility is very understandable due to Tokyo's extreme metropolitan size, its density, and the distances one needs to travel. Transport accessibility is key for other services, customers, wellbeing, and sustaining formal and informal networks, which from the perspective of creative individuals offer enormous multiplicative effects and add to the quality of one's work.

Transport accessibility also stands out as one of the main factors in cases when respondents wanted to change the present location of work. Approximately, one-third (32.4%) of respondents wanted to relocate in the next three years for various reasons (e.g., to find another job in the same or different innovative field, to open a new company, etc.). When asked: »In comparison to your present job location, what are the main advantages of the location that you listed as your favorite working environment in Tokyo?« the advantage most often named (in 70.7% of cases) was location and its proximity to main public transport routes (Figure 3). Even though respondents may work in a well-networked location in terms of transport, they have aspirations to improve it in order to obtain a better workplace.

In comparison to other spatial factors that stand out when choosing the present location for work (Figure 3) for example, the need for adequate work infrastructure, good interior (attractive) design of the workplace, or affordable rent at the workplace when choosing a desired location for work the respondents again stressed the importance of transport accessibility as the main variable for improving their working conditions and businesses. It seems that their perception of a desired location is based on the experience that they acquired during past years of work in the creative field. In economically very competitive environments such as Tokyo, the best locations are occupied by the strongest creative economic actors (i.e., large firms), whereas small creative firms are left to pick secondary locations. Despite being located in central areas of Tokyo, small creative groups cannot afford the premium workplaces, but due to financial limitations choose secondary, peripheral locations inside central areas. Although these are still central locations, they have specific shortfalls, which can be recognized through respondents' indications that show the importance of other location factors (e.g., lots of green areas, good access to customers, the character of a neighborhood, and proximity to similar companies and professional colleagues). Although small creative groups put additional emphasis on other location factors, they first want to improve their accessibility and then obtain access to better »secondary« factors. In this sense, they are aware that location on the periphery of the central districts prevents them from developing their full potential because of the missing additional factors that are not at the selected location.

In the case of Tokyo, the accessibility of transport infrastructure represents the top of the »hard location factors« (Musterd and Gritsai 2012, 346), which also include other variables such as rent, work infrastructure, salary, and so on. The research findings indicate that hard location factors play a significant role in attracting young creative workers. Although the results suggest that hard factors are of extreme importance when choosing the location of work, it is important to mention that »soft factors« (Murphy and Redmont 2008, 36) also play an important role. Soft location factors usually include contextual elements that add to enhancement of social aspects in specific environments. In the case of Tokyo, green, recreational areas and natural amenities were perceived by small creative groups as socially pleasant leisure places that add to the personal quality of life. In our study, they are identified as part of soft attractive factors due to their functional role as a catalyzer of social engagement or sociability. In this sense, soft factors

Figure 3: Attraction characteristics for creative individuals when choosing the present and desired location of work. ➤ p. 166


Vicinity of main public transport routes, networks
Adequate work infrastructure
Good interior (attractive) design of the workplace
Location allows personal growth and individual development
Good access for customers
Affordable rent of working place
Character of the neighbourhood
Good relations between similar firms in the area
Vicinity of Tokyo main (central) districts
Good salary, good profit
The location should be close to home (living place)
Good (attractive) outside architectural appearance of the workplace
Proximity of useful services and offices
(e.g. food, legal offices, university etc.)
Good communication between company and ward authorities
Vicinity of similar companies and working colleagues
Lots of hangout places (bars, cinemas, leisure activities) in vicinity
The location should be close to family
The international flavour of the neighbourhood with lots of foreign people
Lots of shopping areas in vicinity
Lots of affordable parking spaces
The location should be close to friends
Lots of green areas
Lots of sport and recreation facilities in the area
0
10
20
30
40
50
60
70
80
90
%
Desired location
Present location

prove to be decisive in cases when creative individuals compare working spaces with similar transport accessibility, price of rent, or work infrastructure. Similar findings are drawn also from the ACRE study (2010) and other authors (Musterd and Murie 2010; Martin-Brelot et al. 2010; Ravbar 2011) that analyze soft factors in Europe.

Based on these studies, we may speculate that, when comparing working spaces with similar transport accessibility, price of rent, or work infrastructure, creative individuals would prefer to choose locations that offer better soft location attributes (e.g., plenty of greenery, lots of sports and recreation facilities, good access to customers, a good neighborhood character, etc.), even at the expense of some of the hard attraction factors such as a good salary or a large number of affordable parking spaces. Even more, the data from Figure 3 suggest that, based on their experience, creative individuals look to soft location factors when making a final decision on where to possibly relocate. It appears that in the »second stage« of creative working development (i.e., after some years of experience at a specific location), individuals recognize the importance of or can afford more soft location attributes when they search for a new desirable location. According to the data in Figure 3, it can be observed that some soft location factors (e.g., green areas, sports and recreation facilities, the character of the neighborhood, proximity to similar companies and professional colleagues, etc.) climbed the preference ladder in comparison to their position between the attraction characteristics at the present location of work. In general, transport accessibility as the most important spatial factor stayed at the top position, but the importance of other hard location factors such as work infrastructure or rent considerably diminished in the second step.

The interplay between hard and soft location factors can also be observed through the analysis of other factors, which emerged after detailed questioning of the interviewees. For example, the creative individuals were asked to form specific opinions regarding the statements presented in Figures 4 and 5.

The analysis shows that the image of physical location as the dominant spatial factor in the creative ecosystem is softened by the sensitivity of the respondents toward specific socio-spatial transformations that are occurring in Tokyo and may change the character of their working environment in the long term. They are aware that economic development results in new jobs and supports their work aspirations (Statement 2 in Figure 4) but are also fully aware that intense urban restructuring, renovation, and urban competitiveness may diminish the quality of their living and working environment in the long run (Statements 1, 3, 4, and 5 in Figure 4). Although Statements 1 and 4 seem ambiguous at first glance, it is understandable

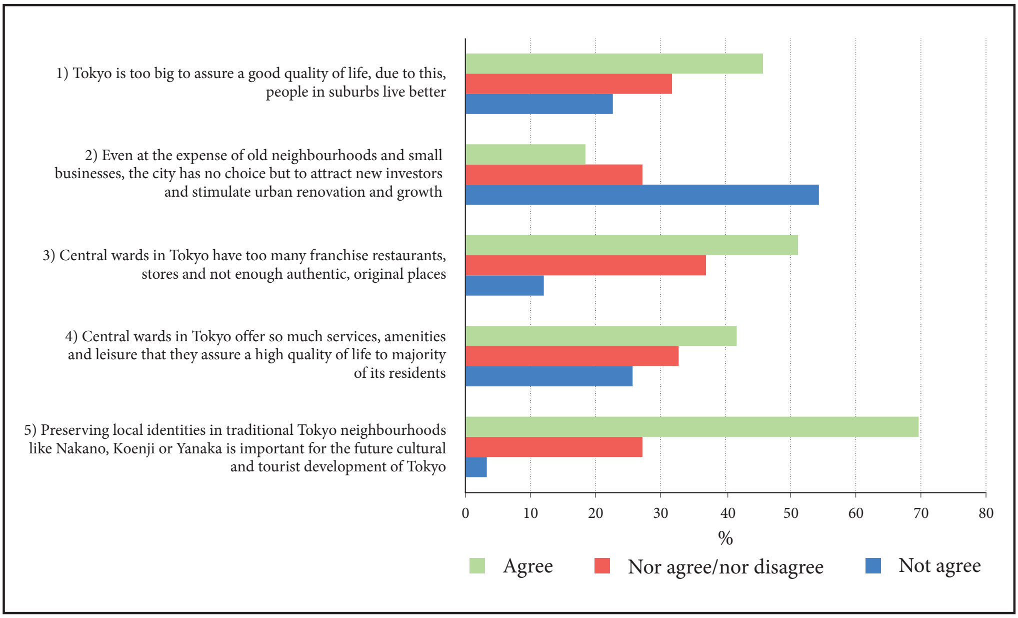


Figure 4: Please state how much you agree or disagree with the following statements.

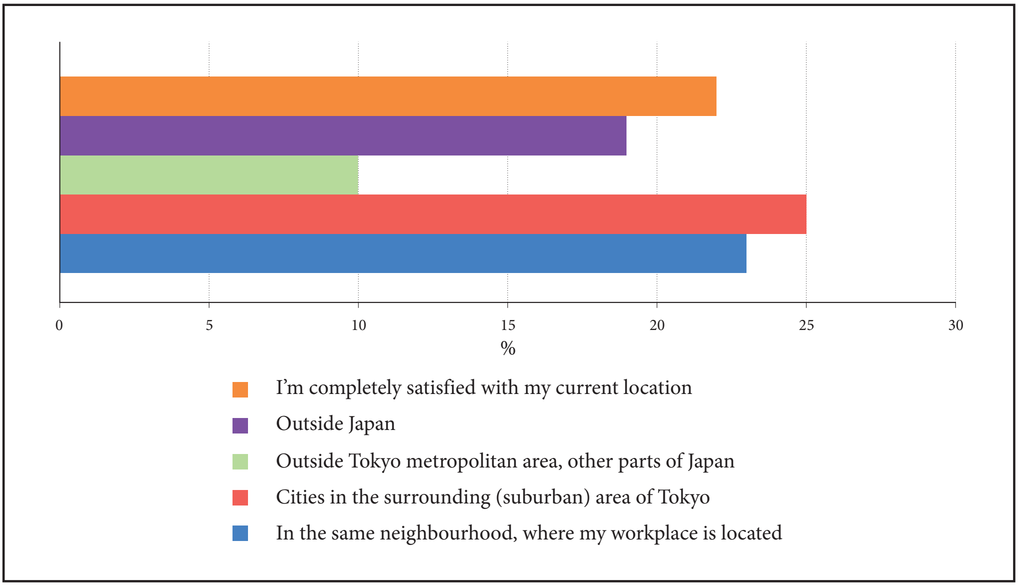


Figure 5: Where would you like to live if you could freely choose your location?

that respondents highly value the advantages offered by both central areas (e.g., access to services and infrastructure) and suburban areas (e.g., access to green areas and natural amenities, less traffic, and urban density; see Figure 5).

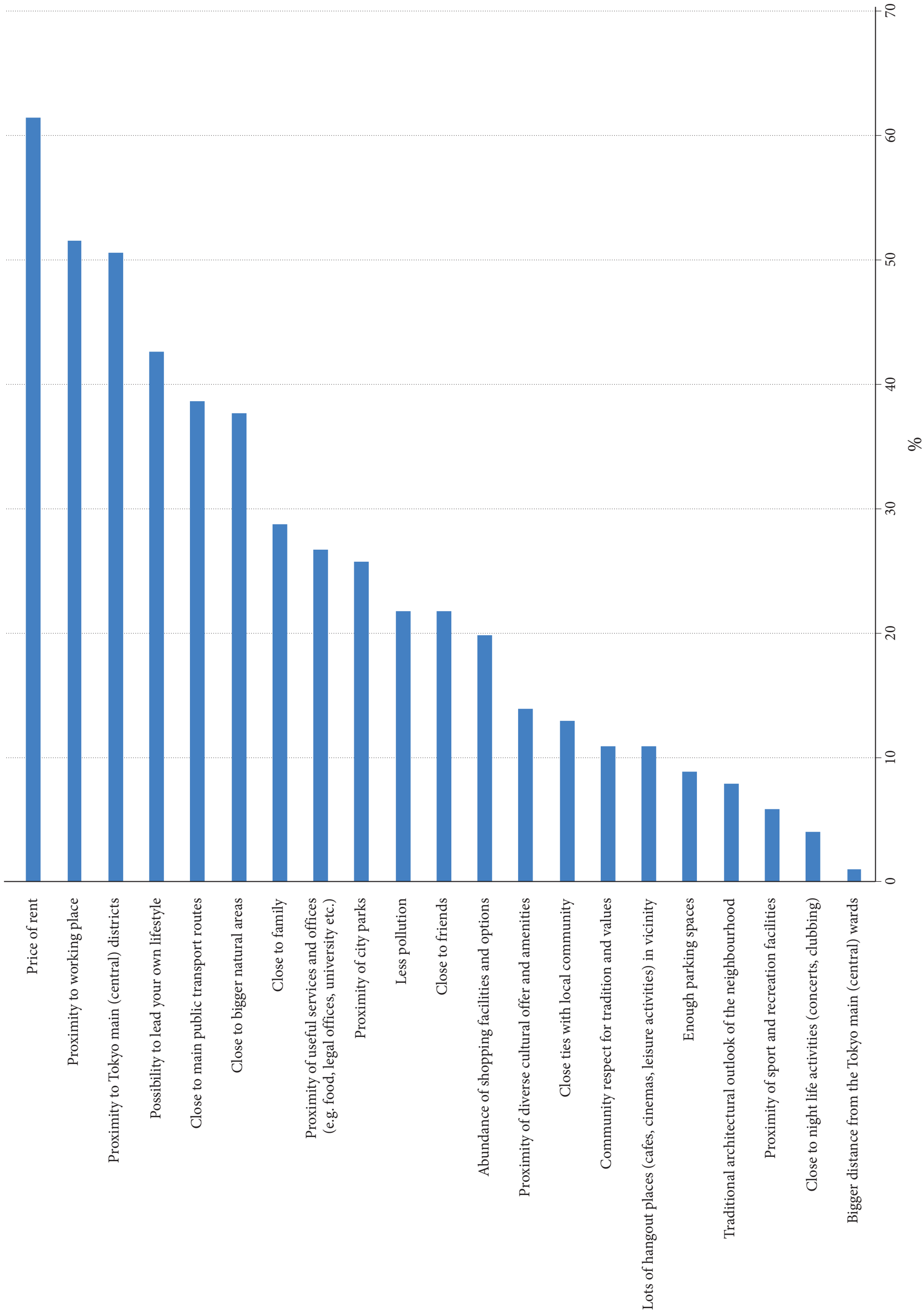
Similarly to the data in Figures 4, 5, and 6, the respondents latently show a high interest in soft location factors, which gain more importance when not directly linked to working conditions. In Figure 6, the respondents were asked to evaluate the main attraction factors for home; that is, the location where they (would like to) live.

In the Japanese context, which highly values work and the work ethic, the hard location factors that add to work still remain at the top of the priority list for creative workers. However, when offered additional possibilities of evaluation, the quality of the living and working environment is not perceived by creative individuals only in terms of access to hard spatial factors and economic incentives, but also in terms of access to natural amenities (e.g., proximity to large natural areas and city parks), which scored particularly high in the evaluation of soft factors that are important when choosing a place to live.

5 Conclusions

The research showed that Japanese creative workers in small firms highly value specific spatial factors that add to their personal growth and quality of work. It also showed that the Tokyo creative ecosystem is still based on hard location factors such as access to public transport and provision of adequate working infrastructure, whereas soft location factors such as natural amenities, sports and recreation facilities, diversity, and international flavor play an important secondary role. Natural amenities thus do not play a primary role for the distribution of small creative firms, but they do play a very important secondary role in cases when creative workers balance similar hard attraction characteristics for specific areas in Tokyo. In the case of Tokyo's small creative groups, green amenities, in order to »survive« in the very harsh inter-company competitive environment, do not function as an important category for selecting a working space. In order to improve their status, creative workers in small firms would rather obtain access to a better working location than to greenery, parks, or natural and recreational areas.

Figure 6: What are the most important reasons when it comes to choosing your home or where you live? ➤


Price of rent
Proximity to working place
Proximity to Tokyo main (central) districts
Possibility to lead your own lifestyle
Close to main public transport routes
Close to bigger natural areas
Close to family
Proximity of useful services and offices (e.g. food, legal offices, university etc.)
Proximity of city parks
Less pollution
Close to friends
Abundance of shopping facilities and options
Proximity of diverse cultural offer and amenities
Close ties with local community
Community respect for tradition and values
Lots of hangout places (cafes, cinemas, leisure activities) in vicinity
Enough parking spaces
Traditional architectural outlook of the neighbourhood
Proximity of sport and recreation facilities
Close to night life activities (concerts, clubbing)
Bigger distance from the Tokyo main (central) wards
0
10
20
30
40
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60
70
%

The strong hierarchy of attraction characteristics for work shows that policy could take some precautionary measures to ease the burden of small and vulnerable creative actors that are just entering a very competitive market. It also points to the relatively diminished importance of natural spatial attraction characteristics, which is not the case in other cities and countries in the world (see Poljak Istenič 2016, WCCF 2012 2015; Ravbar, Bole and Nared 2005; Huggins and Clifton 2011; Clifton and Kozina 2015). If internationalization in terms of transfer of sociocultural trends really influences the creative global sectors in Tokyo, the importance of natural amenities could significantly change in the future. Some authors (Møller 2008; Moreno-Peñaranda 2011) have already noticed the increasing importance of natural and green areas as an asset for socio-spatial development. From this perspective, natural amenities that are currently not on the priority list of small creative groups in Tokyo's central districts could greatly influence the distribution and density of creative occupations in the future. Specific urban policies in Tokyo on a grand scale (i.e., at the instrumentalist level) already focus on the development of green areas in central parts of the city (e.g., the Marunouchi project, Toranomon, the Umi no Mori »Sea Forest« marine park, etc.), but they do not systematically integrate environmental factors into the scheme of sustainable development and connect it with general urban development of the city.

A similar situation is reflected at the more general level of urban competitiveness of cities, where Tokyo is seeking to retain its role among global cities and to implement various strategies and projects to revitalize its economic potential (see Tokyo Metropolitan Government Bureau … 2013; Tokyo Metropolitan Government 2014). These strategies mainly rely on improving hard location factors, which partly helps in revitalizing specific city areas but also opens the discussion on whether the strategies should have been more oriented toward soft location factors, including improving quality and access to natural, green, and recreational areas, which also play an important role in other global cities (Sassen 2001; Machimura 1997; Pain et al. 2015).

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Review papers (narratives, best-practice examples, systematic approaches, etc.) should have the following structure:
- **Introduction:** include 1) the background; 2) the problem: trends, new perspectives, gaps, and conflicts; and 3) the motivation/justification.
- **Material and methods:** provide information such as data sources (e.g., bibliographic databases), search terms and search strategies, selection criteria (inclusion/exclusion of studies), the number of studies screened and included, and statistical methods of meta-analysis.

- **Literature review:** use subheadings to indicate the content of the various subsections. Possible structure: methodological approaches, models or theories, extent of support for a given thesis, studies that agree with one another versus studies that disagree, chronological order, and geographical location.
- **Conclusions:** provide implications of the findings and your interpretations (separate from facts), identify unresolved questions, summarize, and draw conclusions.

– **Acknowledgement:** use when relevant.
– **Reference list:** see the guidelines below.

2 Paper submission

2.1 Open journal system

Author(s) must submit their contributions through the *Acta geographica Slovenica* Open Journal System (OJS) using the Word document template.

Enter all necessary information into the OJS. Any addition, deletion, or rearrangement of names of the author(s) in the authorship list should be made and confirmed by all coauthors before the manuscript has been accepted, and is only possible if approved by the journal editor.

To make anonymous peer review possible, the paper text and figures should not include names of author(s).

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.

If a text is unsatisfactory, the editorial board may return it to the author(s) for professional copyediting or reject the paper. See the section on the peer-review process for details. Author(s) may suggest reviewers when submitting a paper.

2.2 Language

Papers are published in English.

Papers are submitted in English or Slovenian and copyedited/translated after acceptance by a professional chosen by the editorial board.

The translation or copyediting costs are borne by the author(s) (translation €500, copyediting €200) and must be paid before layout editing.

All papers should have English and Slovenian abstracts.

2.3 Supplementary file submission

Supplementary files (figures) can be submitted to the OJS packed in one zip file not exceeding 50 MB.

2.4 Submission date

The journal publishes the submission date of papers. Please contact the editor with any questions.

3 Citations

Examples for citing publications are given below. Using "gray literature" is highly discouraged.

3.1 Citing papers

- 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
- Perko, D. 1998: The regionalization of Slovenia. Geografski zbornik 38.
- 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.
- de Kerk, G. V., Manuel, A. R. 2008: A comprehensive index for a sustainable society: The SSI – the Sustainable Society Index. Ecological Economics 66-2,3. DOI: https://doi.org/10.1016/j.ecolecon.2008.01.029
- van Hall, R. L., Cammeraat, L. H., Keesstra, S. D., Zorn, M. 2016: Impact of secondary vegetation succession on soil quality in a humid Mediterranean landscape. Catena, In press. DOI: https://doi.org/10.1016/j.catena.2016.05.021 (25. 11. 2016).

3.2 Citing books

- Cohen, J. 1988: Statistical power analysis for the behavioral sciences. New York.
- Nared, J., Razpotnik Visković, N. (eds.) 2014: Managing cultural heritage sites in Southeastern Europe. Ljubljana.
- 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

3.3 Citing parts of books or proceedings

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

3.4 Citing expert reports, theses, and dissertations

- Breg Valjavec, M. 2012: Geoinformatic methods for the detection of former waste disposal sites in karstic and nonkarstic regions (case study of dolines and gravel pits). Ph.D. thesis, University of Nova Gorica. Nova Gorica.
- Hrvatin, M. 2016: Morfometrične značilnosti površja na različnih kamninah v Sloveniji. Ph.D. thesis, Univerza na Primorskem. Koper.
- 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.
- 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).

3.6 Citing online material without authors

- Internet: http://giam.zrc-sazu.si (18. 11. 2016).
- Internet 1: http://giam.zrc-sazu.si/ (22. 7. 2012).
- Internet 2: http://ags.zrc-sazu.si (23. 7. 2012).

3.7 Citing sources without authors

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

3.8 Citing cartographic sources

- Državna topografska karta Republike Slovenije 1 : 25.000, list Brežice. Geodetska uprava Republike Slovenije. Ljubljana, 1998.
- Franciscejski kataster za Kranjsko, k. o. Sv. Agata, list A02. Arhiv Republike Slovenije. Ljubljana, 1823–1869.
- Buser, S. 1986: Osnovna geološka karta SFRJ 1 : 100.000, list Tolmin in Videm (Udine). Savezni geološki zavod. Beograd.
- The vegetation map of forest communities of Slovenia 1 : 400,000. Biološki inštitut Jovana Hadžija ZRC SAZU. Ljubljana, 2002.
- Digitalni model višin 12,5. Geodetska uprava Republike Slovenije. Ljubljana, 2005.

3.9 Citing official gazettes

- 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).
13. Permission has been obtained for the use of copyrighted material from other sources, including online sources; see the copyright notice below.
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

8 The reference list is suitable (the author cites previously published papers with similar topic from other relevant scientific journal).

Yes, the author cited previously published papers on similar topic.

No, the author did not cite previously published papers on similar topic.

9 Scientific language of the paper is appropriate and understandable.

Yes No

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

11 Describe the possible deficiencies of the supplementary files:

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

ACTA GEOGRAPHICA SLOVENICA REVIEW FORM

1 RELEVANCE

1a) Are the findings original and the paper is therefore a significant one?

Yes No Partly

1b) Is the paper suitable for the subject focus of the AGS journal?

Yes No

2 SIGNIFICANCE

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

Yes No Partly

2b Does it bring relevant results for contemporary geography?

Yes No Partly

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

High Middle Low

3 ORIGINALITY

3a Has the paper been already published or is too similar to work already published?

Yes No

3b Does the paper discuss a new issue?

Yes No

3c Are the methods presented sound and adequate?

Yes No Partly

3d Do the presented data support the conclusions?

Yes No Partly

4 CLARITY

4a Is the paper clear, logical and understandable?

Yes No

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

5 QUALITY

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

Yes No

5b Does the paper take into account relevant current and past research on the topic?

Yes No

Propose amendments, if no is selected:

5d Is the references list the end of the paper adequate?

Yes No

Propose amendments, if no is selected:

5e Is the quoting in the text appropriate?

Yes No Partly

Propose amendments, if no is selected:

5f Which tables are not necessary?

5g Which figures are not necessary?

6 COMMENTS OF THE REVIEWER

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

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

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

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FAQ

Some common questions and answers are available on the journal webpage: ags.zrc-sazu.si.

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JOURNAL HISTORY

Acta geographica Slovenica (print version: ISSN: 1581-6613, digital version: ISSN: 1581-8314) was founded in 1952. It was originally named *Geografski zbornik / Acta geographica* (ISSN 0373-4498). Altogether 42 volumes were published. In 2002 *Geographica Slovenica* (ISSN 0351-1731, founded in 1971, 35 volumes) was merged with the journal.

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

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

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