PAPERS/RAZPRAVE

NATURALNESS LEVEL OF LAND USE IN A HILLY REGION IN NORTH-EASTERN SLOVENIA

STOPNJA NARAVNOSTI GRIČEVNATEGA SVETA SEVEROVZHODNE SLOVENIJE Z VIDIKA RABE TAL

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ABSTRACT

Naturalness level of land use in a hilly region in north-eastern Slovenia

Researchers analyse land use status and its rates of change and try to define the most appropriate structure that suits the environmental characteristics. The article focuses on an analysis of the naturalness level of land use in three hilly regions in north-eastern Slovenia (Slovenske Gorice, Haloze, and Goričko) with the help of geoinformation tools. Land use structure is one of the best indicators of human presence in the landscape. The aim was to expose those parts of catchments that can be regarded as less natural or more natural. We divided the catchments into hydrogeographical areas and analysed them by calculating the urbanity index. The least natural areas in 2018 were located in Slovenske Gorice Hills and the most natural were those in Haloze. The urbanity index diminished between 2002 and 2018 for all the areas except two. The main reason for a higher average of naturalness level is overgrowth – changing agricultural areas into areas with bushes and trees. Natural disasters, e.g. floods and intensive erosion can be mitigated with suitable land use.

KEY WORDS

geography, hydrogeography, urbanity index, land-use change, geographical information systems, Pannonian low hills, Slovenia

IZVLEČEK

Stopnja naravnosti gričevnatega sveta severovzhodne Slovenije z vidika rabe tal

Raziskovalci analizirajo stanje rabe tal in trende spreminjanja ter skušajo ugotoviti, kakšna struktura je okoljsko najbolj sprejemljiva. V prispevku smo se osredotočili na analizo rabe tal treh gričevnatih območij severovzhodne Slovenije (Slovenske gorice, Haloze in Goričko) z vidika stopnje naravnosti s pomočjo geoinformacijskih metod. Raba tal je namreč eden najbolj nazornih pokazateljev človekovega delovanja v pokrajini. Določiti smo želeli posamezna območja porečij, ki jih lahko označimo za bolj naravna, in območja, ki so manj naravna. Porečja smo razdelili na hidrogeografska območja in jih analizirali glede na indeks urbanosti. Glede na izračunane indekse so bila v povprečju leta 2018 najmanj naravna območja v Slovenskih goricah, najbolj pa v Halozah. Indeks urbanosti se je od leta 2002 do 2018 sicer povsod zmanjšal, razen na dveh območjih. Vzrok za povečanje stopnje naravnosti v povprečju gre predvsem na račun zaraščanja oziroma spreminjanja nekoč kmetijskih zemljišč v zemljišča v zaraščanju. Z ustrezno rabo tal lahko omilimo naravne nesreče, na primer pojav poplav in povečane erozije.

KLJUČNE BESEDE

geografija, hidrogeografija, stopnja urbanosti, spreminjanje rabe tal, geografski informacijski sistemi, panonska gričevja, Slovenija

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1 Introduction

A significant share of natural landscapes are being transformed into cultural landscapes, which are themselves constantly changing. The changes to land use and land cover are the result of various driving forces interacting. The five most common factors affecting the land use status are: population, economic development, technology, institutions, and culture (Mather 2006, cited in: Gabrovec, Bičík and Komac 2019). The landscape is being reshaped through the rising influence of agriculture and urbanization, energy flows, biogeochemical cycles, and similar processes. The land use rate of change is predominantly the result of natural resource exploitation (for example, food, water) for the sustenance of the population, however, this also causes a certain rate of environmental degradation and the loss of ecosystem functions (Fouch et al. 2019). The land use or land cover (reciprocally) influences many other processes in the landscape, for example development of biodiversity (Costa et al. 2017), soil water retention capacity (Lóczy and Dezső 2013; Dezső et al. 2019), and erosion (Kerényi 2010; Hrvatin et al. 2019). Certain conflicts can occur even within individual anthropogenous land use types, among the more pressing ones being preserving agriculture on fertile soil (Razpotnik Visković and Komac 2018). The rates of land use change are also very important from the landscape-ecological aspect. Intensive land use types, such as built-up surfaces, are increasingly prevailing in Europe; increasing agricultural intensity leads to monofunctionality and can decrease the cultural and natural diversity (e.g., Jordán et al. 2005). In terms of the significance to the landscape-ecological processes, the landscape can be categorized based on land use changes (especially in agriculture, forestry) into those where the intensity is being decreased and those where the intensity is increasing (Jongman 2005).

Researchers often analyse the directions and rates of land use change to try and determine the most appropriate structure and what kind of land use is the most acceptable from the ecological standpoint. One of the options is also to analyse the naturalness level or inversely, the level or anthropogenousness or urbanity. The naturalness level delineates the current state's similarities to ecosystems and their natural state. A low naturalness level is linked to degradation and the loss of forest biodiversity (Costa et al. 2017). There have been several discussions regarding what actually is a natural landscape (see for example Machado 2004), but no definitive explanation has been established.

In Slovenia, general afforestation is more prevalent in the western half of the country, while the land use processes are much more diverse in eastern Slovenia. Agricultural land use is intensifying on plains, while overgrowth and afforestation are occurring in hilly areas that are less suitable for agriculture. Urbanization is the predominant process around major cities across all of Slovenia (Gabrovec and Kumer 2019). The pilot analysis of land use changes between the 19th and early 21st century that was conducted in a smaller area on the north-western part of Slovenske Gorice Hills indicated that the surface area of forests and overgrown areas has increased, while the share of fields and vineyards decreased (Ciglič et al. 2019; Deriaz et al. 2019).

But what is the most optimal structure of land use? Several studies have been published on land use structure in which the authors tried to assess the natural state of selected areas, for example the Jacaré-Guaçu and Jacaré-Pepira catchments in south-eastern Brazil (Costa et al. 2017) and the area of Rio Grande do Sul (Rovani et al. 2019), or how land use affects natural processes, such as soil water retention (Bystřický et al. 2017) and ecosystem services (Ribeiro and Šmid Hribar 2019). Many of the studies utilized geoinformation tools, as they enable wider areas to be analysed in a more objective manner (Costa et al. 2017). Ribeiro and Šmid Hribar (2019) studied two pilot areas in Slovenia (Črna vas in Ljubljana Marsh and Bojanci in Bela krajina) and determined that the traditional less intensive land use is disappearing, because of a more intense agricultural production on the one hand and abandoning farming practices on less suitable areas on the other. Traditional land use is precisely the one that contributes the most diverse ecosystem services and helps preserve the cultural landscape (Ribeiro and Šmid Hribar 2019). In general, deforestation i.e. lower shares of forest surfaces leads of faster water runoff (Graf 1975; Bystřický et al. 2017). Kladnik et al. (2019) studied eight pilot areas across Slovenia and determined that terraced areas are significantly more prone to changes in land use than non-terraced areas. This made it even more important to verify the actual land use status in the hilly areas of north-eastern Slovenia. The Pannonian low hills have 1.9% of terraced areas, placing them in third place in Slovenia, just behind Mediterranean hills and Mediterranean plateaus. Goričko has 2.5% of terraced areas, Slovenske Gorice Hills have 1.4%, and Haloze as much as 4.1% terraced areas (Bole et al. 2016; Perko 2016).

The article analyses land use from the aspect of its naturalness level in three hilly areas of north-eastern Slovenia (Slovenske Gorice Hills, Haloze, and Goričko) using geoinformation methods. Land use structure is one of the best indications of human activities in the landscape. Our aim was to determine the areas that can be designated as more or less natural. We wanted to highlight the areas that require more attention during any future landscape management (for example, preventing floods, soil erosion). We also compared all three hilly areas in this respect.

2 Research area

We studied the hilly regions of Haloze, Slovenske Gorice Hills, and Goričko and the source areas of the local catchments, which were divided into smaller hydrogeographical areas. These hilly regions had been included in physico-geographical and human geographical analyses within the Slovenian-Hungarian research project *Possible ecological control of flood hazard in the hilly regions of Hungary and Slovenia* [*Primerni ekološki ukrepi na področju poplavne nevarnosti v hribovitem območju Madžarske in Slovenije*]. The low hills make up the western edge of the Pannonian Basin and are interspersed with plains or valleys. The expansive Slovenske Gorice Hills are nestled between the Drava and Mura Rivers, Goričko is to the north of the Mura River Plain, while Haloze is located to the south of the Dravinja River, along the border with Croatia (Figure 1).

All of the hilly regions have fairly similar physico-geographical features: less resistant tertiary rocks against weathering and erosion (for example, marl, sandstone, conglomerate, sands, clays), a varied hilly terrain locally with quite steep slopes, a continental climate with the precipitation maximum in the summer and a diverse forest-vineyard land use with settlements on the ridges.

The hills of north-eastern Slovenia are mostly built up of conglomerate, silty and clay marl, sandstone, gravel, sand, and clay. They encircle terraces of thick loam layers (Belec 1998). Compared to the other two regions, the relief of Goričko is less varied. The average slope is 5.7°; half of the surface has slopes under 6° and the average elevation is 275.1 m (Olas and Orožen Adamič 1998). The average elevation of Slovenske Gorice Hills is 268.3 m and the average slope is 7.1° (Kert 1998). The average elevation of Haloze is 316.7 m and the average slope is 14.6° (Vovk 1998). The climate is continental with cold winters and warm summers. The amount of precipitation decreases from the south-west towards the north-east and its dispersion indicates a continental precipitation regime with a summer precipitation maximum. April temperatures are somewhat higher than October temperatures; according to data from the Slovenian Environment Agency, the yearly precipitation (for the period 1981–2010) is between 800 and 1100 mm and increased evapotranspiraton in the summers threaten droughts. The main precipitation maximum is in July and August, with a secondary one in November. The average annual temperature mostly ranges between 9 and 10 °C. The higher-lying hilly areas have a distinct thermal belt with more suitable conditions for viticulture. Shady slopes are mostly covered in forest (Belec 1998). Recent research categorized the area of north-eastern Slovenia as having a subcontinental climate (Kozjek, Dolinar and Skok 2017). Periods of drought have been very characteristic for the previous few decades, especially between April and September (Žiberna 2017). About 700 and 800 mm of water evaporates from the area each year and between 300 and 550 mm runs off (Frantar 2008a). The areas of eastern tertiary low hills (for example Haloze, western Slovenske Gorice Hills) have a specific runoff of between 10 and 20 $l/s/km^2$, while the low hills on the north-eastern most edge (for example, eastern Slovenske Gorice Hills, Goričko) have a runoff of under 10 $l/s/km^2$. The runoff coefficient is below 45%, and even below 20% in Goričko (Frantar 2008b; 2008c). The watercourses have a Pannonian rain-snow regime. The early spring and late autumn maximums are very similar, while the main minimums occur in the summer and the secondary ones occur in the winter (Frantar and Hrvatin 2005). Due to the different rock structure, the soils in the hills are diverse (Belec 1998), especially with rendzinas, eutric brown soils, and dystric brown soils (Repe 2010). The area is mostly covered by an association of European beech and sweet chestnut and a secondary association of Scots pine and round-leaved bedstraw. Pine forests generally grow on the most depleted and weathered areas (Marinček and Čarni 2002).

The analysis included catchments divided into hydrogeographical areas in the selected hills within the borders of the Republic of Slovenia. The areas were determined based on data on the catchments and drainage divides from the European Environment Information and Observation Network (EIONET) in Slovenia, managed by the Slovenian Environment Agency. The entire surface area of all three regions encompasses 1649 km^2, the average size of a hydrogeographical area is 39,3 km^2; the smallest hydrogeographical area spans just 9 km^2, while the largest encompasses 174 km^2.

3 Methods and data

The article analysed the land use status for the years 2002 and 2018 in terms of the level of naturalness or anthropogenic impact. Geoinformatic tools were used to overlay the data layers to create a database. The hydrographical areas were represented with a vector polygon layer. The land use data for 2002, which was the first recorded year available, and for 2018 were acquired from the Ministry of Agriculture, Forestry and Food. Both layers were converted to the raster format with 5 m resolution.

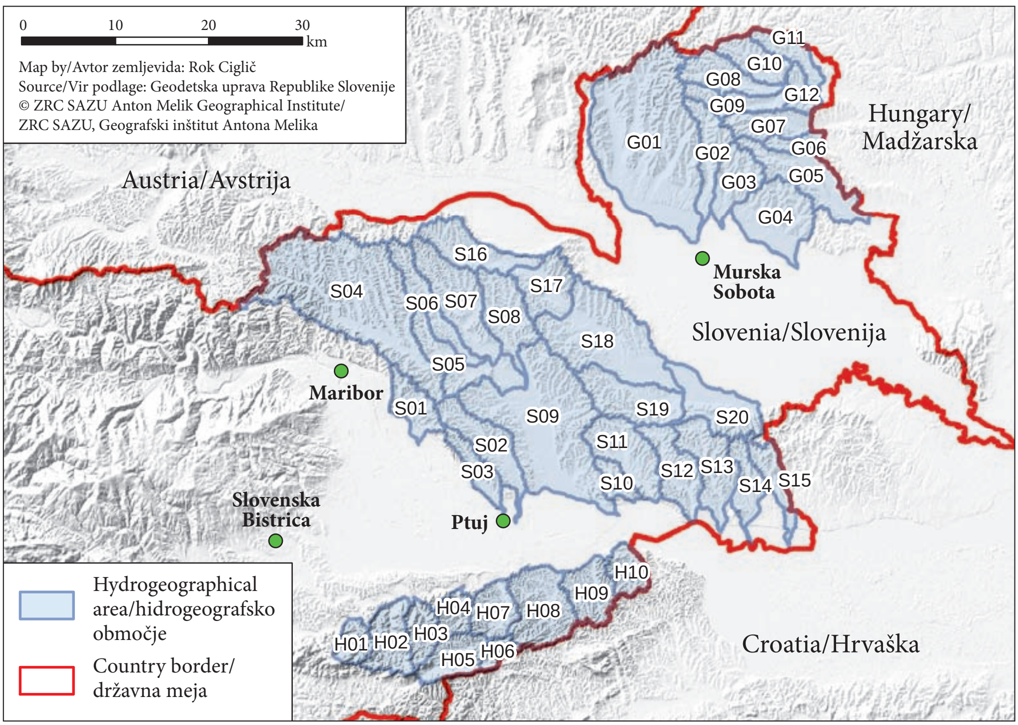

Figure 1: The overview map of the hydrogeographical areas.

Several methods have been established for assessing and measuring the naturalness or anthropogenous level i.e. the degree of human presence (Machado 2004; Lóczy and Pirkhoffer 2009). The presented study opted to evaluate the state of the hydrogeographical areas based on land use, because these data are very precise for Slovenia. The urbanity index (UI) was calculated for each area based on the land use data, in order to extract the level of naturalness or anthropogenic impact. The equation for the urbanity index is: $\frac{\quad}{\mathrm{I}}$. The inputs are: *A* – agricultural area, *U* – built-up area, *F* – natural vegetation, *W* – water and wetland. The areas with the highest naturalness level have lower index values, while the areas with the lowest naturalness level have the highest index levels. The individual original land use categories had to be merged into individual land use groups (Table 1). The urbanity index shows how much the landscape has been altered and how much the anthropogenously altered systems dominate the [more] natural ones (Costa et al. 2017). The index is an indicator of which landscapes are more influenced by human presence and has been used before (for example, Wrbka et al. 2004; Costa et al. 2017; Rovani et al. 2019).

The individual areas as well as all three regions (Haloze, Slovenske Gorice Hills, Goričko) were then compared according to the calculated index values. We then evaluated the calculated values from the aspect of certain natural geographical features relating to morphology, climate, and hydrological features.

Table 1: Combining the original land use categories into simplified categories that were used to calculate the urbanity index. The symbols of the simplified categories mean: A – agricultural area, U – built-up area, F – natural vegetation, W – water and wetland.

Land use ID	Original land use category	Simplified category
1100	Field	A
1160	Hopfield	A
1180	Permanent crops on fields	A
1190	Greenhouse	A
1211	Vineyard	A
1212	Mother-block vineyard	A
1221	Intensive orchard	A
1222	Extensive or meadow orchard	A
1240	Other permanent crops	A
1300	Permanent meadow	A
1321	Wet meadow	A
1410	Overgrown agricultural land	F
1420	Forest tree plantation	F
1500	Trees and shrubs	F
1600	Uncultivated agricultural land	A
1800	Agricultural land overgrown with forest	F
2000	Forest	F
3000	Built-up areas and similar	U
4100	Marsh	W
4210	Reeds	W
4220	Different marshy areas	W
5000	Dry surface area with a specific vegetation cover	A
6000	Other surface with no or an insignificant vegetation cover	A
7000	Water (including man-made retention ponds)	W

4 Results and discussion

The calculated values differ significantly across individual areas (Table 2). According to the calculated indexes, the least natural areas are currently (in the year 2018) in Slovenske Gorice Hills. The hydrogeographical areas of Trnava (S15) and Pesnica 2 (S05) have by far the highest values, with an index of over 0.5; these are followed by Globovnica (S06), Pesnica 3 (S09), and Ščavnica 4 (S20), which have values between 0.35 and 0.40. In Goričko, the most anthropogenously altered area is Ledava (G01) with an index value of 0.26 and Bela in Haloze (H09), which has an index of 0.19 (Figure 3). The lowest value in Slovenske Gorice Hills was calculated for the area Cvetkovski potok (S10), Ivanjševski potok for Goričko (G06), and Tisovec in Haloze (H06). The urbanity level decreased from 2002 to 2018 in all the areas, except two (Rogoznica – S02, Grajena – S03) (Figure 4). In 2002, Trnava also had the highest value in Slovenske Gorice Hills (S15), while Tisovec (H06) had the lowest value in Haloze (Figure 2).

Hydrogeographical areas in Haloze had the lowest average levels in 2018, which means that the land use has been the least altered by human impact (–0.22), while the areas in Slovenske Gorice Hills have the most anthropogenously altered land use (0.28). The areas in Goričko are right between the other two regions (0.01). The ratio between regions was similar in 2002, however, Slovenske Gorice Hills were somewhat more altered (value 0.31), as well as Haloze (–0.14), and Goričko (0.07).

On average, the reason for the lower urbanity index or increase in the naturalness level is mostly afforestation or the fact that once cultivated agricultural surfaces are being overgrown (Table 3). In both years, the majority of surfaces were agricultural fields, meadows, forests, and built-up lots; in 2002, they covered a total of about 90% of the surfaces, and 87% in 2018. The share of meadows remained practically unchanged (previously 19.5%, now 19.3%), surprisingly, the share of built-up lots decreased from 6.1% to 5.6%, the share of forests decreased from 35.8% to 35.2%, the share of fields decreased from 29.4% to 27.3%. Relatively speaking, the surface share of vineyards decreased: from 3.8% to 2.8%. There are somewhat more extensive orchards (previously 2.2%, now 2.7%). The agricultural lots being overgrown increased significantly (previously 0.6%, now 2.1%) and trees and shrubs (previously 1.1%, now 2.6%). The share of water surfaces decreased from 0.06% to 0.05%.

In our aim to assess the urbanity index, combining the categories generally helped us avoid the influence of differences between the categories, deriving from the mapping methodology. The specific analysis of individual land use categories must also account for slight deviations, which are the consequence of mapping land use in every individual period. The categories that were only recorded in 2018 and not 2002 cover a total of 1% of the area. The categories that were only documented in 2002, but not in 2018 (despite the fact that the category existed), cover only 0.03%.

Land use has a decisive influence on natural processes, for example soil water retention, erosion level, and landslide susceptibility. At the same time, people (more or less) adapt the land use to the natural conditions. In order to prevent weakening of ecosystem services, extreme situations should be avoided: land use intensification on the one hand and forestation or the lack of landscape cultivation on the other. Less intensive agriculture should be encouraged (Ribeiro and Šmid Hribar 2019).

An increased share of build-up lots negatively affects the hydrological conditions, as water runoff in source areas rises and increases flood hazard on valley bottoms. The increased area of forests has a positive influence on soil water retention and flood prevention, including increased evapotranspiration (Bystřický et al. 2017; Szilassi et al. 2017). From that aspect, the hilly areas of north-eastern Slovenia are evolving toward a more suitable land use structure.

The increased number of overgrown surfaces and surfaces overgrown with trees also prevents the intensity of slope processes and soil erosion, which were also noticed by Pipan and Kokalj (2017). The decreased share of vineyards (especially in steep slopes, which are now overgrown with forests) has already been documented in other studies (for example Ciglič et al. 2019; Deriaz et al. 2019). The reverse phenomenon, for example when overgrown areas on steep slopes are turned into new vertical vineyards or a pasture, can result in landslides or slumps (Figures 5 and 6).

Table 2: Naturalness index by hydrogeographical areas.

Region	Hydrogeographical area ID	Urbanity index		Change of urbanity index (2018–2002)
		2002	2018	
Goričko	G01	0.26	0.22	–0.04
	G02	0.09	0.05	–0.04
	G03	0.15	0.10	–0.05
	G04	0.25	0.20	–0.04
	G05	0.10	0.04	–0.06
	G06	–0.05	–0.14	–0.09
	G07	0.03	–0.05	–0.08
	G08	0.01	–0.06	–0.07
	G09	0.02	–0.08	–0.10
	G10	0.00	–0.04	–0.04
	G11	0.00	–0.07	–0.07
	G12	0.00	–0.07	–0.07
Haloze	H01	–0.36	–0.38	–0.02
	H02	–0.29	–0.33	–0.04
	H03	–0.21	–0.30	–0.09
	H04	–0.28	–0.40	–0.11
	H05	–0.16	–0.19	–0.03
	H06	–0.56	–0.59	–0.03
	H07	0.03	–0.07	–0.10
	H08	0.06	–0.10	–0.16
	H09	0.19	0.08	–0.11
	H10	0.15	0.06	–0.09
Slovenske Gorice Hills	S01	0.32	0.31	–0.01
	S02	0.21	0.22	0.00
	S03	0.21	0.21	0.00
	S04	0.38	0.30	–0.07
	S05	0.51	0.50	–0.01
	S06	0.38	0.37	–0.02
	S07	0.32	0.31	–0.01
	S08	0.32	0.31	–0.01
	S09	0.35	0.34	–0.01
	S10	0.07	0.03	–0.04
	S11	0.24	0.21	–0.03
	S12	0.24	0.19	–0.04
	S13	0.33	0.29	–0.04
	S14	0.29	0.27	–0.03
	S15	0.57	0.52	–0.05
	S16	0.19	0.16	–0.03
	S17	0.29	0.26	–0.03
	S18	0.29	0.26	–0.03
	S19	0.29	0.26	–0.02
	S20	0.35	0.33	–0.02

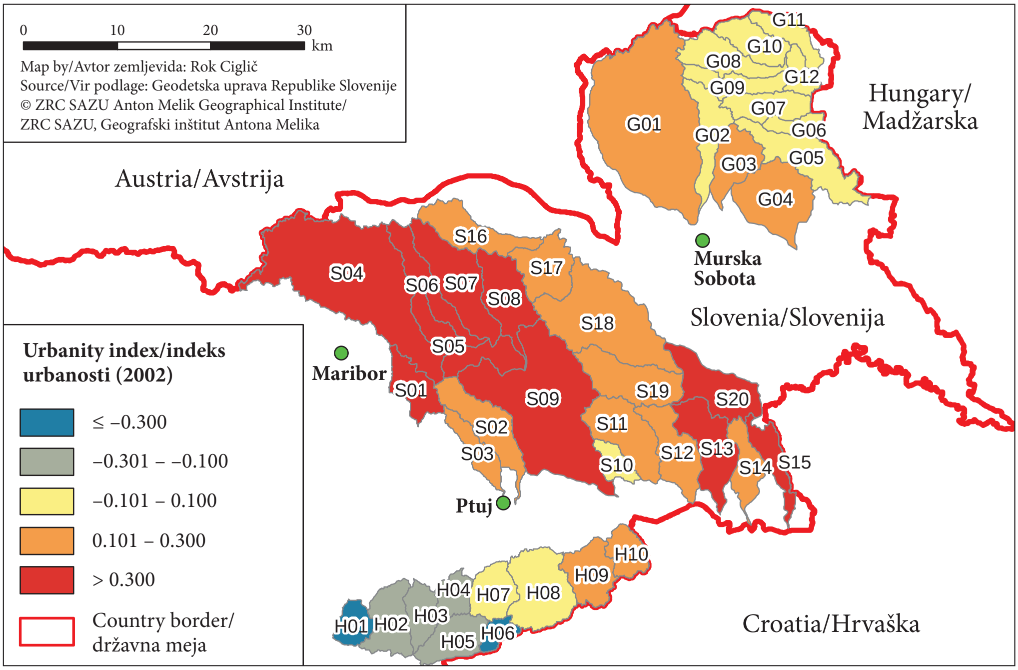

Figure 2: Urbanity index in 2002.

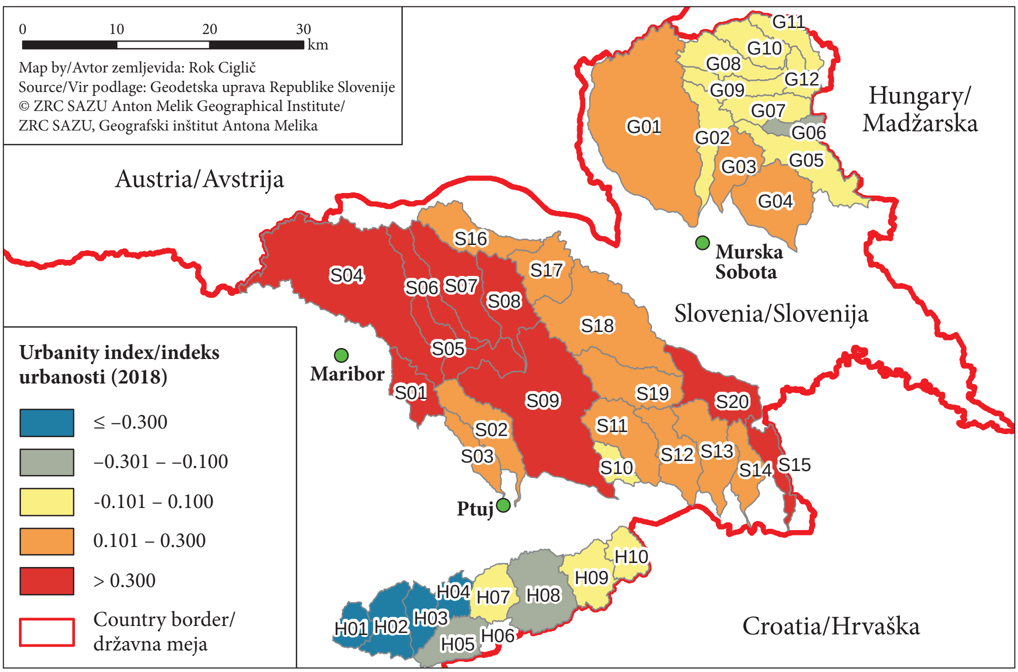

Figure 3: Urbanity index in 2018.

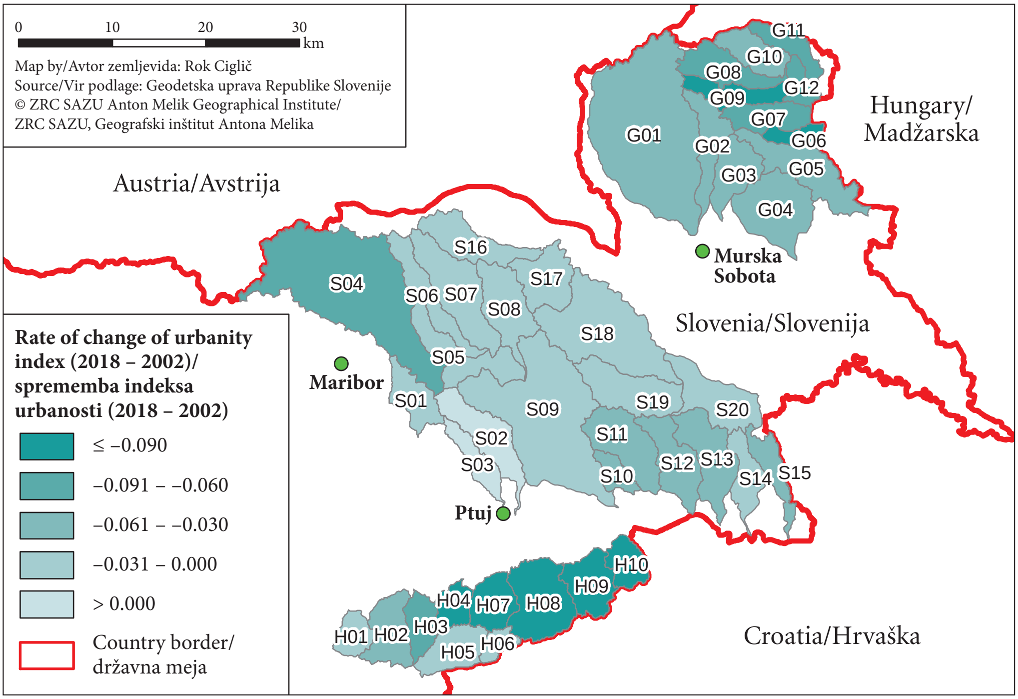

Figure 4: Difference in the urbanity index between 2018 and 2002.

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Figure 5: Transformation of orchards and overgrown surfaces into vertical vineyards in the area of Jareninski dol in Slovenske Gorice Hills created a slump.

*Table 3: Share of categories in 2002 and 2018 (*not defined in 2002).*

Land use ID	Land use category	Share 2002 (%)	Share 2018 (%)
1100	Field	29.4	27.3
1160	Hopfield	0.0	0.0
1180	Permanent crops on fields	0.0*	0.0
1190	Greenhouse	0.0*	0.0
1211	Vineyard	3.8	2.8
1212	Mother-block vineyard	0.0*	0.0
1221	Intensive orchard	0.8	0.6
1222	Extensive or meadow orchard	2.2	2.7
1240	Other permanent crops	0.0	0.1
1300	Permanent meadow	19.5	19.3
1321	Wet meadow	0.0	0.0
1410	Overgrown agricultural land	0.6	2.1
1420	Forest tree plantation	0.0	0.0
1500	Trees and shrubs	1.1	2.6
1600	Uncultivated agricultural land	0.0*	1.1
1800	Agricultural land overgrown with forest	0.0	0.1
2000	Forest	35.8	35.2
3000	Built-up areas and similar	6.1	5.6
4100	Marsh	0.0	0.0
4210	Reeds	0.0	0.0
4220	Different marshy areas	0.0	0.0
5000	Dry surface area with a specific vegetation cover	0.0	0.0
6000	Other surface with no or an insignificant vegetation cover	0.0	0.0
7000	Water (including man-made retention ponds)	0.6	0.5
Total		100.0	100.0
Total surface area of agricultural area (A) and built-up area (U)		61.9	59.5
Total surface area of natural vegetation (F) and water surfaces and wetlands (W)		38.1	40.5

The lowest urbanity index value or the lowest naturalness level was observed in the Haloze (Figure 7). Agriculture being abandoned there is a consequence of depopulation of the more hilly areas (Korošec 2010), where the relief slopes are by far the highest between all three regions and represent an obstacle for agriculture.

With the shifting climate, natural processes will have to be even more seriously considered in the future. Žiberna (2017) had already performed a water balance analysis for north-eastern Slovenia for the period 1961–2016. The air temperature trends are positive and the annual precipitation trends are negative. In general, the amount of precipitation is lower in the summer and spring months, while the trend is mostly positive in the autumn and winter months. Since the period of active vegetation is concluding in the autumn, this means more water runs off; alongside the positive temperature trend, more precipitation in the form of rain increases the flood hazard.

Figure 6: After trees were cut down and the roadside drainage was altered near Šentilj in Slovenske Gorice Hills, the area became prone to landsliding.

Figure 7: The area of Haloze has very steep slopes that are therefore often covered in forests. Some areas also feature vineyards and have a visible old (terraced) and new (vertical)vine layout.

5 Conclusion

The article presents the calculation of the urbanity index used to analyse the level of naturalness or human impact in the hilly regions of north-eastern Pannonian Slovenia (Goričko, Slovenske Gorice Hills, Haloze) from the aspect of land use structure in 2002 and 2018. We analysed the subunits of the catchments – hydrogeographical areas. We determined that, in general, the highest urbanity index in both periods were recorded in the hydrogeographical areas in Slovenske Gorice Hills (in 2018: 0.28), and the lowest in Haloze (in 2018: –0.22). The latter have the steepest slopes, which is probably one of the main reasons for abandoning agricultural surfaces and the resulting overgrowth. The increase in overgrown surfaces is present across the entire area, which is also one of the main reasons that the urbanity index reduced in all areas except for two between 2002 and 2018, thus increasing the naturalness level. On average, all three regions had higher urbanity indexes in 2002. The differences between the individual regions remained in a similar proportion: the most favourable or highest naturalness indexes can be found in Haloze, followed by Goričko, while Slovenske Gorice Hills are the most anthropogenously altered. In 2018, the studied areas had an urbanity index from –0.58 to 0.52. The individual areas in 2018 with the highest urbanity index were: Trnava (S15), Pesnica 2 (S05), Globovnica (S06), Pesnica 3 (S09), Ščavnica 4 (S20), Velka (S07), Drvanja (S08), Mlinski potok (S01), and Pesnica 1 (S04). All the mentioned areas had an index value above 0.3.

Land use is extremely important from the landscape-ecological aspect. In the catchments of the Tertiary hills of north-eastern Slovenia, the most pressing issues include soil erosion (Hrvatin et al. 2019), landslides and slumps (Komac and Zorn 2009), floods, and droughts (Kikec 2015). Natural hazards can be at least partially alleviated with appropriate land use. Water soil retention in source areas of the hills can be improved with proper land use, especially in steep slopes where forest or natural vegetation is the most suitable.

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STOPNJA NARAVNOSTI GRIČEVNATEGA SVETA SEVEROVZHODNE SLOVENIJE Z VIDIKA RABE TAL

1 Uvod

Spreminjanje naravnih pokrajin v kulturne pokrajine obsega pomemben del Zemljinega površja, prav tako pa se tudi same kulturne pokrajine nenehno spreminjajo. Sprememba v rabi tal in pokrovnosti tal je rezultat součinkovanja različnih gonilnih sil. Pet dejavnikov je najbolj pogostih: prebivalstvo, gospodarski razvoj, tehnologija, institucije in kultura (Mather 2006, citirano v: Gabrovec, Bičík in Komac 2019). Preobrazba pokrajine se dogaja prek povečanega vpliva kmetijstva in urbanizacije, energijskih tokov, biogeokemijskih ciklov in podobnega. Spreminjanje rabe tal je sicer predvsem posledica pridobivanja naravnih virov (na primer hrane, vode), a hkrati s tem prihaja tudi do določene degradacije okolja in izgube ekosistemskih funkcij (Fouch s sodelavci 2019). Raba tal oziroma pokrovnost (povratno) namreč vpliva na številne druge procese v pokrajini, na primer neposredno na razvoj biodiverzitete (Costa s sodelavci 2017) ter na sposobnost zadrževanja vode (Lóczy in Dezső 2013; Dezső s sodelavci 2019) in erozijo (Kerényi 2010; Hrvatin s sodelavci 2019). Tudi znotraj različnih antropogenih rab tal prihaja do navzkrižij, med katerimi je najbolj pereč problem ohranjanja kmetijstva na rodovitnih prsteh (Razpotnik Visković in Komac 2018). Tudi s pokrajinskoekološkega vidika je poudarjen pomen spreminjanja rabe tal. Intenzivne oblike rabe tal, kot so na primer pozidana zemljišča, so v Evropi čedalje bolj dominantne. Povečanje kmetijske intenzivnosti vodi v monofunkcionalnost ter lahko zmanjšuje kulturno in naravno raznolikost (na primer Jordán s sodelavci 2005). Z vidika pomena za pokrajinskoekološke procese lahko pokrajino na podlagi sprememb v rabi tal (predvsem kmetijstvu, gozdarstvu), delimo na tisto, kjer se intenzivnost manjša, in tisto, kjer se intenzivnost povečuje (Jongman 2005).

Raziskovalci zato pogosto analizirajo stanje rabe tal ter trende spreminjanja in skušajo ugotoviti, kakšna struktura je najbolj ustrezna ter kakšna raba tal je okoljsko najbolj sprejemljiva. Ena izmed možnosti je tudi analiza stopnje naravnosti oziroma – nasprotno – stopnje antropogenosti ali urbanosti. Stopnja naravnosti (*naturalness level*) označuje podobnost trenutnega stanja ekosistemov njihovemu naravnemu stanju. Nizka stopnja naravnosti je povezana z degradacijo in izgubo gozdne biodiverzitete (Costa s sodelavci 2017). Razprav o tem, kaj je naravno okolje, je bilo več (glej na primer Machado 2004), a dokončne razlage ni.

V Sloveniji ogozdovanje na splošno prevladuje v zahodni Sloveniji, na vzhodu države pa so procesi spreminjanja rabe tal precej bolj pestri. Intenzifikacija kmetijske rabe je prisotna na ravninah, zatravljanje in ogozdovanje pa sta prisotna v gričevnatem oziroma hribovitem delu, ki je manj primerno za kmetijstvo. Urbanizacija je prevladujoč proces okoli večjih mest po vsej Sloveniji (Gabrovec in Kumer 2019). Pilotna analiza sprememb rabe tal med 19. in začetkom 21. stoletja za manjše območje severozahodnega dela Slovenskih goric je pokazala, da se je površina gozdov in zemljišč v zaraščanju povečala, površina njiv in vinogradov pa se je zmanjšala (Ciglič s sodelavci 2019; Deriaz s sodelavci 2019).

A kakšna je najbolj optimalna sestava rabe tal? Objavljenih je bilo več študij o strukturi rabe tal, s katerimi so avtorji želeli oceniti naravno stanje izbranih območij, na primer za porečji Jacaré-Guaçu in Jacaré-Pepira v jugovzhodni Braziliji (Costa s sodelavci 2017) in območje Rio Grande do Sul (Rovani s sodelavci 2019), oziroma kako raba tal vpliva na naravne procese, na primer zadrževanje vode (Bystřický s sodelavci 2017) in ekosistemske storitve (Ribeiro in Šmid Hribar 2019). Veliko študij uporablja tudi geoinformacijska orodja, saj je s tem omogočena analiza širših območij na bolj objektiven način (Costa s sodelavci 2017). Za dve pilotni območji v Sloveniji (Črna vas na Ljubljanskem barju in Bojanci v Beli krajini) sta Ribeirova in Šmid Hribarjeva (2019) ugotovili, da zaradi intenziviranja kmetijske pridelave na eni strani in opuščanja kmetijstva na manj ugodnih območjih izginja tradicionalna manj intenzivna raba zemljišč. Prav tovrstna tradicionalna raba prispeva več bolj raznolikih ekosistemskih storitev ter pripomore k ohranjanju kulturne pokrajine (Ribeiro in Šmid Hribar 2019). Na splošno pa velja, da deforestacija oziroma nižanje deleža gozdnih zemljišč vodi k hitrejšemu odtekanju vode (Graf 1975; Bystřický s sodelavci 2017). Kladnik s sodelavci (2019) je na primeru osmih pilotnih območjih po vsej Sloveniji ugotovil, da so terasirana območja precej bolj podvržena spremembam v rabi tal kot pa neterasirana območja. Zaradi tega je še toliko bolj pomembno, da se preveri stanje rabe tal na območju gričevnatega sveta v severovzhodni Sloveniji. Namreč, panonska gričevja imajo terasiranega 1,9 % površja, kar jih v Sloveniji uvršča na tretje mesto, takoj za sredozemska gričevja in sredozemske planote. Goričko ima terasiranih 2,5 % zemljišč, Slovenske gorice 1,4 %, Haloze pa celo 4,1 % (Bole s sodelavci 2016; Perko 2016).

V prispevku smo se osredotočili na analizo rabe tal z vidika stopnje naravnosti treh gričevnatih območij severovzhodne Slovenije (Slovenske gorice, Haloze in Goričko) s pomočjo geoinformacijskih metod. Sestava rabe tal je eden najboljših pokazateljev človekovega delovanja v pokrajini. Določiti smo želeli območja, katera lahko označimo kot manj naravna ali kot bolj naravna. Na ta način smo si prizadevali izpostaviti območja, ki potrebujejo večjo pozornost v prihodnjem urejanju prostora (na primer z vidika preprečevanja poplav, erozije prsti). Prav tako smo med seboj primerjali vsa tri gričevnata območja.

2 Raziskovalno območje

Preučili smo gričevnate regije Haloze, Slovenske gorice in Goričko oziroma povirne dele tamkajšnjih porečij, ki smo jih razdelili na manjša hidrogeografska območja. Omenjena gričevja so bila vključena v naravnogeografske in družbenogeografske analize slovensko-madžarskega raziskovalnega projekta *Primerni ekološki ukrepi na področju poplavne nevarnosti v hribovitem območju Madžarske in Slovenije*. Gričevja predstavljajo zahodni rob Panonske kotline, med seboj pa so ločena z vmesnimi ravninami oziroma dolinami. Obsežne Slovenske gorice so med rekama Drava in Mura, severno od Murske ravni je Goričko, južno od Dravinje, ob meji s Hrvaško, pa so Haloze (slika 1).

Vsa gričevja imajo precej podobne naravnogeografske značilnosti: proti preperevanju in eroziji slabo odporne kamnine terciarne starosti (na primer lapor, peščenjak, konglomerat, peski, gline), razgibano gričevnato površje s ponekod precej strmimi pobočji, celinsko podnebje z viškom padavin poleti ter pestro gozdnato-vinogradniško sestavo rabe tal s poselitvijo na vrhu slemen.

Gričevja v severovzhodni Sloveniji sestavljajo v glavnem konglomerat, peščeni in glinasti lapor, peščenjak, prod, pesek in glina. Gričevja pa obrobljajo terase iz debelih plasti ilovice (Belec 1998). Relief na Goričkem je v primerjavi z ostalima regijama manj razgiban. Povprečni naklon je 5,7°, polovica površja ima naklon pod 6°, povprečna nadmorska višina je 275,1 m (Olas in Orožen Adamič 1998). Povprečna nadmorska višina Slovenskih goric je 268,3 m, povprečni naklon pa 7,1° (Kert 1998). Povprečna nadmorska višina Haloz je 316,7 m, povprečni naklon pa 14,6° (Vovk 1998). Podnebje je celinsko s hladnimi zimami in toplimi poletji. Količina padavin se zmanjšuje od jugozahoda proti severovzhodu, njihova razporeditev pa kaže na celinski padavinski režim s poletnim viškom. Aprilske temperature so nekoliko višje od oktobrskih, letna količina padavin po podatkih Agencije Republike Slovenije za okolje (za obdobje 1981–2010) pa je med 800 in 1100 mm; poleti je zaradi povečanega izhlapevanja nevarnost pojava suše. Glavni padavinski višek je julija in avgusta, drugotni novembra. Povprečna letna temperatura se večinoma giblje med 9 in 10 °C. V gričevju je zastopan izrazit termalni pas, kjer so ugodne razmere za rast vinske trte. Osojna pobočja so povečini gozdnata (Belec 1998). Sodobne raziskave so območje severovzhodne Slovenije uvrstile v subkontinentalno podnebje (Kozjek, Dolinar in Skok 2017). Za zadnja desetletja je značilno pojavljanje sušnih obdobij, predvsem med aprilom in septembrom (Žiberna 2017). Na območju skozi leto izhlapi približno od 700 do 800 mm (tudi več), odteče pa približno 300 do 550 mm (Frantar 2008a). Južna in zahodna območja terciarnih gričevij (na primer Haloze, zahodne Slovenske gorice) imajo specifični odtok med 10 in 20 $l/s/km^2$, specifični odtok pod 10 $l/s/km^2$ pa imajo gričevja na severovzhodu (na primer vzhodne Slovenske gorice, Goričko). Odtočni količnik je manjši od 45 %, na Goričkem celo pod 20 % (Frantar 2008b, 2008c). Vodotoki imajo panonski dežno-snežni režim. Zgodnjepomladanski in poznojesenski viški so močno izenačeni, glavni nižki se pojavljajo poleti, drugotni nižki nastopijo pozimi (Frantar in Hrvatin 2005). Zaradi raznolike kamninske sestave so prsti gričevij pestre (Belec 1998), najdemo predvsem rendzine, evtrične rjave prsti ter distrične rjave prsti (Repe 2010). Na območju večinoma rase združba bukve in pravega kostanja ter drugotna združba rdečega bora in okroglolistne lakote. Borovi gozdovi se pojavljajo na najbolj degradiranih in izpranih prsteh (Marinček in Čarni 2002).

V analizo smo vključili na hidrogeografska območja razdeljena porečja v izbranih gričevjih, ki so znotraj meja Republike Slovenije. Območja so bila določena na podlagi podatkov o porečjih in razvodnicah Evropskega okoljskega informacijskega in opazovalnega omrežja (EIONET) v Sloveniji, za katerega skrbi Agencija Republike Slovenije za okolje. Celotna površina vseh treh regij obsega 1649 km^2, povprečna velikost posameznega hidrogeografskega območja je 39,3 km^2; najmanjše hidrogeografsko območje je veliko 9 km^2, največje pa 174 km^2.

Slika 1: Pregledna karta hidrogeografskih območij.
Glej angleški del prispevka.

3 Metode in podatki

V prispevku smo analizirali stanje rabe tal za leti 2002 in 2018 z vidika stopnje naravnosti oziroma antropogenosti. Uporabili smo geoinformacijska orodja za prekrivanje podatkovnih slojev, s katerimi smo pripravili podatkovno bazo. Hidrogeografska območja so bila predstavljena z vektorskim slojem poligonov. Podatke o rabi tal za leto 2002, ki je najstarejše v tej zbirki, in leto 2018 smo pridobili na Ministrstvu za kmetijstvo, gozdarstvo in prehrano. Oba sloja smo spremenili v rastrski zapis z ločljivostjo 5 m.

Obstaja več različnih metod, s katerimi lahko ocenjujemo oziroma merimo stopnjo naravnosti ali antropogenosti oziroma stopnjo človekovega vpliva (Machado 2004; Lóczy in Pirkhoffer 2009). V našem primeru smo se odločili oceniti stanje hidrogeografskih območij na podlagi rabe tal, saj je ta podatek za Slovenijo zelo natančen. Za vsako območje smo na podlagi podatkov o rabi tal izračunali indeks urbanosti (UI), s katerim smo želeli prikazati stopnjo naravnosti oziroma antropogenosti. Enačba za izračun indeksa urbanosti je: $\frac{}{\mathrm{I}}$. Pri tem pomenijo *A* – površina kmetijskih zemljišč, *U* – površina pozidanih zemljišč, *F* – površina naravne vegetacije, *W* – vodna površina in površina mokrišča. Območja z največjo stopnjo naravnega stanja imajo nižjo vrednost indeksa, območja z najmanjšo stopnjo naravnega stanja pa imajo višjo vrednost indeksa. Za posamezno skupino rabe tal smo morali združiti posamezne izvirne kategorije rabe tal (preglednica 1). Indeks urbanosti kaže, koliko je pokrajina spremenjena oziroma kako močno antropogeno spremenjeni sistemi prevladujejo nad (bolj) naravnimi (Costa s sodelavci 2017). Indeks je pokazatelj, katere pokrajine so pod večjim človekovim vplivom in je bil že večkrat uporabljen (na primer Wrbka s sodelavci 2004; Costa s sodelavci 2017; Rovani s sodelavci 2019).

Posamezna območja in tudi vse tri regije (Haloze, Slovenske gorice, Goričko) smo nato med seboj primerjali glede na izračunane vrednosti indeksa. V sklopu primerjav smo nato ovrednotili izračunane vrednosti z vidika nekaterih naravnogeografskih značilnosti, ki so povezane z izoblikovanostjo površja, podnebnimi značilnostmi in hidrološkimi značilnostmi.

4 Rezultati in razprava

Izračunane vrednosti se precej razlikujejo po posameznih območjih (preglednica 2). Glede na izračunane indekse so v povprečju trenutno (oziroma glede na leto 2018) najmanj naravna območja

Preglednica 1: Združevanje izvirnih kategorij rabe tal v poenostavljene kategorije, ki so bile uporabljene za izračun indeksa urbanosti. Oznake poenostavljenih kategorij pomenijo: A – površina kmetijskih zemljišč, U – površina pozidanih zemljišč, F – površina naravne vegetacije, W – vodna površina in površina mokrišča.

ID rabe tal	izvirna kategorija rabe tal	poenostavljena kategorija
1100	njiva	A
1160	hmeljišče	A
1180	trajne rastline na njivskih površinah	A
1190	rastlinjak	A
1211	vinograd	A
1212	matičnjak	A
1221	intenzivni sadovnjak	A
1222	ekstenzivni oziroma travniški sadovnjak	A
1240	ostali trajni nasadi	A
1300	trajni travnik	A
1321	barjanski travnik	A
1410	kmetijsko zemljišče v zaraščanju	F
1420	plantaža gozdnega drevja	F
1500	drevesa in grmičevje	F
1600	neobdelano kmetijsko zemljišče	A
1800	kmetijsko zemljišče, poraslo z gozdnim drevjem	F
2000	gozd	F
3000	pozidano in sorodno zemljišče	U
4100	barje	W
4210	trstičje	W
4220	ostalo zamočvirjeno zemljišče	W
5000	suho odprto zemljišče s posebnim rastlinskim pokrovom	A
6000	odprto zemljišče brez ali z nepomembnim rastlinskim pokrovom	A
7000	voda (vključno z umetnimi zadrževalniki)	W

v Slovenskih goricah. Daleč najvišji vrednosti imata hidrogeografski območji Trnava (S15) in Pesnica 2 (S05), kjer je indeks višji od 0,5; sledijo Globovnica (S06), Pesnica 3 (S09) in Ščavnica 4 (S20), ki imajo vrednosti med 0,35 in 0,40. Na Goričkem je najbolj antropogeno preoblikovano območje Ledava (G01) z vrednostjo indeksa 0,26, v Halozah pa Bela (H09) z indeksom 0,19 (slika 3). Najnižja vrednost v Slovenskih goricah je bila izračunana za območje Cvetkovski potok (S10), na Goričkem za Ivanjševski potok (G06), v Halozah pa za Tisovec (H06). Stopnja urbanosti se je od leta 2002 do 2018 zmanjšala pri vseh območjih, razen pri dveh (Rogoznica – S02, Grajena – S03) (slika 4). Leta 2002 je najvišjo vrednost prav tako imelo območje Trnava (S15) v Slovenskih goricah, najnižjo pa Tisovec (H06) v Halozah (slika 2).

Hidrogeografska območja v Halozah imajo v povprečju v letu 2018 najnižje vrednosti, kar pomeni, da je tam raba tal najmanj antropogeno spremenjena (–0,22), območja v Slovenskih goricah pa imajo najbolj antropogeno spremenjeno rabo tal (0,28). Območja na Goričkem imajo povprečje ravno med obema ostalima regijama (0,01). Leta 2002 je bilo razmerje med regijami podobno, opazno pa je, da so bile Slovenske gorice še nekoliko bolj antropogeno preoblikovane (vrednost 0,31), prav tako Haloze (–0,14) in Goričko (0,07).

Preglednica 2: Indeks naravnosti po hidrogeografskih območjih.

regija	oznaka hidrogeografskega območja	indeks urbanosti		sprememba indeksa urbanosti (2018–2002)
		leto 2002	leto 2018	
Goričko	G01	0,26	0,22	–0,04
	G02	0,09	0,05	–0,04
	G03	0,15	0,10	–0,05
	G04	0,25	0,20	–0,04
	G05	0,10	0,04	–0,06
	G06	–0,05	–0,14	–0,09
	G07	0,03	–0,05	–0,08
	G08	0,01	–0,06	–0,07
	G09	0,02	–0,08	–0,10
	G10	0,00	–0,04	–0,04
	G11	0,00	–0,07	–0,07
	G12	0,00	–0,07	–0,07
Haloze	H01	–0,36	–0,38	–0,02
	H02	–0,29	–0,33	–0,04
	H03	–0,21	–0,30	–0,09
	H04	–0,28	–0,40	–0,11
	H05	–0,16	–0,19	–0,03
	H06	–0,56	–0,59	–0,03
	H07	0,03	–0,07	–0,10
	H08	0,06	–0,10	–0,16
	H09	0,19	0,08	–0,11
	H10	0,15	0,06	–0,09
Slovenske gorice	S01	0,32	0,31	–0,01
	S02	0,21	0,22	0,00
	S03	0,21	0,21	0,00
	S04	0,38	0,30	–0,07
	S05	0,51	0,50	–0,01
	S06	0,38	0,37	–0,02
	S07	0,32	0,31	–0,01
	S08	0,32	0,31	–0,01
	S09	0,35	0,34	–0,01
	S10	0,07	0,03	–0,04
	S11	0,24	0,21	–0,03
	S12	0,24	0,19	–0,04
	S13	0,33	0,29	–0,04
	S14	0,29	0,27	–0,03
	S15	0,57	0,52	–0,05
	S16	0,19	0,16	–0,03
	S17	0,29	0,26	–0,03
	S18	0,29	0,26	–0,03
	S19	0,29	0,26	–0,02
	S20	0,35	0,33	–0,02

Slika 2: Indeks urbanosti leta 2002.
Glej angleški del prispevka.

Slika 3: Indeks urbanosti leta 2018.
Glej angleški del prispevka.

Slika 4: Razlika v indeksu urbanosti med letoma 2018 in 2002.
Glej angleški del prispevka.

Vzrok za zmanjšanje indeksa urbanosti oziroma povečanje stopnje naravnosti gre v povprečju predvsem na račun zaraščanja oziroma spreminjanja nekoč kmetijskih zemljišč v zemljišča v zaraščanju (preglednica 3). Največ površin v obeh letih so zajemali njive, travniki, gozdovi in pozidana zemljišča; leta 2002 so skupaj pokrivali približno 90 % površin, leta 2018 pa 87 %. Delež travnikov se praktično ni spremenil (prej 19,5 %, sedaj 19,3 %), delež pozidanih zemljišč se je presenetljivo zmanjšal s 6,1 % na 5,6 %, delež gozdov se je zmanjšal s 35,8 % na 35,2 %, delež njiv pa z 29,4 % na 27,3 %. Relativno

*Preglednica 3: Delež kategorij leta 2002 in 2018 (*kategorije ni v letu 2002).*

ID rabe tal	kategorija rabe tal	delež 2002 (%)	delež 2018 (%)
1100	njiva	29,4	27,3
1160	hmeljišče	0,0	0,0
1180	trajne rastline na njivskih površinah	0,0*	0,0
1190	rastlinjak	0,0*	0,0
1211	vinograd	3,8	2,8
1212	matičnjak	0,0*	0,0
1221	intenzivni sadovnjak	0,8	0,6
1222	ekstenzivni oziroma travniški sadovnjak	2,2	2,7
1240	ostali trajni nasadi	0,0	0,1
1300	trajni travnik	19,5	19,3
1321	barjanski travnik	0,0	0,0
1410	kmetijsko zemljišče v zaraščanju	0,6	2,1
1420	plantaža gozdnega drevja	0,0	0,0
1500	drevesa in grmičevje	1,1	2,6
1600	neobdelano kmetijsko zemljišče	0,0*	1,1
1800	kmetijsko zemljišče, poraslo z gozdnim drevjem	0,0	0,1
2000	gozd	35,8	35,2
3000	pozidano in sorodno zemljišče	6,1	5,6
4100	barje	0,0	0,0
4210	trstičje	0,0	0,0
4220	ostalo zamočvirjeno zemljišče	0,0	0,0
5000	suho odprto zemljišče s posebnim rastlinskim pokrovom	0,0	0,0
6000	odprto zemljišče brez ali z nepomembnim rastlinskim pokrovom	0,0	0,0
7000	voda	0,6	0,5
skupaj	100,0	100,0	
skupna površina kmetijskih zemljišč (A) in urbanih zemljišč (U)		61,9	59,5
skupna površina naravne vegetacije (F) ter vodnih površin in mokrišč (W)		38,1	40,5

gledano so se precej zmanjšala zemljišča vinogradov: s 3,8 % na 2,8 %. Ekstenzivnih sadovnjakov je nekoliko več (prej 2,2 %, sedaj 2,7 %). Precej so se relativno povečala kmetijska zemljišča v zaraščanju (prej 0,6 %, sedaj 2,1 %) ter drevesa in grmičevje (prej 1,1 %, sedaj 2,6 %). Delež vodnih površin se je zmanjšal z 0,06 % na 0,05 %.

V splošnem sklepanju glede na indeks urbanosti smo se pri združevanju kategorij izognili vplivu razlik med kategorijami, ki so posledica metodološkega zajema. Pri bolj specifični analizi posameznih kategorij rabe tal, pa moramo upoštevati tudi rahla odstopanja, ki so posledica zajema rabe tal v vsakokratnem obdobju. Kategorij, ki so zavedene zgolj leta 2018 in ne tudi leta 2002 je skupaj 1 %. Kategorij, ki so bile zavedene zgolj leta 2002 leta 2018 pa ne (kljub temu, da je kategorija obstajala), je le 0,03 %.

Raba tal odločilno vpliva na naravne procese, na primer na zadrževanje voda, stopnjo erozije in plazovitost. Hkrati tudi človek (bolj ali manj) prilagaja rabo tal naravnim razmeram. Da preprečimo izgubo ekosistemskih storitev, bi bilo treba omejevati skrajne razmere: intenzifikacijo rabe tal na eni strani in zaraščanje oziroma opuščanje kultiviranja pokrajine na drugi strani. Spodbujati bi morali obstoj manj intenzivnega kmetijstva (Ribeiro in Šmid Hribar 2019).

Sicer pomeni povečanje pozidanih zemljišč negativen vpliv na hidrološke pogoje, saj se poveča odtok vode v povirnih delih in zato povečuje pogostost pojava poplav v dnu dolin. Povečanje gozdnih zemljišč pa ima pozitiven vpliv na zadrževanje vode in preprečevanje poplav, med drugim tudi s povečano evapotranspiracijo (Bystřický s sodelavci 2017; Szilassi s sodelavci 2017). S tega vidika smo v gričevnatih območjih severovzhodne Slovenije priča spreminjanju h bolj ugodni strukturi rabe tal.

Večje število zemljišč v zaraščanju ter zemljišč z drevesi pomeni tudi preprečevanje oziroma zmanjševanje intenzivnosti pobočnih procesov ter erozije prsti, kar sta opazila tudi Pipan in Kokalj (2017). Zmanjšanje vinogradov (predvsem na najbolj strmih delih, ki jih sedaj preraščajo gozdovi) je bilo opaženo tudi v drugih študijah (na primer Ciglič s sodelavci 2019; Deriaz s sodelavci 2019). Pri obratnem pojavu, ko na primer na strmih pobočjih iz zaraščenih zemljišč naredijo nove vinograde z vertikalno razporeditvijo trt ali pa pašnik, se lahko pojavijo plazovi ali usadi (sliki 5 in 6).

Najnižja vrednosti indeksa urbanosti oziroma najvišja stopnja naravnosti je v Halozah (slika 7). Tam je opuščanje kmetijstva posledica izseljevanja v bolj vzpetih predelih (Korošec 2010), kjer so tudi nakloni reliefa daleč najvišji med vsemi tremi regijami in ki predstavljajo oviro za kmetovanje.

Slika 5: Po spremembi sadovnjakov in zemljišč v zaraščanju v vinograd z vertikalnim potekom trt, je na območju Jareninskega dola v Slovenskih goricah nastal usad.
Glej angleški del prispevka.

Slika 6: Po poseku dreves in spremenjenem obcestnem odvodnjavanju v okolici Šentilja v Slovenskih goricah, se je na pobočju pojavilo plazenje.
Glej angleški del prispevka.

Slika 7: Na območju Haloz zaradi velikih naklonov pobočja zelo pogosto pokrivajo gozdovi. Na nekaterih mestih so urejeni tudi vinogradi, kjer je vidna stara (terasirana) in nova (vertikalna) struktura zasaditve trt.
Glej angleški del prispevka.

Naravni procesi bodo v prihodnosti morali vseeno biti deležni še večje pozornosti, saj se podnebje spreminja. Žiberna (2017) je za severovzhodno Slovenijo namreč za obdobje 1961–2016 opravil analizo vodne bilance. Trendi temperature zraka so pozitivni, trendi letne količine padavin pa negativni. Količina padavin se v splošnem niža v poletnih in pomladanskih mesecih, v jesenskih in zimskih mesecih pa je trend pretežno pozitiven. Ker se jeseni obdobje aktivne vegetacije zaključuje, to pomeni, da več vode odteče; hkrati je ob pozitivnem trendu temperatur več padavin v obliki dežja, kar povečuje nevarnost poplav.

5 Sklep

V prispevku smo z izračunom indeksa urbanosti analizirali stopnjo naravnosti oziroma antropogenosti v gričevnatem svetu severovzhodne panonske Slovenije (Goričko, Slovenske gorice, Haloze) z vidika strukture rabe tal v letih 2002 in 2018. Analizirali smo podenote porečij – hidrogeografska območja. Ugotovili smo, da so v obeh obdobjih v povprečju največjo stopnjo urbanosti dosegala hidrogeografska območja v Slovenskih goricah (leta 2018: 0,28), najmanjšo pa v Halozah (leta 2018: –0,22). Slednja imajo najbolj strma pobočja, kar je verjetno eden od poglavitnih vzrokov za opuščanje kmetijskih zemljišč in posledično zaraščanje. Povečanje zemljišč v zaraščanju je sicer prisotno na celotnem območju, kar je tudi eden izmed glavnih vzrokov, da se je indeks urbanosti pri vseh območjih, razen dveh, med letoma 2002 in 2018 znižal in tako povečal stopnjo naravnosti. V povprečju so namreč vse tri regije leta 2002 imele višje stopnje indeksa urbanosti. Razlike med posameznimi regijami so ostale v podobnem razmerju – najbolj ugodno oziroma največje indekse naravnosti imajo območja v Halozah, sledi Goričko, najbolj antropogeno preoblikovane pa so Slovenske gorice. Posamezna območja so sicer leta 2018 imela vrednosti indeksa urbanosti od –0,58 do 0,52. Med posameznimi območji so leta 2018 največje vrednosti indeksa urbanosti dosegla: Trnava (S15), Pesnica 2 (S05), Globovnica (S06), Pesnica 3 (S09), Ščavnica 4 (S20), Velka (S07), Drvanja (S08), Mlinski potok (S01) in Pesnica 1 (S04). Vsa omenjena območja so imela vrednosti indeksa nad 0,3.

Raba tal je izrednega pomena s pokrajinskoekološkega vidika. V porečjih terciarnega gričevja severovzhodne Slovenije so med perečimi problemi erozija (Hrvatin s sodelavci 2019), zemeljski plazovi in usadi (Komac in Zorn 2009), poplave in suše (Kikec 2015). Z ustrezno rabo tal lahko vsaj deloma omilimo naravne nesreče, ki temeljijo na omenjenih pojavih. Zadrževanje prsti in vode v povirnih delih gričevij lahko s pomočjo ustrezne rabe tal izboljšamo, predvsem na strmih delih je to na primer gozd oziroma naravno rastje.

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6 Viri in literatura

Glej angleški del prispevka.