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THE (NON)USEFULNESS OF THE REGISTER OF EXISTING AGRICULTURAL AND FOREST LAND USE FOR MONITORING THE PROCESSES IN URBAN AREAS

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Urban land use, which covers all built-up areas, areas with infrastructure facilities, and other areas that permanently changed from a natural to a built environment, is in general increasing in all countries and environments.

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The (non)usefulness of the Register of Existing Agricultural and Forest Land Use for monitoring the processes in urban areas

ABSTRACT: The changing of urban land use is the key indicator of spatial processes at work. The only systemic data source in Slovenia that can be employed to monitor land use changes is the Register of Existing Agricultural and Forest Land Use. The hypothesis that the Register is not suitable for monitoring urban land use changes was tested by comparing the data in the »built-up and related land« category for 2002, 2005, 2009, 2011, and 2013. The analysis was carried out at the level of Slovenia, and the results were interpreted in relation to small testing areas in NE Slovenia. We found that the methodology of data capture varied to such a degree that the data fail to reflect the actual changes in urban areas.

KEY WORDS: spatial planning, land use, urban land use, spatial monitoring, Register of Existing Agricultural and Forest Land Use, Slovenia

(Ne)uporabnost Evidence dejanske rabe kmetijskih in gozdnih zemljišč za spremljanje procesov na urbanih območjih

POVZETEK: Spreminjanje urbane rabe prostora je ključni pokazatelj prostorskih procesov. Edini sistemski vir podatkov v Sloveniji, ki je lahko namenjen tudi spremljanju sprememb rab prostora, je Evidenca dejanske rabe kmetijskih in gozdnih zemljišč. Hipotezo, da evidenca ni ustrezna za spremljanje sprememb urbane rabe prostora, smo preverjali s primerjavo podatkov kategorije »pozidana in sorodna zemljišča« v letih 2002, 2005, 2009, 2011 in 2013. Analizo smo opravili na ravni Slovenije in rezultate interpretirali na manjših testnih območjih severovzhodne Slovenije. Ugotovili smo, da se je metodologija zajema podatkov tako spreminjala, da podatki ne odsevajo dejanskih sprememb na urbanih območjih.

KLJUČNE BESEDE: prostorsko načrtovanje, raba zemljišč, urbana raba, spremljanje stanja prostora, Evidenca dejanske rabe kmetijskih in gozdnih zemljišč, Slovenija

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1 Introduction

Knowing the situation and trends of land use and land cover changes is essential in order to make informed decisions concerning spatial planning, land management, and economic planning. The changes in land use and land cover are indicative of natural processes (e.g. transition from agricultural to forest land use) or human activities (e.g. transition from agricultural to urban land use). Land use changes are often reflected in changes to land cover, as land cover and land use are often correlated (Arnold et al. 2014; Antrop 2005; Ellis 2010; Tavares, Pato and Magalhaes 2012), except for land use changes in urban areas. In urban space only a small proportion of changes is detected as a change in land cover (e.g. change of a brownfield into a park), while changes from housing to services can only be detected by having insight into social and economic activities in the study area. It is accordingly important to distinguish between *land use* – defining the purpose of using the Earth's surface (INSPIRE 2013a; INSPIRE 2013b) – and *land cover* – defining the biological and physical cover of the Earth's surface (INSPIRE 2013a; INSPIRE 2014); by knowing land use and land cover we are able to provide more accurate information about space (Hovenbitzer et al. 2014). Land use is split up into the existing land use, and intended or planned land use (INSPIRE 2013b). Existing land use is independent of legal provisions, which lay down the ways of acquiring ownership and the rights thereof, and can be generally recorded on the ground (Metodologija … 2013), unlike intended land use. Transitions into urban land use are mostly regulated by spatial planning documents.

A detailed review of the literature by Slovenian authors dealing with identifying and monitoring land use changes was undertaken by Gabrovec and Kladnik (1997). The studies until 1997, and also thereafter, focused on studying agricultural land use changes (Vrščaj 2007; Miličić and Udovč 2012; Lisec, Pišek and Drobne 2013) or landscape changes (Petek 2002; 2005; 2007; Petek and Urbanc 2004; Kladnik and Petek 2007), and through this lens they indirectly touch upon urban land use areas. Urban land use changes have been addressed by Bogataj and Drobne (2002), Krevs (2004), and Topole et al. (2006). Bole (2014, 2015) focused on identifying Slovenian traffic areas and how they are changing.

The data on the surface area of urban land for Slovenia could be acquired from the Statistical GIS Land Cover and Land Use database (Skumavec and Šabić 2005, SURS 2007), but since 2005 it is no longer updated, while already Krevs (2004) pointed out to its deficiencies.

The CORINE Land Cover (CLC) database of the European Environment Agency (EEA) (Corine … 2014) provides the data for Slovenia for 1995, 2000 and 2006, which are shown in the Environmental Atlas (Atlas … 2014) and the Urban Atlas (Urban … 2014). This grid density is too low (cell spatial resolution is 100 × 100 m) to identify the existing land cover changes in urban areas.

Many authors (Ilešič 1950; Medved 1970; Gabrovec and Kladnik 1997; Gabrovec, Kladnik and Petek 2000; Lisec, Pišek and Drobne 2013; Bole 2014, 2015) used land cadastre data. The Surveying and Mapping Authority of the Republic of Slovenia stopped updating these data, but instead acquires them from the records kept by other sectors (Metodologija … 2013).

The Register of Existing Agricultural and Forest Land Use (hereinafter: Register) is based on the method of visual interpretation of orthophotos (DOF) with a resolution of 1 m, and the result is a topologically correct vector database of existing agricultural and forest land use. Vector data for 2002, 2005, 2009, 2011, and 2013 are publicly accessible at the website of the ministry responsible for agriculture (Internet 1). Although the register was set up for agricultural policy needs, it was used in real property valuation (Zakon o množičnem vrednotenju … 2006), pursuant to the Spatial Planning Act (2007) and the Rules on Land Use and Legal Regimes Data (2008), as well as for showing the discrepancy between the existing and the planned land use and for calculating the environmental indicator TP03 Built-up Land (Kazalci okolja v Sloveniji 2014).

The data from the Register were used to test the hypothesis on the suitability of the register on monitoring urban land use changes and the processes therein. We compared the categories of »built-up and related land« (hereinafter: PiSZ) at different time points, i.e. for 2002, 2005, 2009, 2011, and 2013, and, based on the findings, we gave recommendations with a view to establishing better and more wide-scale use of the EDRKGZ.

2 Data and methodology

2.1 Data from the Register and interpretation keys

The data from the Register for 2002, 2005, 2009, 2011, and 2013 are freely available at the Ministry of Agriculture, Forestry and Food's website (Internet 1). The Register's timeline is presented in detail in the paper by Miličić and Udovč (2012). The key to understanding and interpreting data is to know the interpretation keys (hereinafter: IK) (Interpretation Key 1.0 2002; Interpretation Key 2.0 2004; Interpretation Key 3.0 2005; Interpretation Key 4.0 2006; Interpretation Key 4.1 2008; Interpretation Key 5.0 2009; Interpretation Key 5.2 2011; Interpretation Key 6.0 2013) with a comprehensive description of land use capture, illustrative examples, and size of the areas. There are major modifications in IK 2.0, 3.0, 4.0, 5.0, and 6.0, and only minor modifications in 4.1, 5.1, and 5.2, which relate to agricultural land and do not influence the PiSZ land use capture.

The IK structure from versions 2.0 to 6.0 remained the same. In IK (2004), the use of PiSZ is defined as land with buildings, roads leading to urban areas and houses, parking lots, mines, quarries and other infrastructures intended for human activities. This category includes undeveloped land that is inseparably connected with human activities, such as:

- industrial and domestic waste sites,
- abandoned land inside built-up areas,
- city parks and gardens,
- recreational areas,
- gardens and extensive orchards next to buildings if they are smaller than the minimum area prescribed, and appertaining land of buildings,
- weirs, embankments and bridges if larger than 25 m^2,
- hay barns fall within this category if they have a roof or are situated in land zoned for building,
- permanent buildings in agricultural land if they are larger than 25 m^2 (apiaries, barns, sheds, etc.),
- zones along motorways, sown with grasses, trees and shrubs, and enclosed by fencing, are part of the motorway,
- grass-covered areas at airfields and airports are included only if enclosed by fencing,
- rural roads and forest roads are included in agricultural and forest land, respectively,
- land within urban areas exceeding 5000 m^2 is excluded.

Changes regarding PiSZ land use capture were made to the following versions of interpretation keys:

IK 4.0, 2006: changed the criteria for connecting too small pieces of land to neighbouring land,

IK 4.1, 2008: all GERKs (Graphical Agricultural Unit of a Farm Holding) smaller than 5000 m^2 and meadow orchards in appertaining land of structures exceeding 5000 m^2 are excluded from PiSZ use; smaller pieces of land are excluded only if they are classified as a GERK,

IK 5.0, 2009: all roads, cart tracks, and ditches wider than 2 m are excluded from primary land use and classified as PiSZ,

IK 5.2, 2011: walled slurry pits larger than 25 m^2 are included under PiSZ land use,

IK 6.0, 2013: grass runway surfaces in small airfields are included under PiSZ,

The smallest surface area of PiSZ land use capture increased from 10 m^2 in 2002 to 25 m^2 in 2005, and then stabilised (Table 1). The number of polygons of PiSZ land use capture significantly increased, i.e. from 71,279 in 2002 to 171,165 in 2013, possibly indicating the increased level of data capture accuracy.

To understand the Register it is necessary to know the general instructions for data capture, where the emphasis is on the generalisation of linear structures narrower than 2 m, and the exclusion of details smaller than 2 m, the criteria of merging and connecting polygons that do not meet the minimum illustration criteria, and simplifications and positioning of lines. Since IK 2.0 (2004) onwards, the general instructions for data capture did not significantly change, and we feel that they did not affect the quality of data.

2.2 Methods

The analysis was carried out at the level of Slovenia, as well as at the level of small testing areas. At the level of Slovenia, the data for 2009, 2011 and 2013 are divided into four areas (Figure 1), and the polygons are designated as OB_ID_1, 2, 3, 4. The data of 2002 and 2005 are adapted to these territorial areas.

A detailed data analysis was conducted for NE Slovenia (area 4 designated as NES, Figure 1), where the A5 Maribor–Pince motorway section was built or upgraded.

Because the data for area 4 NES do not reflect the expected increase in PiSZ land use, a further analysis in selected testing areas was conducted:

- an analysis of three continuous and three dispersed rural settlements,
- an analysis of infrastructure installations (motorway, rural roads and cart tracks, railway, small airfields and energy facilities).

The analysis was performed in 0.5 × 0.5 km quadrants, where the DOFs of 2002 and 2013 show no considerable changes that could be reflected in PiSZ land use data. The selection of areas without any actual changes in space is essential, because then the data acquired would reflect both the methodological changes in data capture as well as the capturer's interpretive abilities. The data analysis and processing were performed by using the functions of merging, overlaying and clipping of vector data layers in *ArcMap 10.2* and *Excel* 2007.

Table 1: Basic characteristics of PiSZ land use category at various points in time (Interpretacijski ključi . . . MKGP, author's calculations).

Basic data	2002	2005	2009	2011	2013
Year of digital ortophoto image production as the source of data capture	1997–2002	2000–2003	2006	2010, 2011	2011, 2012, 2013
Minimum PiSZ land use capture area	10 m^2	25 m^2	25 m^2	25 m^2	25 m^2
No. of independent PiSZ and use polygons out of all polygons	71,279 (654,270) (10.8%)	79,340 (715,243) (11.1%)	140,226 (965,793) (14.5%)	170,250 (1,481,001) (11.5%)	171,165 (1,639,321) (10.4%)
Interpretation Key (version)	1.0	2.0, 3.0	4.0, 4.1	5.0, 5.1, 5.2	6.0, 6.1
Distinctive features in interpretation keys for PiSZ land use			All land **smaller** than 5000 m^2 and the land classified as GERK is excluded.	Cart tracks and rural roads wider than 2 m and walled slurry pits larger than 25 m^2 are captured.	The built-up and related land use includes grass-covered runways at small airfields.

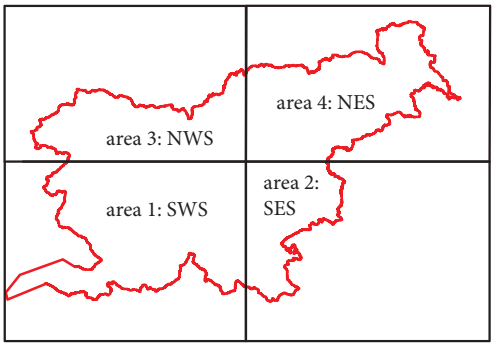


Figure 1: Data processing areas for the territory of Slovenia.

3 Results

3.1 Analysis of land use »built-up and related land« for the territory of Slovenia

The graphic calculation of PiSZ land use for each study area (Figure 1), and for the entire Slovenia is given in Table 2 and Figure 2. The proportion of PiSZ land use related to the surface of all land uses in the Register is

also calculated. The surface of all land uses in the Register varied between 2,036,575 ha in 2002 and 2,032,710 ha in 2013, i.e. by 3.865 ha. The total surface of all land uses in the Register stabilised in 2011 and 2013, as there was only a 2-ha variation between the last two periods.

First, the PiSZ surface and proportion from the first data capture in 2002 until 2005 rose substantially from 108,473 ha to 114,456 ha (by 2983 ha) or 0.3%, and then in 2009 they decreased to the lowest level of 107,397 ha or a 5.28% proportion of all land uses. From 2011 to 2013, the PiSZ land use surface area grew by 363 ha or 0.02%.

Table 2: The graphic calculation of PiSZ land use per individual areas in Slovenia (Figure 1) and for the entire Slovenia in 2002, 2005, 2009, 2011 and 2013 (MKGP 2013; authors' calculation).

Year of the data from the Register analysed		2002		2005		2009		2011		2013	
Quantified graphic surface of all land uses in the Register (ha)		2,036,575		2,032,733		2,032,617		2,032,712		2,032,710	
		Built-up and related land (PiSZ)		Built-up and related land (PiSZ)		Built-up and related land (PiSZ)		Built-up and related land (PiSZ)		Built-up and related land (PiSZ)	
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Study area	area 1: SWS	35,026	1.72	37,160	1.83	36,509	1.80	37,179	1.83	37,016	1.82
	area 2: SES	15,338	0.75	16,230	0.80	15,688	0.77	15,567	0.77	15,640	0.77
	area 3: NWS	15,382	0.76	16,067	0.79	14,889	0.73	15,913	0.78	16,096	0.79
	area 4: NES	42,727	2.10	44,999	2.21	40,310	1.98	40,173	1.98	40,443	1.99
	Slovenia	**108,473**	**5.33**	**114,456**	**5.63**	**107,397**	**5.28**	**108,832**	**5.35**	**109,195**	**5.37**

Figure 2: Illustration of PiSZ surface changing per individual study areas (Figure 1) in various periods (MKGP 2013; author's illustration).

Between 2002 and 2005 the data capture methodology's criterion regarding PiSZ increased from 10 m^2 to 25 m^2. It can be said that the accuracy of acquisition decreased, which probably affected the determination of the maximum PiSZ land use in the time period in question. Based on the reduced surface in 2009 we can conclude that in the previous observation cycle there was no significant urbanisation growth. The reduced surface in 2009 could result from the changed data capture methodology concerning agricultural land within urban areas, since until 2008 it only covered continuous agricultural land larger than 5000 m^2, while after 2008 also land smaller than 5000 m^2, complying with the criteria for capturing other types of existing use, and extensive meadow orchards smaller than 1000 m^2 if they are inscribed as GERKs.

3.2 Analysis of »built-up and related land« land use acquisition for NE Slovenia

During 2000–2009 the construction of the A5 Maribor–Pince motorway section was underway in area 4 NES (Figure 1). The Pomurje motorway branch consists of seven sections, and the connecting regional roads

Table 3: Built-up and related land associated to the A5 Maribor–Pince motorway section (Arh 2012).

Year	Built-up and related land (PiSZ), associated to the Maribor–Pince A5 motorway section (ha)
2002	0
2005	76
2009	198
2011	465

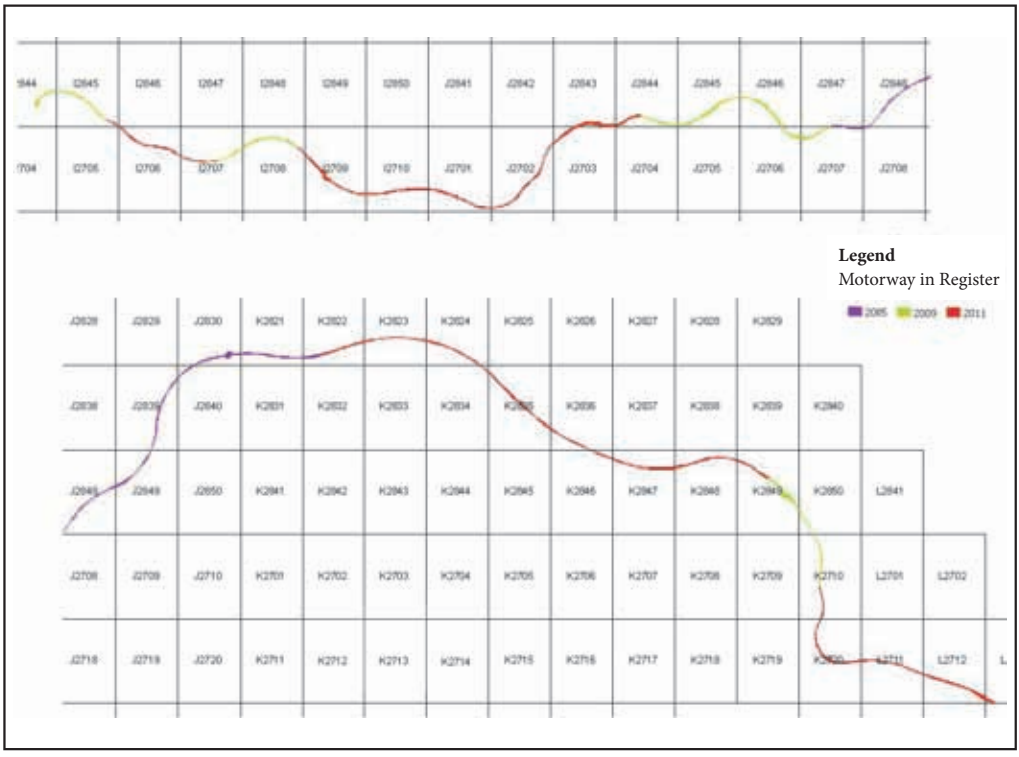


Figure 3: The progression of the A5 Maribor–Pince motorway construction in the Register by years, shown on the grid of sheets of the Basic Topographic Map (Arh 2012).

to Murska Sobota are included in the total length. The construction of the first motorway section Vučja vas–Beltinci in a length of 14.6 km started in 2000, and was put into service in 2002/2003, while the rest of the motorway of 71.2 km was completed between 2006 and 2008 (DARS 2006). As this was the only major building intervention in the 2000–2009 period, we analysed the PiSZ land use change in area 4NES. From the data from the Register we specifically excluded the motorway A5 branch (Figure 3) and graphically calculated the associated motorway area (Table 3).

The 2011 data from the Register show that the surface of the A5 Maribor–Pince section is 465 ha. From 2002 to 2011, the surface of PiSZ land use should increase by at least this amount, but this is not reflected in the data, as shown in Table 2 and Graph 1. On the contrary, in this period PiSZ decreased in area 4 NES, – the most among all Slovenian areas in question.

3.3 Analysis of PiSZ land use capture on the sample of settlements

We selected three dispersed and three continuous test settlements, and calculated, for 0.5 × 0.5 km areas, the graphic surface of PiSZ land use from the Register. The results are presented in Table 4 and Figure 4.

The decrease in PiSZ land use surface between 2011 and 2013 was established in three testing areas, even though, based on the results for the entire Slovenia, we thought that the data capture methodology had stabilised. In testing area 6 (Figure 5), the surface reduction was mostly due to the exclusion of extensive orchards in the settlements and at their edges. Extensive orchards in the settlements right next to housing and agricultural structures are the appertaining land of the structures and thus in spatial sciences considered as part of the built-up area.

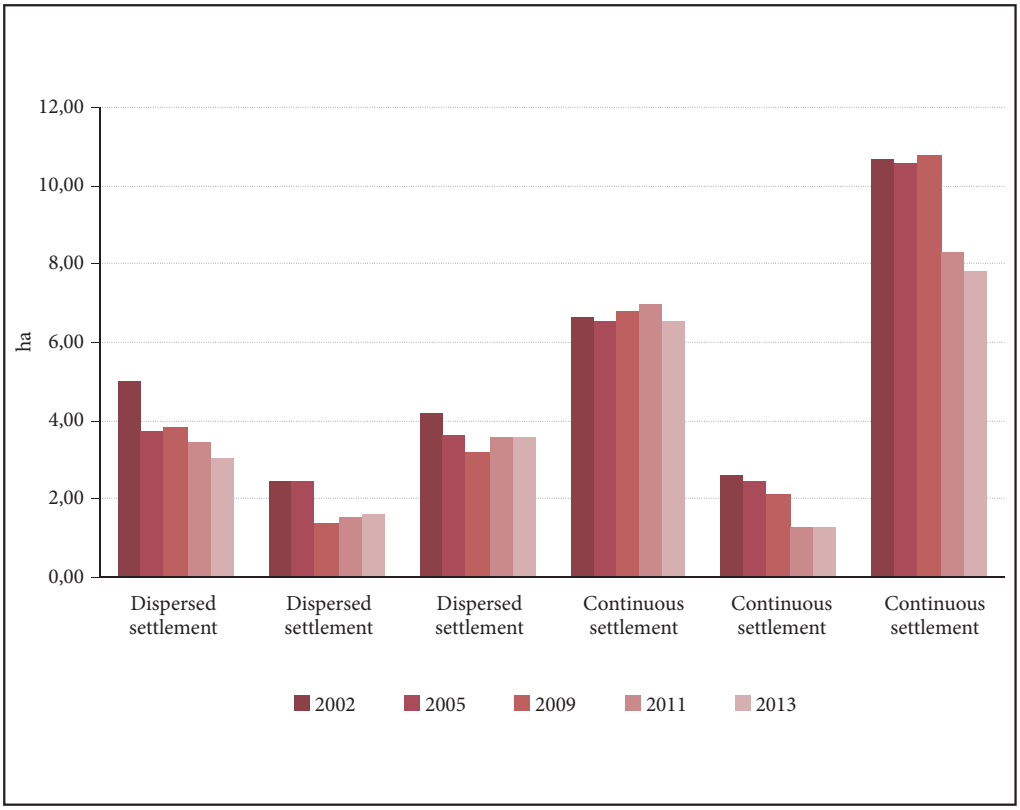


Figure 4: PiSZ use from the Register in testing areas of settlements (MKGP, author's illustration).

Table 4: PiSZ use from the Register in testing areas of settlements (MKGP, author's calculation).

	Testing area 1 dispersed settlement	Testing area 2 dispersed settlement	Testing area 3 dispersed settlement	Testing area 4 continuous settlements	Testing area 5 continuous settlements	Testing area 6 continuous settlements
Area centroid	Y: 578989 X: 165290	Y: 584012 X: 185752	Y: 614838 X: 157074	Y: 595499 X: 171530	Y: 613490 X: 159598	Y: 579040 X: 167805
						
	Built-up and related land (PiSZ) in the Register in testing areas 0.5 × 0.5 km					
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
2002	4.986	2.417	4.221	6.647	2.576	10.677
2005	3.718	2.417	3.600	6.531	2.418	10.561
2009	3.815	1.357	3.174	6.807	2.144	10.753
2011	3.469	1.543	3.565	6.957	1.275	8.302
2013	3.021	1.568	3.565	6.514	1.275	7.792

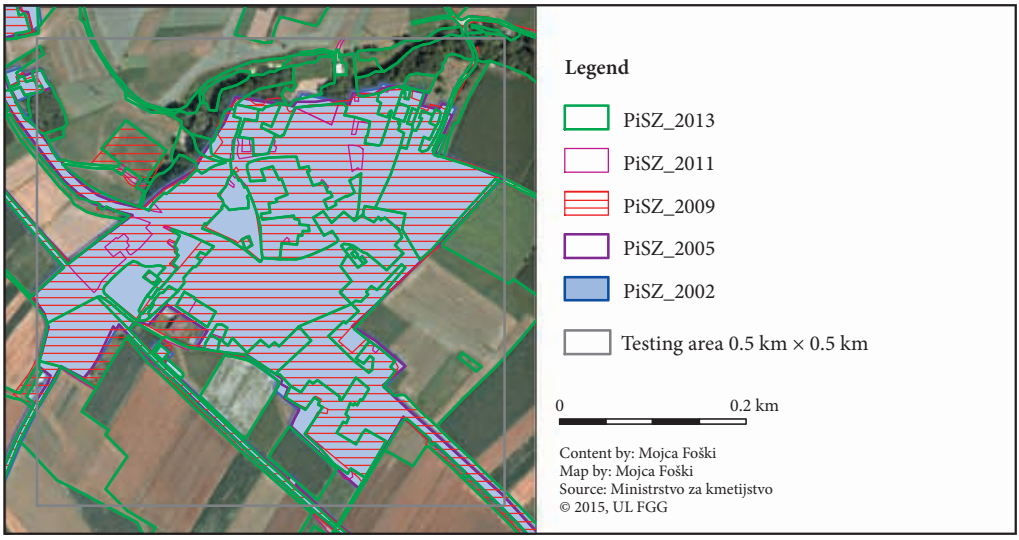


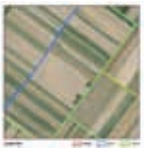
Figure 5: PiSZ use from the Register in the case of testing area 6 (MKGP, author's illustration).

3.4 Analysis of PiSZ land use acquisition for infrastructure

We randomly selected six testing areas of a size of 0.5 × 0.5 km with various infrastructure facilities and installations.

Even though there are no methodological changes in the interpretation keys concerning motorways, there are significant discrepancies in the surface area of PiSZ land use (testing areas 7 and 8 in Table 5, Figure 6). In the testing area of a small airfield (testing area 10) the impact of the changed data capture methodology

Table 5: PiSZ use from the Register in the area of infrastructures (MKGP, author's calculation) *In 2002 and 2005 there was no motorway yet, so the PiSZ land use was not captured.

	Testing area 7 motorway.	Testing area 8 motorway _2	Testing area 9 cart tracks/ rural roads	Testing area 10 small airfield	Testing area 11 railway	Testing area 12 power plant
Area centroid	Y: 588188 X: 166209	Y: 575096 X: 160374	Y: 596278 X: 164261	Y: 590505 X: 165752	Y: 589637 X: 170578	Y: 560870 X: 145147
						
	Built-up and related land (PiSZ) in the Register in testing areas 0.5 × 0.5 km					
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
2002	0*	0.510	0	1.326	1.862	7.658
2005	0*	0.246	0	1.073	0.925	7.636
2009	4.039	2.124	0.282	1.499	1.336	6.530
2011	2.652	5.231	0.453	1.377	1.037	6.577
2013	2.917	2.998	0.363	6.749	1.064	7.931

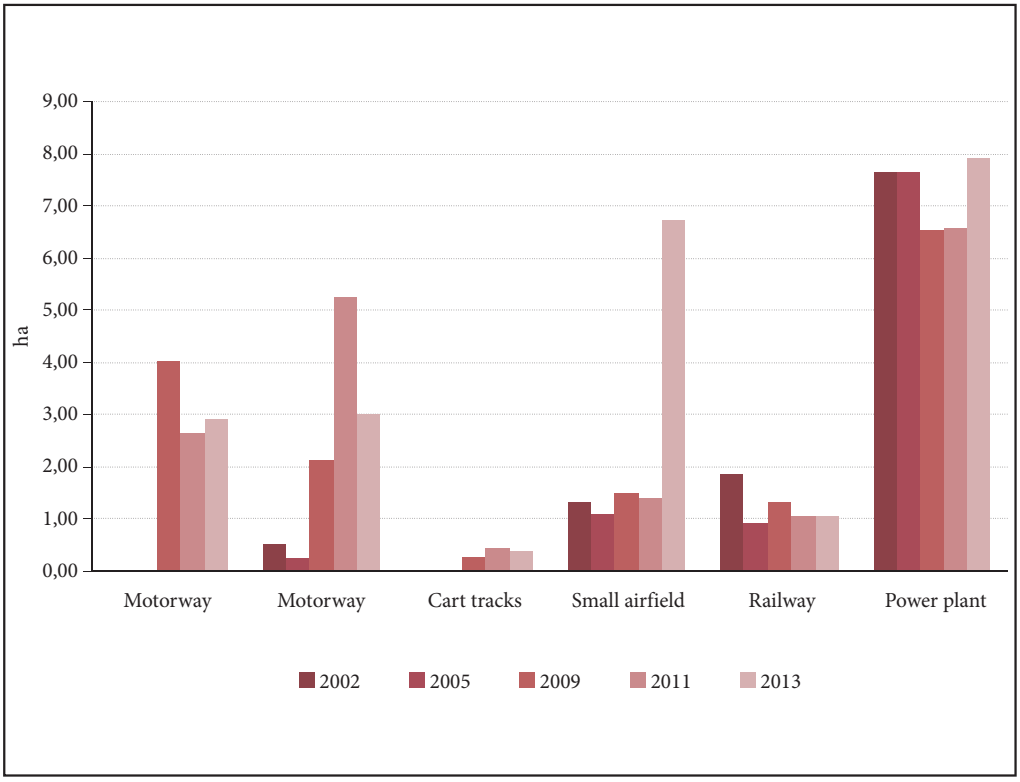


Figure 6: »Built-up and related land« from the Register in the area of infrastructures ((MKGP, author's illustration).

is evident (IK 6.0 2013), because the runway previously classified under the category of permanent meadows is now also classified as PiSZ. The surface changes in testing area 12 (power plant) cannot be attributed to the changed data capture methodology; we think that the discrepancy is the result of the capturer's interpretive abilities. The smallest discrepancies are associated with the railway area.

4 Discussion

Urban land use, which covers all built-up areas, areas with infrastructure facilities, and other areas that permanently changed from a natural to a built environment, is in general increasing in all countries and environments. We are certain that this is also the case in Slovenia, since SURS data (2013) show that, from 2007 to 2013, 29,972 building permits were issued for new spatial interventions. In Slovenia there are no in-depth analyses of the situation and trends concerning the urban area changes; Topole et al. (2006) and Bole et al. (2007) analysed several rural settlements, Ravbar (2007) noticed the trend of increasing settlement surfaces in suburban settlements and on urban outskirts, while Bole (2015) noticed the trend of increasing traffic surfaces.

The data from the Register for the level of Slovenia in the first three data capture campaigns (2002, 2005, 2009) vary considerably and indicate even a decrease in PiSZ surfaces, which is a rare occurrence, i.e. that urban land would be restored to its original use. Golobič (2013) reports only one such case, i.e. the Gorenjska motorway section between Črnivec and the Peračica viaduct, which the municipality converted back to agricultural land after the completion of the motorway.

After 2009 there are no major variations in PiSZ use, so the change in PiSZ land use could be the reflection of increased urbanisation. However, the results for testing area 4 of NE Slovenia (NES) (Figure 1) rejected this claim, as between 2005 and 2011 there was no considerable increase in surface area by 465 ha, i.e. the surface area of the newly built motorway A5 Maribor–Pince branch.

Urbanisation cannot be accountable for the rise by 0.02% or 360 ha of PiSZ land use from 2011 to 2013, because in the most recent period the analysis of 12 testing areas also revealed huge discrepancies in the data capture methodology. The increase in PiSZ areas is the result of methodological changes of settlement data capture (exclusion of agricultural land from settlements), capture of rural roads and cart tracks wider than 2 m, and some other types of land (the case of small airports). There is a general tendency that the PiSZ land use is captured increasingly closer to the structures, as also reported by Arh (2012). There is a particularly large discrepancy concerning dispersed settlements where the PiSZ land use is limited by many polygons. Land use by appertaining land of structures was not captured.

We can confirm the hypothesis that the existing Register is not suitable for determining urban land use areas and their changes, and also not for formulation of the indicator of urban land use changes in the territorial monitoring system (Poročilo … 2015). The deficiency of the Register for determining the areas zoned for development is also pointed out by Lampič and Repe (2012).

At the same time, we draw attention to the fact that its use for determining the discrepancy between the actual situation in space and the planned land use in the illustration of spatial situation in the Municipal Spatial Plan Preparation Procedure is unsuitable, even though the use of the Register is prescribed both by the Spatial Planning Act (2007) and the Rules on Land Use and Legal Regimes Data (2008). The discrepancies in the illustration of spatial condition may be due to the Register's shortcomings, and do not necessarily reflect the spatial potential; indeed, this can lead to professional errors.

Next to the spatial non-homogeneity of the source DOFs in various periods, as pointed out by Krevs (2004), we find that the data capture methodology is inhomogeneous as well, and that there are missing urban land use subcategories, which causes problems in data interpretation. Miličić and Udovč (2012), Mivšek et al. (2012), Lisec, Pišek and Drobne (2013), and Nastran and Žižek Kulovec (2014) also pointed out the deficiencies of the Register.

We propose that a single record be established, i.e. as those used in Austria (Land Information System Austria 2014), Germany (Hovenbitzer et al. 2014), Spain (Valcarcel et al. 2008) and the Netherlands (Hazeu 2014), which keep, maintain and interconnect data on land cover and land use in a single system. The integrated systems for establishing spatial and environmental monitoring, thus supporting spatial, economic and social planning and decision-making, are affected positively by the results of the project HELM (internet 2; HELM 2014), which dealt with the methodology of establishing a land use and land cover system, and the ongoing project EAGLE (EAGLE-Eionet … 2014).

5 Conclusion

Currently, the data from the Register are the only systemic and updated data source of the existing land use. By analysing records from the period between 2002 and 2013 we found that the methodological changes of urban use capture were so significant that the data do not reflect the actual urban land change. This is why the Register is unsuitable for spatial monitoring – the necessary component of spatial planning and its related activities. This means that it is necessary to establish a single system that would provide the data both on land cover and land use, and allow for monitoring of spatial and socio-economic spatial processes.

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