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Land Cover and Land Use in Slovakia within the LUCAS 2015 Pan-European Harmonized Survey

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Abstract. The LUCAS project was launched following a decision by the European Parliament and Council of the European Union in May 2000. Eurostat started the LUCAS pilot project in close cooperation with the technical support of the Directorate General for Agriculture and Rural Development's Joint Research Centre in 2001. The main aim of the project is to provide a common, aligned, in situ overview of agricultural and environmental data, using GNSS and photo documentation for specific, georeferenced points. Research was carried out in Slovakia over a three-year period, starting in 2006. In 2009, an evaluation of land cover/use was carried out. This article presents the process of preparing, securing, conducting and researching the management of land cover and land use in Slovakia. The survey was launched in 2012. The classification base consists of eight categories of land cover and land use, which are broken down into more detail. The result is a structured database of images and digital records for 2,455 selected points. The largest class mapped is forestland. The stabilization of the sampling scheme allowed the construction of a time series for monitoring land cover changes for selected types.

Keywords: land cover, land use, nomenclature standardization and harmonization, European survey

1 Introduction

The INSPIRE Directive (Infrastructure for Spatial Information in the European Community) defines principles for the harmonization of spatial data infrastructure in the European Community, including land use and land cover. INSPIRE defines a methodology for transforming datasets into common data models, but does not cover data collection and updating, which are beyond its scope (Kliment et al. 2014). In general, land cover and land use are the results of successive adaptations to the original landscape as a result of human influence. How land is used, and fields and forests cultivated, creating new urban and technological elements, define the character of the present cultural and natural landscape. These elements are excellent indicators of the current state of land use (Feranec and Oťahel 2001; Oťahel at al. 2003). Forman and Gordon (1993) defined landscape as a heterogeneous part of the Earth's surface, consisting of a set of interacting ecosystems repeated in similar forms over parts of the surface. The cultural and natural landscape as an entity has properties which are not integral to it. Landscape composition is complemented by natural and semi-natural ecosystems such as solitaires, forest fragments, wetlands, rock forest associations and the ecosystems of urban settlements and agricultural cooperatives (Sabo and Kováč 2005; Cebecauerova and Madajová 2015). Each tract of land has different characteristics. Human beings must interact with the land carefully. Any intervention affects the landscape and may lead to it losing its distinctiveness (Hilbert 1981).

The cultural and natural landscape is where most biological and human activities on Earth take place.

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Zemljišni pokrov i upotreba zemljišta u Slovačkoj unutar paneuropske usklađene izmjere LUCAS 2015

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Sažetak. Projekt LUCAS pokrenut je na temelju odluke Europskog parlamenta i Vijeća Europske unije u svibnju 2000. Eurostat je 2001. godine pokrenuo pilot projekt LUCAS u bliskoj suradnji s Ravnateljstvom za poljoprivredu i tehničku podršku ruralnom razvoju Zajedničkog istraživačkog centra. Glavni je cilj projekta zajednička, usklađena izmjera poljoprivrednih podataka i podataka okoliša *in situ* primjenom dokumentacije GNSS-a i fotografija određenih, georeferenciranih točaka. Istraživanje je provedeno u Slovačkoj u razdoblju od tri godine s početkom 2006. godine. U 2009. provedena je procjena zemljišnoga pokrova i upotrebe zemljišta. U radu se opisuje postupak pripreme, osiguravanja, vođenja i upravljanja istraživanjem zemljišnog pokrova i upotrebe zemljišta u Slovačkoj. Izmjera je pokrenuta 2012. godine. Osnova klasifikacije sastoji se od osam glavnih klasa zemljišnog pokrova i upotrebe zemljišta koje se dijele u detaljnije klase. Rezultat istraživanja je strukturirana baza slika i digitalnih zapisa za 2455 odabranih točaka. Najveća kartirana klasa je šumsko zemljište. Stabilizacija sheme uzorkovanja omogućila je izradu vremenskih nizova za nadzor promjene zemljišnog pokrova na odabranim tipovima zemljišnog pokrova..

Ključne riječi: zemljišni pokrov, upotreba zemljišta, standardizacija i usklađivanje nomenklature, europska izmjera

1. Uvod

Direktiva INSPIRE (Infrastruktura prostornih podataka u Europskoj zajednici) određuje pravila usklađivanja infrastrukture prostornih podataka u Europi, što uključuje podatke o zemljišnom pokrovu i upotrebi zemljišta. INSPIRE određuje metodologiju transformacije skupova podataka u zajedničke modele podataka, no prikupljanje i ažuriranje podataka izvan su njezina djelokruga (Kliment i dr. 2014). Općenito, zemljišni pokrov i upotreba zemljišta nastaju uzastopnim promjenama prirodnog krajolika pod utjecajem ljudi. Način upotrebe zemljišta, obrađivanje polja i šuma, stvaranje novih urbanih i tehnoloških elemenata određuju karakter sadašnjega kulturnog i prirodnog krajolika. Ti su elementi vrlo dobar pokazatelj trenutačnoga stanja upotrebe zemljišta (Feranec i Oťahel 2001; Oťahel i dr. 2003). Forman i Gordon (1993) definirali su krajolik kao raznolik dio Zemljine površine koji se sastoji od skupa ekosustava u uzajamnom djelovanju i koji se na određenom dijelu površine ponavlja u sličnim oblicima. Kulturni i prirodni krajolik kao cjelina imaju svojstva koja nisu njihovi dijelovi. Taj sastav krajolika upotpunjuju prirodni i poluprirodni ekosustavi kao što su dijelovi šuma, močvare te ekosustavi urbanih naselja i poljoprivrednih zajednica (Sabo i Kováč 2005; Cebecauerova i Madajová 2015). Svaki dio zemljišta ima različita svojstva. Ljudi trebaju biti vrlo oprezni sa svakim zemljištem. Svaka intervencija djeluje na krajolik i može se dogoditi da on potpuno izgubi svoju jedinstvenost (Hilbert 1981).

Kulturni i prirodni krajolik temelj su većine bioloških i ljudskih aktivnosti na Zemlji. Poljoprivreda, šumarstvo, industrija, prijevoz, stambena izgradnja i

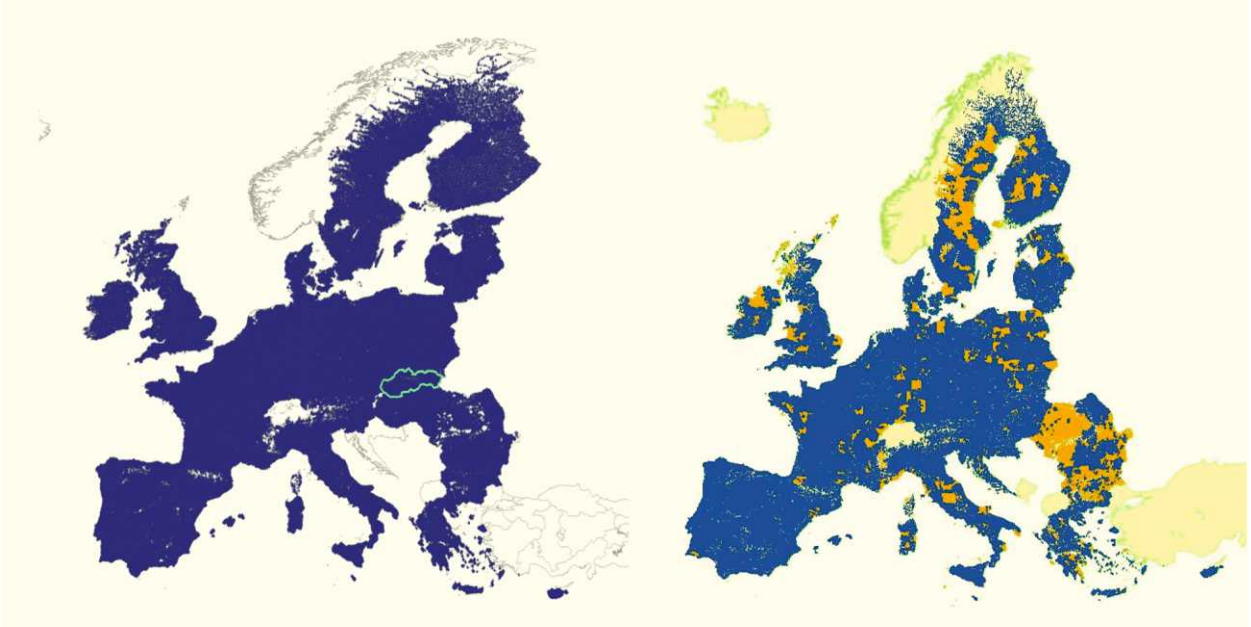

Fig. 1 Point distribution according to the 2012 LUCAS survey of the EU (left). Point distribution according to the 2015 Lucas survey (as at 29 September 2015), covering 28 member states (right)
Slika 1. Raspodjela točaka projekta LUCAS iz 2012. (lijevo), raspodjela točaka projekta LUCAS iz 2015. (stanje na 29. 9. 2015.) koja pokriva 28 zemalja članica (desno)

Agriculture, forestry, industry, transport, housing and other services all use land as a natural or economic resource. The landscape is also an integral part of ecosystems, and is vital for biodiversity and the carbon cycle. The landscape is divided into two intertwined concepts in the LUCAS survey concept: a) land cover, relating to the biophysical cover (e.g. crops, grasslands, forests, built-up areas etc.), and b) land use, indicated socio-economically, e.g. agriculture, forestry, or recreation (Eurostat 2016).

Land use and land cover change, also known as land change, are general terms for how the Earth's terrestrial surface is modified by human intervention. Changes involve the greatest environmental concerns of human populations today, including climate change, biodiversity loss, and pollution of water, soil and air. While land cover may be observed directly in the field, or by remote sensing, observations on land use and changes generally require the integration of natural and social scientific methods (expert knowledge, interviews with land managers, etc.) to determine which human activities are present in different parts of the landscape, even when land cover appears to be the same (Ellis 2007).

Since 2009, Eurostat has provided a harmonized overview of the conditions and dynamics of changes in land use and land cover in the European Union (EU), and Figure 1 shows point distribution. Surveys were carried out *in situ* in three-year cycles. Three types of information resulted (URL 1): i) microdata: land cover, land use and environmental data related to the survey point; ii) photo documentation of points and landscape in four basic directions, and iii) statistical tables with aggregated results of land cover and land use at the geographic level. The data obtained from the LUCAS project are used for the statistical assessment of land cover and land use at the European level (for publication in the Eurostat Yearbook, Agricultural Pocketbook, Eurobase, etc.). Data are used also to monitor agro-environmental changes, and as initial surface observations in activities related to remote sensing, e.g. CORINE Land Cover, GMES Global Monitoring for Environment and Security projects, etc. (Hutár et al. 2012).

The aim of the LUCAS project is to provide a standardized, harmonized, *in situ* overview important for many European services. This georeferenced dataset can be used for verification and validation of several information services, particularly within the Copernicus Land Monitoring Service. In the national context, changes in land cover are outlined to demonstrate data use. Along with the observation of the Earth via satellite sensors, the LUCAS in situ data represent the only Pan-European harmonized source of ground truth data appropriate for validation in the European framework (Palmieri 2016).

2 Material and Methods

The EU territory is covered by a 2-km regular grid with more than 1,100,000 points for the statistical sample of the LUCAS survey. In 2015, the LUCAS survey was

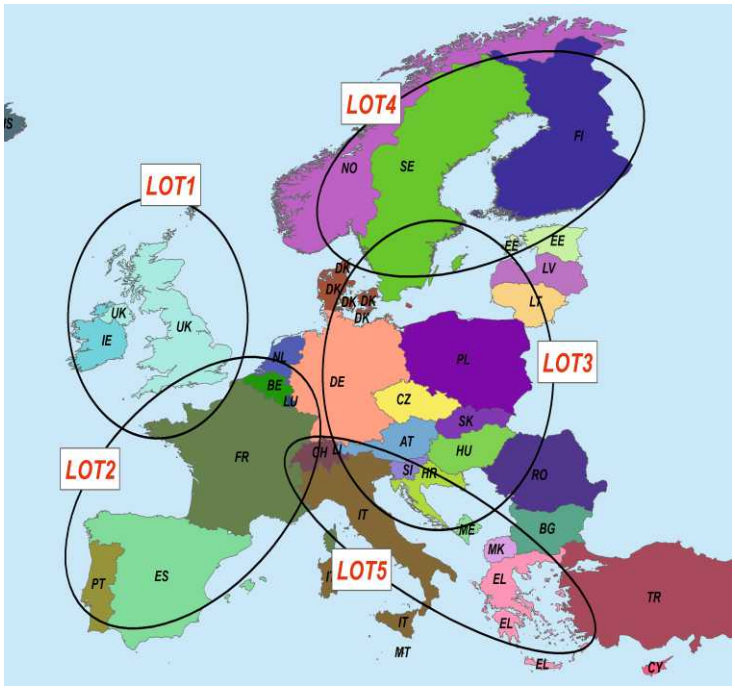

Fig. 2 Division of LUCAS into lots
Slika 2. Zemlje uključene u LUCAS grupirane u skupine

druge usluge – svi rabe zemljište kao prirodni ili ekonomski izvor. Krajolik je također sastavni dio ekosustava, gdje je on neophodan za bioraznolikost i ugljikov ciklus. U LUCAS-ovoj konceptualnoj izmjeri krajolik se dijeli na dva međusobno povezana koncepta: a) zemljišni pokrov, koji se odnosi na biofizički pokrov na zemljištu (npr. usjevi, travnjaci, pašnjaci, građevine, itd.) b) upotreba zemljišta, koja pokazuje socioekonomsku upotrebu zemljišta (npr. poljoprivreda, šumarstvo, rekreacija, itd.) (Eurostat 2016).

Promjena upotrebe zemljišta i zemljišnog pokrova (što se također naziva promjena zemljišta) opći je naziv za čovjekovo mijenjanje Zemljine površine. Te su promjene od najvećeg značaja za ljudski okoliš, a uključuju klimatske promjene, smanjenje bioraznolikosti te zagađenje voda, tla i zraka. Dok se zemljišni pokrov može izravno opažati na terenu ili daljinskim istraživanjima, opažanje upotrebe zemljišta i njegove promjene u pravilu zahtijeva integraciju metoda prirodnih i društvenih znanosti (znanje stručnjaka, intervjui s upraviteljima zemljišta) kako bi se utvrdilo koje se čovjekove aktivnosti događaju u različitim dijelovima krajolika, čak i kad se čini da je zemljišni pokrov jednak (Ellis 2007).

Slike 1a i 1b su Eurostatovi podaci za 2009. koji prikazuju raspodjelu točaka usklađene izmjere uvjeta i dinamike promjena upotrebe zemljišta i zemljišnog pokrova u Europskoj uniji (EU). Izmjere se provode *in situ* u trogodišnjim ciklusima. Tri su tipa informacija rezultati izmjere (URL 1): i) mikropodaci: zemljišni pokrov, upotreba zemljišta i podaci o okolišu koji se odnose na točku izmjere; ii) fotografije točke i izjere krajolika u četirima osnovnim smjerovima; iii) statističke tablice sa skupnim podacima zemljišnog pokrova i upotrebe zemljišta na geografskoj razini. Podaci dobiveni u projektu LUCAS upotrebljavaju se za statističku procjenu zemljišnog pokrova i upotrebe zemljišta na razini Europe (i objavljeno je u Eurostat Yearbook, Agricultural Pocketbook, Eurobase i drugdje). Podaci se također upotrebljavaju za nadgledanje promjena agrookoliša te kao početna opažanja površina u daljinskim istraživanjima, npr. CORINE Land Cover, projekti GMES globalnog nadgledanja za okoliš i sigurnost i dr. (Hutár i dr. 2012).

Cilj projekta LUCAS je standardizirani, usklađeni *in situ* pregled važan za mnoge europske usluge. Taj georeferencirani skup podataka može se upotrijebiti za provjeru i potvrdu nekoliko informacijskih usluga, a posebno *Copernicus Land Monitoring Service*. U nacionalnom kontekstu, promjena zemljišnog pokrova dana je kao demonstracija upotrebe podataka. Zajedno sa satelitskim snimkama Zemlje, podaci LUCAS-a su jedini paneuropski usklađeni izvor podataka s terena prikladan za provjeru u europskom okviru (Palmieri 2016).

2. Materijali i metode

Teritorij Europske unije pokriva 2-kilometarska pravilna mreža s više od 1 100 000 točaka za statistički uzorak projekta LUCAS. Izmjera je 2015. godine provedena u 28 europskih zemalja. Istraživači su na terenu prikupljali relevantne podatke na temelju usklađene metodologije i nomenklature LUCAS-a – ukupno oko 273 533 točaka. Ispunjavali su formulare alfanumeričkim podacima za svako mjesto koje su posjetili, a ti su podaci poslije ugrađeni u sustav za upravljanje podacima izmjere DMT.

conducted in 28 European countries. Field researchers collected relevant data on the basis of the LUCAS harmonized methodology and nomenclature, covering approximately 273,533 points. The surveyors completed the field forms using alphanumeric data for each place visited, and the data were later entered into the DMT survey management environment.

It was necessary to build a linked, hierarchical structure of data flow for such an extensive survey, whereby individual member states were grouped into Lot 1 (the UK and Ireland), Lot 2 (Belgium, France, Luxembourg, the Netherlands, Portugal, and Spain), Lot 3 (Austria, Bulgaria, Czech Republic, Denmark, Slovakia, Estonia, Germany, Hungary, Latvia, Lithuania, Poland and Romania), Lot 4 (Finland and Sweden), and Lot 5 (Cyprus, Greece, Italy, Malta and Slovenia). Croatia, as a new member of the EU, stood alone. Lot 6 represented external quality control, data transport to Eurostat, training project managers, and visits to individual countries. Lot 7 ensured the communications infrastructure through a centralized data management DMT suite to support the client/server environment during the survey. The Slovak Republic was assigned to Lot 3, with 11 other countries, as shown in Figure 2.

Field researchers documented points by taking pictures, generating more than two million photographs for the campaign. For each point, the transect (250m walking east) was recorded. As the surveyors passed through each transect, they registered all transitions of land cover (classes of surface cover, linear elements), which they observed according to the code list. Samples of the surface horizon weighing 500 g were selected from 10% of the places visited (part of the surveys in 2009 and 2015) (Eurostat 2015a). This information collection process was performed regularly during each survey (without soil collection), with the emphasis placed on methodology and nomenclature (Eurostat 2015b).

2.1 Technical reference documents

The data collection methodology consisted of a set of standardized Eurostat documents (2015a, b, c, d), for which comparisons, updates and translation were provided by the Soil Science and Conservation Research Institute. It should be emphasized that a relatively broad set of documents and attachments were included in the Instructions for Surveyors: Technical Reference Document C-1, Eurostat (2015a), Classification of Land Use and Land Cover – Technical Reference Document C-3, Eurostat (2015b), Quality Control Procedures – Technical Reference Document C-4, Eurostat (2015c), Plant Identification Guide – Technical Reference Document C-5, Eurostat (2015d) and the Data Management Tool Identification Guide, Eurostat, LUSIS (2015).

Table 1 Basic classification and administration of land cover according to technical reference document C3 (Eurostat, 2015b)

A	ARTIFICIAL LAND	**A10** Roofed built-up areas, **A20** Artificial non-built areas, **A30** Other artificial areas
B	CROPLAND	**B10** Cereals, **B20** Root crops, **B30** Non-permanent industrial crops, **B40** Dry pulses, vegetables and flowers, **B50** Fodder crops, **B70** Permanent crops: Fruit trees, **B80** Other permanent crops
C	WOODLAND	**C10** Broadleaved woodland, **C20** Coniferous woodland, **C30** Mixed woodland
D	SHRUBLAND	**D10** Shrubland with sparse tree cover, **D20** Shrubland without tree cover
E	GRASSLAND	**E10** Grassland with sparse tree/shrub cover, **E20** Grassland without tree/shrub cover, **E30** Spontaneously re-vegetated surfaces
F	BARE LAND AND LICHENS/MOSS	**F10** Rock and stones, **F20** Sand, **F30** Lichens and moss, **F40** Other bare soil
G	WATER AREAS	**G10** Inland water bodies, **G20** Inland running water, **G30** Transitional water bodies, **G50** Glaciers, permanent snow
H	WETLANDS	**H10** Inland wetlands, **H20** Coastal wetlands

The Instructions for Surveyors provide detailed reference information for researchers regarding data collection in the field. It refers to data to be monitored and recorded during field surveys, and instructions on how to make accurate notes. The field form is the basic data record. Transcriptions of data into digital form, along with photographs and data from the GNSS, constitute the core of the DMT (data management tool).

The classification/nomenclature of land use provides detailed information regarding the classification system. There are separate classification systems for land cover and land use. Land cover means the physical cover of the Earth's surface, while land use is the socio-economic function of the landscape. This taxonomy is connected to existing systems (e.g. Food and Agriculture Organization – FAO methodology, NACE statistical

Za tako opsežnu izmjeru bilo je potrebno proizvesti povezanu hijerarhijsku strukturu toka podataka, pri čemu su pojedinačne zemlje članice grupirane u jedinice 1. skupine (Ujedinjeno Kraljevstvo, Irska), 2. skupine (Belgija, Francuska, Luksemburg, Nizozemska, Portugal, Španjolska), 3. skupine (Austrija, Bugarska, Češka, Danska, Slovačka, Estonija, Njemačka, Mađarska, Latvija, Litva, Poljska, Rumunjska), 4. skupine (Finska, Švedska), 5. skupine (Cipar, Grčka, Italija, Malta, Slovenija). Hrvatska je ostala sama, s obzirom na to da je riječ o novoj članici Europske unije. Šesta skupina predstavljala je vanjsku kontrolu kvalitete, prijenos podataka Eurostatu, trening projektnih menadžera i posjete pojedinim zemljama. Sedma skupina osiguravala je komunikacijsku infrastrukturu kroz centralizirano upravljanje podacima te podršku okolini korisnik/poslužitelj za vrijeme izmjere. Republika Slovačka pripada 3. skupini, zajedno s još 11 drugih zemalja, što je prikazano na slici 2.

Istraživači na terenu dokumentirali su točke, pri čemu je u projektu nastalo više od dva milijuna fotografija. Za svaku točku zabilježen je transekt (zamišljena linija 250 m u smjeru istoka od točke LUCAS-a). Istraživači koji prolaze transektom trebaju zabilježiti sve promjene zemljišnoga pokrova (klase površinskog pokrova, linearne elemente), što su ih opazili, uz pomoć popisa kodova. Uzorak površinskog horizonta mase 500 g biran je iz 10% posjećenih mjesta (dio izmjere iz 2009. i 2015., Eurostat 2015a). Taj proces prikupljanja podataka obavljan je regularno za vrijeme svake izmjere (bez prikupljanja tla), pri čemu je naglasak bio na metodologiji i nomenklaturi (Eurostat 2015b).

2.1. Tehnička referentna dokumentacija

Metodologija prikupljanja podataka sadrži skup standardiziranih dokumenata Eurostata (2015a,b,c,d), koju uspoređuje, ažurira i prevodi *Soil Science and Conservation Research Institute*. U Uputama za osobe koje provode izmjeru (mjernike) treba spomenuti relativno širok skup dokumenata i priloga: *Technical reference document C-1* (Eurostat 2015a), *Classification of land use and land cover Technical reference document C-3* (Eurostat 2015b), *Quality control procedures Technical reference document C-4* (Eurostat 2015c), *Plant Identification Guide Technical reference document C-5* (Eurostat 2015d) te *Identification guide of data management data management tool DMT* (Eurostat, LUSIS 2015).

Upute sadrže detaljne referentne informacije koje su potrebne istraživačima za prikupljanje podataka na terenu. Ti se podaci odnose na podatke koji će biti nadgledani i zabilježeni tijekom terenskih izmjera, kao i točnost bilježaka. Terenski formulari osnova su bilježenja podataka. Prebacivanje podataka u digitalni oblik zajedno s fotografijama i podacima GNSS-a čine jezgru DMT-a (*data management tool*, alat za upravljanje podacima).

Tablica 1. Osnovna klasifikacija i upravljanje zemljišnim pokrovom prema tehničkom referentom dokumentu C3 (Eurostat, 2015b)

A	UMJETNO ZEMLJIŠTE	**A10** Građevine s krovom, **A20** Umjetna područja koja nisu izgrađena, **A30** Druga umjetna područja
B	USJEVI	**B10** Žitarice, **B20** Usjevi s korijenom, **B30** Nestalni industrijski usjevi, **B40** Suhe mahunarke, povrće i cvijeće, **B50** Krmno bilje, **B70** Stalni usjevi: voćke, **B80** Drugi stalni usjevi
C	ŠUMA	**C10** Širokolisna šuma, **C20** Četinarska šuma, **C30** Miješana šuma
D	GRMLJE	**D10** Grmovito zemljište s rijetkim stablima, **D20** Grmovito zemljište bez stabala
E	PAŠNJAK	**E10** Pašnjak s rijetkim stablima, **E20** Pašnjak bez stabala i grmlja, **E30** Površina na koju se spontano vratila vegetacija
F	GOLET I LIŠAJ/MAHOVINA	**F10** Stijene i kamenje, **F20** Pijesak, **F30** Lišaj i mahovina, **F40** Drugo golo zemljište
G	VODNA PODRUČJA	**G10** Vodno tijelo u unutrašnjosti, **G20** Tekućica u unutrašnjosti, **G30** Prijelazna vodna tijela, **G50** Ledenjaci, stalan snijeg
H	MOČVARE	**H10** Močvara u unutrašnjosti, **H20** Močvara na obali

Klasifikacija/nomenklatura upotrebe zemljišta nudi detaljne informacije o sustavu klasifikacije. Posebni sustavi klasifikacije postoje za zemljišni pokrov i upotrebu zemljišta. Zemljišni pokrov je fizički pokrov na Zemljinoj površini, a upotreba zemljišta je socioekonomska funkcija krajolika. Ta taksonomija povezuje se s postojećim sustavima (npr. *Food and Agriculture Organization – FAO methodology, NACE statistical classification of economic activities in the European Community te Survey of Farm Structure*). Osam glavnih klasa u tablici 1 čine osnovu klasifikacije zemljišnog pokrova. Osnova se formira zajedno s detaljnim klasama te kodira osnovnim alfanumeričkim kodovima od tri (četiri u slučaju tipova šume) znaka (URL 1).

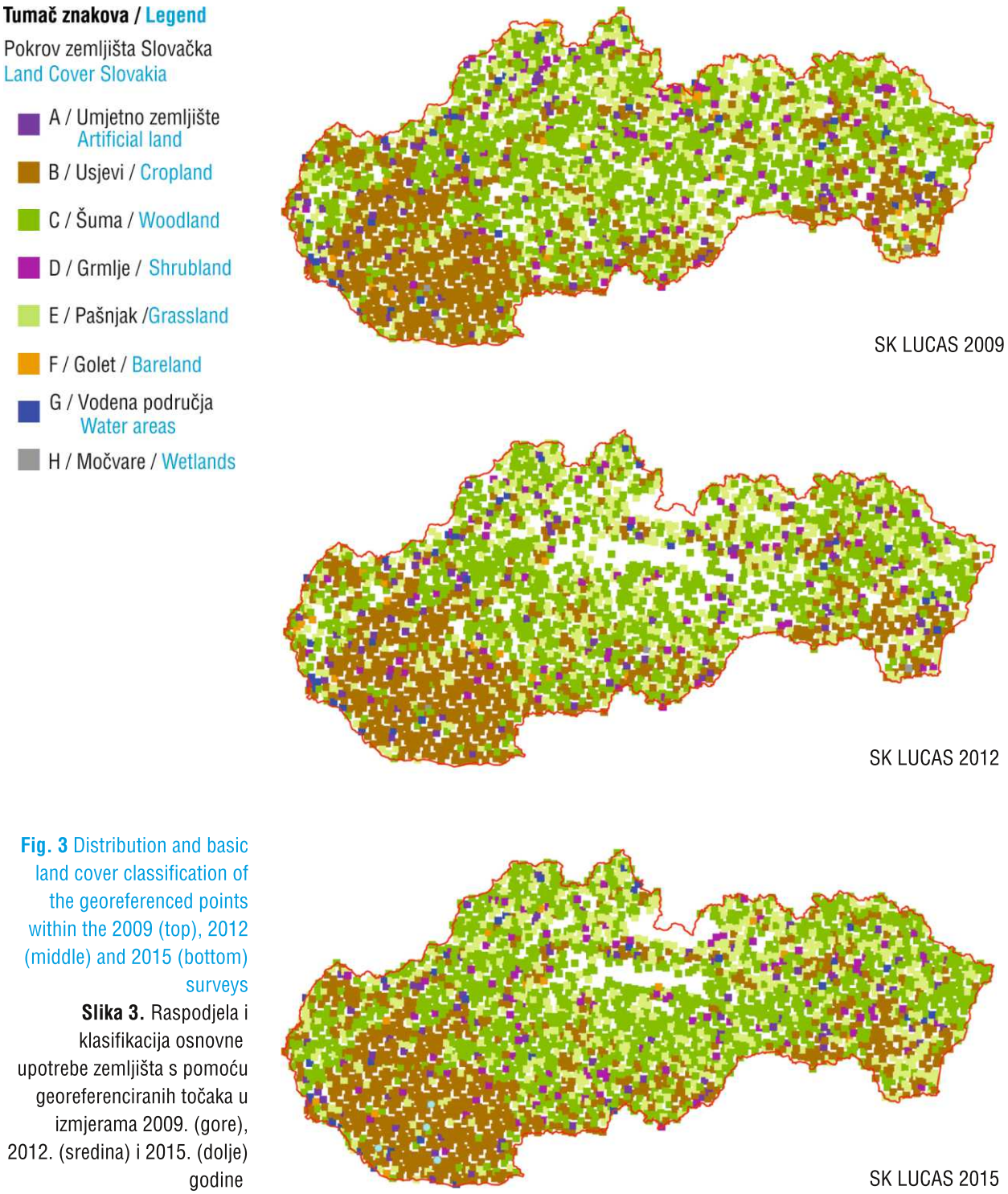

Fig. 3 Distribution and basic land cover classification of the georeferenced points within the 2009 (top), 2012 (middle) and 2015 (bottom) surveys

Slika 3. Raspodjela i klasifikacija osnovne upotrebe zemljišta s pomoću georeferenciranih točaka u izmjerama 2009. (gore), 2012. (sredina) i 2015. (dolje) godine

classification of economic activities in the European Community and the Survey of Farm Structure). The eight main classes listed in Table 1 form the basis of land cover classification. It is accompanied by detailed classes, coded using a basic three-digit alphanumeric code (four digits for forest types, URL 1).

Land use is the description of the same areas with respect to their socio-economic functions. Land use has 15 main categories and sub-categories, with more detailed classes assigned basic three-digit alphanumeric codes as displayed in Table 2. There is a matrix of combinations (Appendix 5, C-1 Technical reference document) for the proper assignment of land use to land cover, defining the relationship as a) permitted, b) rare, or c) unauthorized.

2.2 Data management in DMT Suite

In order to manage data entry and the transfer and checking of information collected in the field, a collection of software called DMT 2015 Suite has been developed (Eurostat and Lusis 2015). The five applications (DMT Client, Agent, Server, Viewer, Map)

Upotreba zemljišta odnosi se na ista područja, ali s aspekta njihove socioekonomske funkcije. Upotreba zemljišta dijeli se na 15 glavnih kategorija, koje se zajedno s detaljnijim klasama kodiraju s pomoću alfanumeričkih kodova od triju znakova koji su prikazani u Tablici 2. Postoji matrica kombinacija (prilog Br. 5 C-1 *Technical reference document*) za odgovarajuće dodjeljivanje upotrebe zemljišta zemljišnom pokrovu, što određuje njihov odnos po kategoriji kao a) dozvoljen, b) rijedak c) nedozvoljen.

Tablica 2. Osnovna klasifikacija i upravljanje upotrebom zemljišta prema tehničkom referentnom dokumentu C3 (Eurostat, 2015b)

U110	POLJOPRIVREDA
U120	ŠUMARSTVO
U130	AKVAKULTURA I RIBARSTVO
U140	RUDARENJE I KAMENOLOM
U150	OSTALA PRIMARNA PROIZVODNJA
U210	PROIZVODNJA ENERGIJE
U220	INDUSTRIJA I PRERADA
U310	PRIJEVOZ, KOMUNIKACIJSKE MREŽE, SKLADIŠTENJE, ZAŠTITA
U320	POSTUPANJE S VODOM I OTPADOM
U330	IZGRADNJA
U340	TRGOVINSKE, FINANCIJSKE, PROFESIONALNE I INFORMACIJSKE USLUGE
U350	USLUGE STANOVNIŠTVU
U360	REKREACIJA, SLOBODNO VRIJEME, SPORT
U370	STANOVANJE
U400	NEUPOTREBLJENA I NAPUŠTENA PODRUČJA

2.2. Alat za upravljanje podacima

Za upravljanje unosom, prijenosom i kontrolom podataka prikupljenih na terenu razvijen je niz programa sa zajedničkim nazivom DMT 2015 Suite (Eurostat i Lusis 2015). Pet programa (DMT Client, Agent, Server, Viewer, Map) mjernicima omogućuje unos podataka. Centralizaciju i usklađivanje podataka u bazi podataka pohranjenoj na udaljenom poslužitelju omogućuje program prijenosa podataka (DMT Agend), koji sprema i učitava podatke s lokalnog uređaja na udaljeni poslužitelj i obratno. Podaci se prikupljaju i kontroliraju na lokalnim mjestima (to radi mjernik). Nakon što se unesu i prekontroliraju, podaci se šalju i pohranjuju na središnji poslužitelj u Parizu (Eurostat, Lusis 2015). Hijerarhijsku strukturu toka podataka i upravljanja podacima čini niz SU (*surveyor level* – razina mjernika) – RO (*regional level* – razina regije) – CO (*central office level* – razina središnjeg ureda) – XC (*external control level* – razina vanjske kontrole) – EU (*Eurostat level* – razina Eurostata). Takav niz omogućuje povećanu kvalitetu kontrole podataka. Ako se u nekom podatku pronađe proturječnost, on se vraća na nižu razinu kako bi se popravio i/ili upotpunio. Konačni integrirani podaci čine strukturiranu bazu podataka (mikropodaci o zemljišnom pokrovu, upotrebi zemljišta i parametri o okolišu koji se odnose na mjerene točke) s fotografijama točaka i krajolika u četirima glavnim smjerovima te mjerenjima GPS-om.

2.3. Usporedba referentih točaka zemljišnog pokrova

Što se tiče usklađivanja metodologije tijekom pripremne faze (2001–2006) i utvrđivanja metodologije i sheme uzorkovanja georeferenciranih točaka (2009–2015), usporedili smo razlike između glavnih klasa zemljišnog pokrova za identične referentne točke za razdoblje 2012–2015. Svi podaci za Slovačku preuzeti su sa službene Eurostatove stranice (URL 2), georeferencirane prema koordinatama Lat/Long i povezane s identifikatorima ID. Od skupa 2455 točaka (iz 2009.) te 2755 točaka (iz 2015.), 2153 točke su identične u pogledu zemljišnog pokrova.

Zbog malih promjena u referentnim dokumentima (klasifikacija) i nekoliko proturječnosti (pojedinačna procjena, točnost lokalizacije, dostupnost točaka), nije moguće procijeniti razlike/promjene za cijeli skup podataka. Glavne proturječnosti među klasama u 2015. i 2012. odnose se na razlike daljinskih opažanja, različitim lokalizacijama točaka na rubovima zemljišnog pokrova, postotku procjene obilježja krajolika (što dovodi do različite klasifikacije) i drugo. Trenutačno samo nekoliko dobro opisanih točaka može poslužiti za prikaz značajne usporedbe zemljišnog pokrova i upotrebe zemljišta u razmatranom razdoblju. U sljedećem razdoblju (2018. i dalje), prikupljeni podaci o zemljišnom pokrovu i upotrebi zemljišta zajedno s rutinskim radom bit će primjereniji za procjenu dinamike obilježja zemljišta.

3. Rezultati i rasprava

Izmjera zemljišnog pokrova i upotrebe zemljišta u Slovačkoj započela je 4. svibnja 2015. i svakom mjerniku (osobi koja je provodila izmjeru) dodijeljen je skup od 406 (407) točaka. Šest mjernika je istodobno istraživalo Slovačku. Prosječno je svaki mjernik prikupljao podatke za 6,8 točaka po danu. Prosječno je trebalo 26 minuta za prikupljanje informacija za jednu točku, a raspon prosječnih udaljenosti točaka kretao se od 23 m do 312 m. Glavno ograničenje u prvih četiri mjeseca bili su loši vremenski uvjeti, nepovoljni uvjeti na terenu, posebno u planinskim šumskim područjima te neočekivani događaji (automobilske nesreće, oštećivanje opreme, itd.). Slika 3 prikazuje

Table 2 Basic classification and administration of land use according to technical reference document C3 (Eurostat, 2015b)

U110	AGRICULTURE
U120	FORESTRY
U130	AQUACULTURE AND FISHING
U140	MINING AND QUARRYING
U150	OTHER PRIMARY PRODUCTION
U210	ENERGY PRODUCTION
U220	INDUSTRY AND MANUFACTURING
U310	TRANSPORT, COMMUNICATIONS NETWORKS, STORAGE, PROTECTION WORK
U320	WATER AND WASTE TREATMENT
U330	CONSTRUCTION
U340	COMMERCIAL, FINANCIAL, PROFESSIONAL AND INFORMATION SERVICES
U350	COMMUNITY SERVICES
U360	RECREATION, LEISURE, SPORT
U370	RESIDENTIAL
U400	UNUSED AND ABANDONED AREAS

built into the DMT Suite allow the local collection of data entry at the survey level. The centralization and synchronization of data in a single database stored on a remote server is performed by a data transfer program (DMT Agend) which uploads and downloads information from/to local devices and the remote server. Data are collected and checked at local sites (by surveyors). Once entered or checked, information is sent to and stored on a central server hosted in Paris (Eurostat and Lusis 2015). The hierarchical structure of data flow and management is represented by the sequence SU (surveyor level) – RO (regional level) – CO (central office level) – XC (external control level) – EU (Eurostat level). Within this sequence, escalated data quality control is provided. Any inconsistencies found in any of the data elements result in the point being returned to a lower level for correction and/or completion. The final integrated data survey consists of a structured database (micro-data on land cover, land use and environmental parameters associated with the individual points surveyed) with point and landscape photos taken in the four cardinal directions and GPS track records.

2.3 Land cover comparison of reference points

Regarding the methodology harmonization process during the preparation phase (2001–2006), followed by the stabilization of the methodology and sampling scheme for the georeferenced points (2009–2015), we compared the main land cover class differences for identical reference points between 2012 and 2015. All data for Slovakia were downloaded from the official Eurostat site (URL 2), georeferenced according to the reference Lat/Long coordinate, and joined with identical point ID. From the sets of 2455 points (2009) and 2755 points (2015), 2153 points represented an identical dataset for the land cover comparison.

Due to small changes within the reference documents (classification) from year to year and several inconsistencies (individual assessment, accuracy of localization, point accessibility) it was not possible to evaluate differences/changes for the entire dataset. The main inconsistencies between class differences in 2012 and 2015 were represented by discrepancies in remote observation, different point localization in land cover borders, the percentage estimation of landscape features (resulting in different classifications), etc. At the moment, only a certain number of well-described points can serve to demonstrate significant land cover/use comparison in the period concerned. During the next steps (2018 and beyond), an accumulated LC/LU set of data, along with routine work, is considered more appropriate for evaluating land feature dynamics.

3 Results and Discussion

The survey on land cover and land use in Slovakia started on 4 May 2015 with sets of 406(407) points assigned to each surveyor. In parallel, six surveyors researched Slovakia, covering an average of 6.8 points per surveyor per day. The average time needed to collect the data was 26 minutes, and the range of average point observance distance varied between 23 m and 312 m. The main hindrances during the four-month survey were adverse weather conditions, difficult terrain, especially in mountain forest areas, and unexpected events (car accidents, equipment failures, etc.). Figure 3 shows the distribution and basic land cover classification of the georeferenced points within the 2009, 2012 and 2015 surveys.

The final land cover corresponds with the gradient of the elevation according to the dominance of cropland in the lowlands and woodland in the mountain areas. The main woodland in lowland areas is secondary, combined with water areas, artificial land, small areas of grassland, and wetlands. Uplands and foothills are represented by a combination of cropland and grassland accompanied by shrubland/woodland with small village areas (artificial land). The dominance of woodland and bare land is obvious in mountain areas. These areas are completed by the mosaic of grassland and shrubland. The resulting percentage of final basic land cover categories and land use categories for Slovakia is given in Table 3: the most frequent classes are woodland,

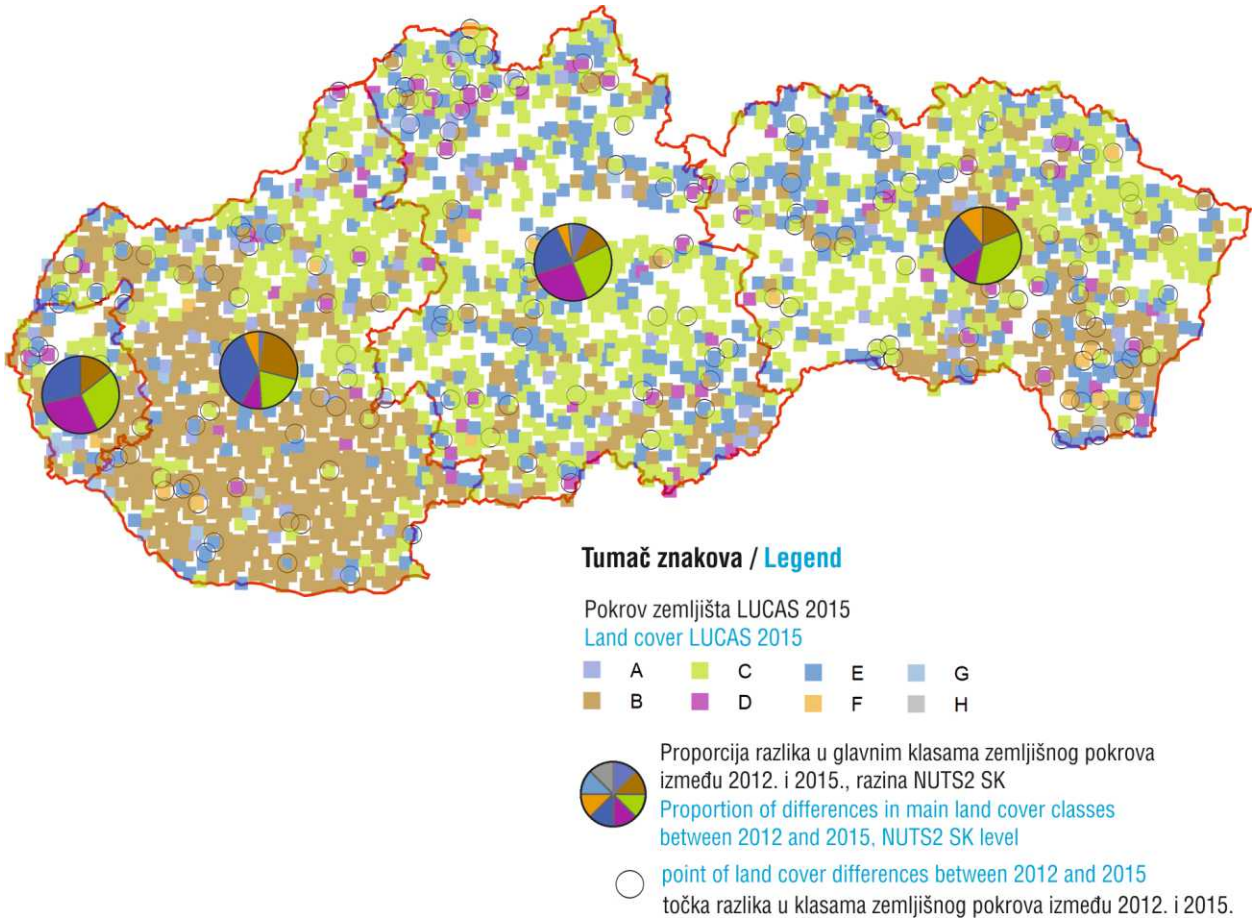

Fig. 4 Proportion of differences in main land cover classes between 2012 and 2015, NUTS2 SK level
Slika 4. Proporcija razlika u glavnim klasama zemljišnog pokrova između 2012. i 2015., razina NUTS2 SK

raspodjelu i osnovnu klasifikaciju zemljišnog pokrova georeferenciranih točaka iz 2009., 2012. i 2015. godine.

Konačan zemljišni pokrov odgovara gradijentu visine prema dominantnosti usjeva u nizinskim područjima te šuma u planinskim područjima. Glavna šuma u nizinskim prostorima je sekundarna, u kombinaciji s vodnim područjima, umjetnim zemljištem, malim područjima pašnjaka i močvara. Uzvisine i podnožja zastupljeni su kombinacijom usjeva i pašnjaka, uz grmlje/šume s malim područjima sela (umjetnog zemljišta). Dominacija šuma i goleti je očita u planinskom područjima. Ta područja upotpunjuje mozaik pašnjaka i grmovitog zemljišta. Tablica 3 prikazuje postotak konačnih osnovnih kategorija zemljišnog pokrova i upotrebe zemljišta u Slovačkoj: najčešće klase su šuma, pa usjevi i pašnjaci (sve tri zajedno iznose više od 91%), rjeđe klase su umjetno zemljište, grmovito zemljište i vodna područja (ukupno manje od 8%). Poljoprivredna područja čine najveći dio (blizu 50%), slijede šumska područja (blizu 35%) i na kraju su sve druge kategorije upotrebe zemljišta (napuštena područja, stanovanje, prijevoz, itd., ukupno manje od 17%).

Tablica 3. Postoci konačnih osnovnih kategorija zemljišnog pokrova i upotrebe zemljišta u Slovačkoj

Zemljišni pokrov 2015. u kodovima	Postotak (%)	Upotreba zemljišta 2015. u kodovima	Postotak (%)
A	2,9	U110	43,63
B	29,95	U120	39,67
C	41,38	U130	0,4
D	3,88	U140	0,15
E	19,71	U150	0,07
F	0,98	U210	0,25
G	1,09	U220	0,18
H	0,11	U310	1,81
		U320	0,36
		U330	0,15
		U340	0,04
		U350	0,47
		U360	0,65
		U370	2,14
		U400	10,02

followed by cropland and grassland (together, these three classes account for more than 91% of land cover), less frequent classes are artificial land, shrubland and water areas (less than 8%). Agriculture accounts for the greatest proportion (almost 50%), then forestry (almost 35%), while all other categories of land use classification (abandoned areas, residential, transport etc., account for less than 17%).

Table 3 Resulting percentage of final basic land cover and land use categories in Slovakia

Land Cover 2015 in codes	Percentage (%)	Land Use 2015 in codes	Percentage (%)
A	2.9	U110	43.63
B	29.95	U120	39.67
C	41.38	U130	0.4
D	3.88	U140	0.15
E	19.71	U150	0.07
F	0.98	U210	0.25
G	1.09	U220	0.18
H	0.11	U310	1.81
		U320	0.36
		U330	0.15
		U340	0.04
		U350	0.47
		U360	0.65
		U370	2.14
		U400	10.02

According to the land cover main class comparison, a set of well-described points with significant land cover change (recorded by ortophoto images from the appropriate time and point landscape photos) may serve to evaluate land cover changes. The first category of significant differences in land cover indicates abrupt, direct, anthropogenic interventions such as the expansion of built-up artificial areas, deforestation, and regulation of water areas, etc. These changes are characteristically rather rapid and usually permanent. Land use changes have been examined practically in this regard, for example by Skokanová et al. (2012), Špulerová et al. (2011), and Tarasovičová et al. (2013). A typical example is the process of urbanization, when new residential areas in cities grow in surface area and height. New features, such as solar energy plants, highways, and communication networks, have appeared in the countryside, sealing the soil cover and/or changing natural features.

The second category of land changes relates to dwindling human activity in agricultural areas (arable land, permanent cultures, grassland etc.), due to the changing way of life in the countryside and the perceptions of the younger generation. Abandoned land changes according to a natural succession of stages, which in these climate conditions lead to the final stage (climax) of vegetation – forestland. The process of reversion to nature is relatively slow and usually interspersed with abrupt, direct anthropogenic interventions. Some indirect aspects of the anthropogenic impact are changes in the hydrological/microclimate cycle and environmental conditions (for example noise, or vibrations), which may interact with other factors in land cover change, with a retarding (inhibiting) or catalytic (gradation) effect. Figure 4 shows an overview of land cover differences observed in the main land cover classes between 2012 and 2015, for identical reference points.

4 Conclusion

Perception of the landscape and human interest in the land are natural and relate to human existential needs in the environment. The identification of spatial objects and their substance is known as land cover, the materialized projection of natural spatial features and social land use.

This article describes the process of data acquisition, management, transmission and control in Slovakia, within the Pan-Europeani survey of land cover and land use data collection. Since 2009, the survey has been harmonized and standardized in terms of methodology and reference documents/materials throughout Europe. In the nine-year history of the survey in Slovakia (in the framework of the fourth cycle), it represents the routine collection of georeferenced information on landscape and, occasionally, soil cover. Apart from the standard data acquisition, an additional environmental module is implemented in the survey during each cycle. This year, it is the collection of soil data samples (similarly to 2009) and an ancillary description of topsoil properties.

The harmonized data collection of the in situ survey forms a unique database for spatial and territorial planning, which is increasingly important in strategic decision-making. Changes in land cover, biophysical attributes, and socio-economic activities and human objectives and goals applied to these attributes, are key aspects in the functioning of ecological and environmental systems. The systematic collection and analysis of these elements enables continuous monitoring and exploitation of land resources based on best practice.

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Prema usporedbi glavnih klasa zemljišnog pokrova, skup dobro opisanih točaka sa značajnom promjenom zemljišnog pokrova (procijenjen na temelju ortofotosnimaka iz odgovarajućeg vremena te fotografija krajolika) može poslužiti pri procjeni razlika u zemljišnom pokrovu. Prvu kategoriju velikih razlika u zemljišnom pokrovu čine iznenadne izravne antropogene intervencije, kao što su širenje izgrađenih umjetnih područja, krčenje šuma, regulacija vodnih područja, itd. Riječ je o relativno brzim promjenama koje su obično trajne. O promjenama upotrebe zemljišta pisali su npr. Skokanová i dr. (2012), Špulerová i dr. (2011), Tarasovičová i dr. (2013). Tipični primjer takvog slučaja je urbanizacija, izgradnja novih područja za stanovanje u gradovima. Novi objekti, kao što su solarne elektrane, autoceste, komunikacijske mreže pojavljuju se u selima i pokrivaju tlo i/ili mijenjaju prirodna obilježja.

Druga kategorija promjene zemljišta odnosi se na smanjenje čovjekove aktivnosti na poljoprivrednim zemljištima (obradivo zemljište, trajne kulture, pašnjaci, itd.) i ponajviše se odnosi na život na selu. Napušteno zemljište mijenja se u skladu s prirodnim fazama, što u tim klimatskim uvjetima dovodi do posljednje faze (vrhunca) vegetacije – šumskog područja. Proces povratka prirodi relativno je spor i obično se prekida iznenadnim antropogenim intervencijama. Posredan aspekt antropogenog utjecaja odnosi se na promjene hidrološkog/mikroklimatskog ciklusa i uvjeta okoliša (na primjer buka, vibracije), što u međudjelovanju s drugim čimbenicima promjene zemljišnog pokrova može imati inhibirajući ili katalitički utjecaj. Na slici 4 nalazi se pregled opaženih razlika u klasama zemljišnog pokrova između 2012. i 2015. na identičnim referentnim točkama.

4. Zaključak

Percepcija krajolika i čovjekov interes za zemljište prirodan je i odnosi se na njegove egzistencijalne potrebe. Pojam zemljišni pokrov odnosi se na identifikaciju prostornih objekata i prepoznavanje njihove suštine, koja je materijalizirana projekcija prirodnih prostornih obilježja, kao i trenutačna društvena upotreba.

U radu se opisuje proces prikupljanja *in situ*, obrade, prijenosa i kontrole podataka u Slovačkoj unutar paneuropske izmjere zemljišnog pokrova i upotrebe zemljišta. Izmjera je od 2009. usklađena i standardizirana u odnosu na metodologiju i referentne dokumente/materijale u cijeloj Europi. U devet godina izmjere (u okviru četvrtog ciklusa) u Slovačkoj, ona uključuje rutinsko prikupljanje georeferenciranih podataka o zemljišnom pokrovu i tlu. Osim uobičajenog prikupljanja podataka, u izmjeru je u svaki cikus ugrađen dodatni modul o okolini. Ove godine, to je prikupljanje uzorka podataka o tlu (slično kao i 2009.) te pomoćno opisivanje svojstava gornjeg sloja tla.

Prikupljanje usklađenih podataka na licu mjesta rezultiralo je jedinstvenom bazom podataka za prostorno i teritorijalno planiranje, čija važnost za strateško donošenje odluka neprekidno raste. Promjene u zemljišnom pokrovu, biofizičkim atributima, upotreba socioekonomskih aktivnosti i ciljeva čovjeka primijenjeni na te atribute ključni su aspekti funkcioniranja ekoloških sustava i sustava okoliša. Sustavno prikupljanje i analiza tih elemenata omogućuje neprekidno nadgledanje i upotrebu zemljišnih resursa utemeljenih na najboljoj praksi.

Napomena

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