MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH

DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni

IZVLEČEK

Za boljše upravljanje podatkov v kmetijstvu so vladne službe razvile geoinformacijske sisteme. Ti sistemi, ki praviloma temeljijo na sodobnih tehnologijah in standardih, se lahko uporabljajo predvsem kot pomoč pri določevanju kmetijskih podpor, pri njihovem nadzoru ter kot podpora odločanju pri uresničevanju drugih nalog javnega sektorja. V okviru ene najstarejših politik Evropske unije, to je skupne kmetijske politike, se je razvil sistem kmetijskih subvencij, z njim pa tudi sistem, ki pomeni pomembno podporo sistemu kmetijskih subvencij. V članku predstavljamo razvoj obširnega geoinformacijskega sistema Republike Srbije ter njegovo verifikacijo s testnimi podatki. V skladu z zahtevami Evropske unije je treba v takšnem sistemu upoštevati posebne zahteve in standarde, kar je tudi pogoj pri približevanju Srbije Evropski uniji. Pri razvoju geoinformacijskega sistema za kmetijske subvencije so bile upoštevane tudi potrebe Srbije, pri čemer smo izhajali iz sedanjega okvira, rešitev pa smo prilagodili standardom in direktivam, kot so INSPIRE, ISO/LADM in LPIS. V članku se osredotočamo na rešitev, ki omogoča uporabo sistema za komunikacijo in predstavitve vsebine podatkovnih zbirk kmetom prek spletnih rešitev, kar je uporabno tudi pri verifikaciji samega sistema.

ABSTRACT

To better manage data in agriculture, governmental services implement geoinformation systems. These systems may be used as an aid to calculation of subsidies, serve as means of control and as support in decision making while following the latest technologies and standards. One of the oldest policies of the EU, the Common Agricultural Policy, implements a system for agricultural subsidies along with an information system to aid in enforcing it. This paper provides one design for an exhaustive geoinformation system in the Republic of Serbia and verification of the mentioned system with test data. The system must fulfil requirements and standards as one of the conditions for accessing the EU. These needs are met by extending the current Serbian framework while conforming to directives and standards such as INSPIRE, ISO/LADM and LPIS. A suggestion is shown in the paper for using this system in communicating and presenting relevant data to the farmers through a geoportal Web application which also serves as a way of verifying the system.

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 51 |

1 INTRODUCTION

Record keeping, analysis of the data and support in agricultural production has increased significantly with the support from standards and concise legislature. Governments and administration services implement information systems which provide an aid in agriculture in many ways. This aid, in the context of the EU, significantly comes in the form of monetary subsidies for the farmers. The EU regulations describe a common policy called the Common Agriculture Policy (CAP), which is an implementation requirement for the member states. The European Commission states that CAP is a connection between the growing urban community and a larger strategic agricultural sector. It is one of the oldest policies of the European Union (EU) and it implements an information system for agricultural subsidies and many rural development programs (European Commission, 2014a).

The Infrastructure for Spatial Information in Europe (INSPIRE) and Integrated Administration and Control System (IACS) describe the spatial domain in the EU for agricultural information systems. ISOTC211[1] (Technical Committee 211 of the ISO) is an international body, which provides specific frameworks and standards for the ISO (International Standard Organization) for development of applications using geographic data. To achieve interoperability, the concepts from these standards should be used as a starting point for an information system. It is also advised to change current information systems in a way to conform to these standards. European legislation must be implemented, and regulations and laws must be adapted in Serbia, because the country is currently in the process of accessing the EU. Currently there is no information system in place that conforms to IACS (see section 2). Therefore, implementing this system, which demands thorough investigation, is of great importance.

This paper gives suggestions for a domain model for an agricultural information system, with respect to spatial data, according to standards and EU recommendations. These suggestions are delineated from EU requirements and available documentation (laws, regulations, etc.). The domain model is formed for an information system by means of conceptual modeling (ISO/TC211, 2015b) and verified by a geoportal Web application as a real world example. Some of the benefits to forming such an information system would be reducing operating costs, reduction in data redundancy, increasing transparency, enabling scalability and a foundation for easier future improvements, etc.

We present a novel generalized agricultural information schema comprising of classes that are mutually exhaustive. This schema can be used as a reference to derive concrete implementations. We also report about one such implementation that we realized and that adopts all the classes proposed by the standards. The work presented in this paper takes into consideration mostly the spatial and temporal aspects of agriculture because the scope of the entire system (administrative, spatial, temporal, legal, etc.) is very broad (see section 2). The model documentation is done using the Unified Modelling Language (UML) notation recommended by ISO 19103 – Conceptual Schema Language (ISO/TC211, 2015a).

2 STATE OF THE ART

2.1 Related work

According to standard documents (Sagris and Devos, 2009), satellite imagery and orthophotos should be used for inspection, delineation, etc. Milenov and Kay (2006) outline that all of the member

---

[1]   http://www.isotc211.org/

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 52 |

states, except UK, use orthoimagery, typically with resolutions under 1 m. They also say that the easiest way to provide LPIS data is through Web-enabled services and that 20 member states had already built such Web systems. Shelestov et al. (2013) have implemented such a Web system in Ukraine through a geoportal of agriculture. The created open-source system consists of two levels, ministerial and agricultural enterprise. The system includes a geoportal with a Web interface and a GIS for analysis.

Ciolkowska et al. (2003) have shown the process of integration of digital aerial orthophotos, satellite images and cadastral data in subsidy applications for the Polish IACS. An advantage of a system based on cadastral parcels is that the cadastral offices regularly update their data. These data are official, and the cadastre should, in practice, provide a unique identification system (Radulovic et al., 2015). However, the cadastre in Serbia is largely out of date, especially when it comes to rural areas. It needs to be harmonized with the systems in the municipal courts (Arcotrass GmbH, 2006). Therefore, the usage of cadastral parcels is not recommended with the current state.

In Czech LPIS (2004), an in-depth documentation of the entire process of implementing the LPIS in the Czech Republic is provided. The documentation shows history of the origination, principles, data, administration and outputs of the system. The main identification unit in the Czech system is the Farmer's block. The Farmer's block is a continuous plot of land cultivated by one farmer, possibly containing more than one crop groups (see section 3). The farmers block may prove useful because this may correlate to the registry of agricultural holdings (see below), where there is a single farmer but multiple crop groups. Problems may arise when there are natural user conflicts with the land ownership and LPIS must be ready to solve such conflicts among users.

Ozcelik and Nisanci (2015) describe a complete conceptual model for the implementation of tea crops in Turkey with the use of INSPIRE, LADM, Land Cadaster, national GIS and the already implemented Agricultural Model. This is a more specialized model where there are special instances of the classes such as *TeaFarmer*, *TeaAgriculturalParcel*, *TeaFarmingLicence*, etc. Therefore, specialized classes for the system are necessary for future extensions.

European Union

The EU has adopted the Common Agriculture Policy which is aimed at helping European farmers to meet the food demands of more than 500 million Europeans. Its main objectives are to provide a stable, sustainably produced supply of safe food at affordable prices for consumers, while also ensuring a decent standard of living for 22 million farmers and agricultural workers (European Comission, 2017a). The objectives, tools, and measures for the implementation of CAP are laid down in the legal acts, adopted by the European Council and the Parliament and, by delegation, by the Commission. One of the main instruments of the CAP is the aids paid to the farmers. Member States are responsible for the implementation of CAP, which comprises of the establishment and running of an Integrated Administration and Control System (IACS). This system supports the aid application process of farmers as well as the work of authorities that control the applications and calculate aids to be paid.

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 53 |

Republic of Serbia

All the processes are handled by the Ministry of Agriculture and Environmental Protection (MAEP). The current legislation in Serbia defines the agricultural policy, types of subsidies, conditions, record keeping through the Registry of Agricultural Holdings, the Integrated Agricultural Information System, etc. (MAEP, 2010). For this paper, relevant information systems and the strategy for the following years will be examined.

The authority of agrarian payments implements a registry of agricultural holdings for the purposes of monitoring agricultural policies and record keeping of holdings and family holdings. The registry data consists of companies, agricultural cooperatives and other legal entities such as schools, churches and monasteries, which perform agricultural production (MAEP, 2010). Specific data about holdings includes data on farmed land, members of the holding, livestock, personal data of farmer, rights and entitlements, etc. (MAEP, 2011).

The Ministry implements the Registry of Agricultural Subsidies that stores the type and number of subsidies per user. The data of the register are public and are kept in an electronic form. These data are used for the purpose of incentivizing agriculture and rural development as well as statistical and analytical analysis in the ministry (MAEP, 2013). Transparency is an issue in Serbia[2,3]. According to regulations the registry of subsidies mentions that the data is public and kept in an electronic form, however these data cannot be found on the internet. It is also not possible to find any technical documentation which describes how the systems work. This needs to be addressed in the future because missing technical documentation makes the current systems less interoperable and hard to manage and extend.

The Ministry of Agriculture and Environmental Protection has also defined a strategy of agriculture and rural development for the period of 2014–2024 that defines current problems, goals and activities for the rural development. The main document of the strategy defines the indicators for assessing the realization of strategic goals including (MAEP, 2014):

– "Established record system Land Parcel Identification System (LPIS) until 2018";
– "Established record system Geographic Information System (GIS) until 2018".

2.2 Standards

Standardization in technical systems is important because of interoperability and ease of use. There are plenty of ways to perform a task, but communication and integration are only possible if each involved stakeholder understands the process. Interoperability and standardization are important in agricultural systems because of different authorities that handle the data such as geospatial experts, agriculture experts, economists, lawyers, farmers. All of them must be able to collaborate. The most relevant standards and legislation for use in agricultural systems of the EU are:

– ISO19152 Land Administration Domain model (LADM) – Defines a formal language in UML for describing land administration (ISO/TC211, 2012);
– INSPIRE[4] Technical Guidelines – The INSPIRE Directive aims to create a EU spatial data infra-

---

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 54 |

structure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment;

– EU regulations 1306/2013 and 1307/2013 – System for the management and control of payments to farmers (together with the Land Parcel Identification System) made by the Member States in application of the Common Agricultural Policy (European Comission, 2013a; European Comission 2013b);

– Open Geospatial Consortium (OGC)[5] – Provides many open standards for Web services and general interoperability of spatial data.

Reference standards (ISO, INSPIRE, OGC)

ISO19100 and INSPIRE are related to IACS, because agriculture is inherently spatial. The ISO subject which deals with land administration is the ISO19152 LADM. This standard proposes a conceptual model to fulfill two goals (ISO/TC211, 2012):

1. To provide an extensible basis for the development and refinement of efficient and effective land administration systems, based on a Model Driven Architecture (MDA);

2. To enable involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary (that is, ontology), implied by the model.

INSPIRE deals with spatial information needed for policies that have an environmental impact. One of the specifications from Annex 1 is the cadastral parcel. This means that cadastral parcels are considered as reference data, i. e. data that constitute the spatial frame for linking and/or pointing at other information that belong to specific thematic field such as environment, soil, land use, and many others. By definition the cadastral parcel is "An area defined by cadastral registers or equivalent" (INSPIRE, 2007). Cadastral parcels are important in agriculture because they also serve as a way of defining legal ownership and other rights for an area which may be used for agricultural production.

OGC provides useful standards for interoperability and Web services such as Web Map Service (WMS)[6], Web Feature Service (WFS)[7] which could prove to be necessary for administration of agricultural data over the Web.

Integrated Administration and Control System (IACS)

IACS is the most important system for the management and control of agricultural subsidies made by the Member States in application of the Common Agricultural Policy. It provides a uniform basis for payment, applications, registering agricultural area, entitlements, and controls such as the administrative and on-the-spot controls of applications. The IT system of IACS supports the national administration in carrying out their functions (European Comission, 2017b). The schema of the IACS domain model consists of seven packages as shown in Table 1. The Base types package is a modeling practice that highlights reusable elements of the system while the latter six packages reflect the requirements of legislation.

---

5   http://www.opengeospatial.org

6   http://www.opengeospatial.org/standards/wms

7   http://www.opengeospatial.org/standards/wfs

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 55 |

Table 1:   IACS Packages (European Comission, 2014b).

Package	Description
Base types	Schema for base types and models used by multiple application schemas within the IACS model.
Aid applications and payment claims	Schema describing the aid applications and payments.
Identification System for Agricultural parcels	Schema commonly named Land Parcel Identification System – LPIS.
Integrated control system	Schema containing information on the control of the system.
System to record the identity of each beneficiary	Schema containing information on record keeping of farmers.
System for identification and registration of animals	Schema about livestock and animals which is not yet complete.
System of entitlements	Schema containing information about entitlements of each beneficiary.

"The Member States shall have this system to ensure a unique identification of the farmers, as well as of all agricultural parcels and, if needed, of livestock. It shall also cover the processing of agricultural subsidies. The fulfilment of the criteria for subsidies is assessed through administrative checks and through on-site inspections" (European Comission, 2007).

Modelling and IACS

ISO 19109:2015 defines rules for creating and documenting application schemas, including principles for the definition of features. It describes how phenomena from the reality in the universe of discourse are captured as feature instances (ISO/TC211, 2015b). ISO 19103:2015 provides rules and guidelines for the use of a conceptual schema language within the context of geographic information. The chosen conceptual schema language is the Unified Modelling Language (UML). The standardization target type of this standard is UML schemas describing geographic information (ISO/TC211, 2015a). These are the main reference schemas for creating a domain model.

As depicted in Figure 1, creating a model fitting the CAP consists of 3 main points (European Commission 2014b):

– *The Requirement model* is used for describing all legal, functional and non-functional aspects of the system. It is a hierarchical structure that helps to manage the complexity of requirements set by the legal framework of CAP to translate them in technical concepts. The requirements model is a structured catalogue of end-user requirements. These are represented as either requirement or feature elements. Functional requirements are use cases that the system must support, such as submissions, applications and calculations of aid, etc. It is organized based on IACS components, e. g. aid applications and payment claims, identification system for agricultural parcels, etc. Non-functional requirements describe properties that the system must possess, such as reliability, security, extensibility, etc.

– *The Dynamic model* describes the behaviour of the system over time. It includes support for activity diagrams, state diagrams, sequence diagrams and extensions including business process modelling. The dynamic model connects the requirement to the conceptual model to get schema that describe the workflow. Traceability models act as starting points for tracing the definition, design and imple-

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 56 |

mentation of a system component or a process. Use case model captures the relationships between actors and the system.

– *The Conceptual model* defines concepts of the universe of discourse (ISO/TC211, 2014). It consists of application schemas. An application schema adds logical structure (as packages) to the semantics defined in the conceptual model. The IACS domain model contains packages related to the subsystems IACS. Each of the packages is also represented through a XML Schema Definition (XSD) file. A XSD file is a machine-readable specification on how to formally describe this application schema in an XML document.
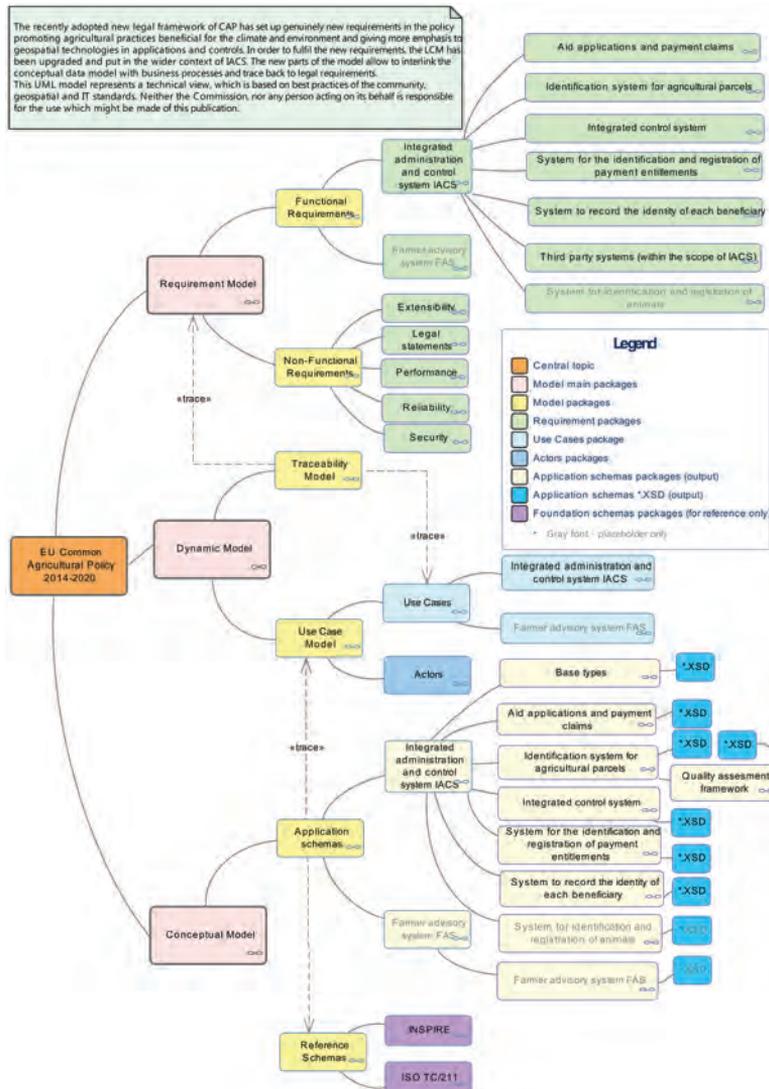

Figure 1:   Modeling diagram of the CAP/IACS system (Tóth and Kučas 2016).

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 57 |

The reference schemas represent an abstract framework or domain-specific ontology consisting of an interlinked set of clearly defined concepts produced by an expert or body of experts in order to encourage clear communication (European Commission, 2014b).

The proposed IACS domain model offers a holistic view of the Common Agricultural Policy from business and information points of view describing the relevant static and dynamic aspects of the domain. The model addresses two high level use-cases. The first deals with operating the Integrated Administration and Control System according to the rules defined in the related EU regulations. The second is about enabling interoperability with mainstream ICT and GIS (Tóth and Kučas, 2016).

From the statements above, we can conclude that the modelling of the entire system is not an easy task. It would take an entire enterprise consisting of geospatial experts, lawyers and lawmakers, agriculture experts, developers, system engineers, etc. The modelling part for this paper is mostly focused on the LPIS and the reference schemas ISO and INSPIRE.

From the outlined points we can conclude that the already existing integrated system, along with the record keeping systems, do not satisfy the criteria of IACS, and therefore need to be upgraded.

3 DOMAIN MODEL

"Why do we model? We build models so that we can better understand the system we are developing" (Booch et al., 1998). The entities are laid out as classes, with connections as relationships. UML is used because all the standards and technical requirements already conform to this standard of notation. A model is an abstraction of some aspects of reality (ISO/TC211, 2015b).

The process consists of a domain model creation and verification. The first step in the conceptual modelling process is synchronizing with standards. The UML model was documented in Enterprise Architect. Afterwards the entire object model was converted in a Data Definition Language (DDL)[8] with Enterprise Architect, and then converted to SQL. The extracted SQL code does not account for complex data types and geometries so therefore it had to be corrected. The next steps were creating a test data set and triggers which further implement the requirements of the system, and validate that data against the triggers. In the end, the data were published for viewing and accessing.

3.1 Domain model profile for the Republic of Serbia

For the documentation, all standards were acquired in the format for Enterprise Architect. Enterprise Architect[9] is a multi-user, graphical tool designed to aid in building robust and maintainable systems. It is possible to do UML modelling and extend models to include the Conceptual and Geographic Markup Language (GML) schema. Because some of the models were not the same as the standard documents they were normalized. This normalization included fixing of attributes and links between classes. For example, the class **ReferenceParcel** from the main LPIS core model was missing a geometry attribute. The relationship between the **extCadParcel** and **ReferenceParcel** from the core model was changed to connect the **SubParcel** to the **RS_Parcel** from the Serbian cadastral system. Additionally, a model was created from an Extensible Markup Language (XML) file found on the website of the Treasury of

---

8   http://www.sparxsystems.com/enterprise_architect_user_guide/9.2/model_transformation/ddltransformation.html
9   http://www.sparxsystems.com/products/ea/

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 58 |

Serbia[10], legal forms (MAEP, 2011) that farmers have to fill out when applying for the registry of an agricultural holding and regulations such as laws, rules, statutes, etc. (Figure 2.). Six classes were formed with attributes which the users should provide when applying. These classes are represented in green, and the definitions are shown in Table 2.

Table 2:   Classes derived for the Serbian registry.

| Class	Description
Holding	Main class that represents the holding. It has attributes about the holding such as address, work activities, date of registration. The attribute MBPG is the unique identifier of the holding.
Crop	Class that represents the crops and has attributes such as area, crop code, entitlement, etc.
PassiveReason	Class that contains reasons for passive status.
Animals	Class that contains attributes for livestock production.
UnreturnedLoan	Class that represents financial status.
Member	Class that contains data of members of the agricultural holding.
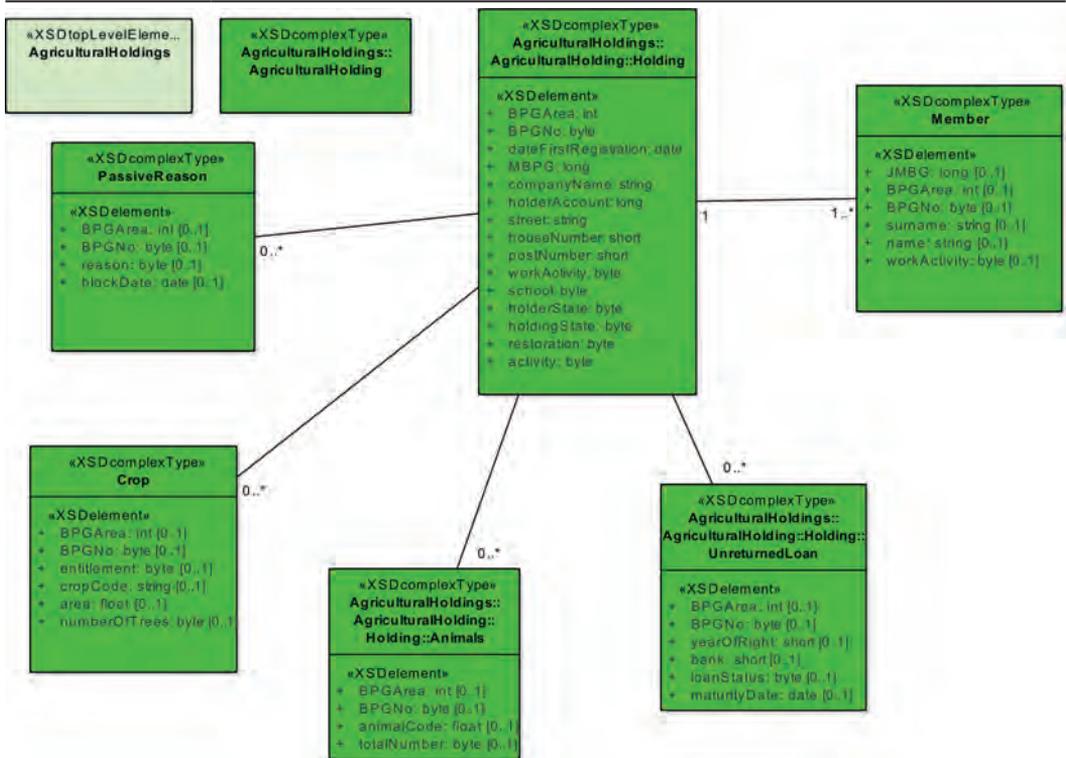
Figure 2:   Model of the Serbian an agricultural holding.

The normalization according to the INSPIRE, LADM and the Serbian cadastral system is shown on Figure 3. In this case the classes **LA_SpatialUnit** and **INSPIRE::CadastralParcel** extend the class **RS_Parcel**. This extension is done because of the fact, that on the conceptual level, the class **RS_Parcel** is the same one as **CadastralParcel** from the INSPIRE, which already extends **SpatialUnit::LA_Spa-**

---

[10]   http://www.trezor.gov.rs/uploads/projects/banke/BBBddmmgg_PP_ODG_xml1467294134547.doc

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 59 |

tialUnit (Radulović, 2015). The attributes of **RS_Parcel** are current numbering systems within the cadastral municipalities and do not represent the National Cadastral Reference numbering. The class **RS_PartOfParcel** is a class meant to distinguish certain purposes of use within a parcel. The official law says that the parcel is the main cadastral, spatial unit representing a piece of land in a cadastral municipality (Republic Geodetic Authority, 2015). The **RS_PartOfParcel** is mainly a class that is used in the context of the administration rather than a property unit. Classes of the Serbian cadastral system are shown in darker frames.
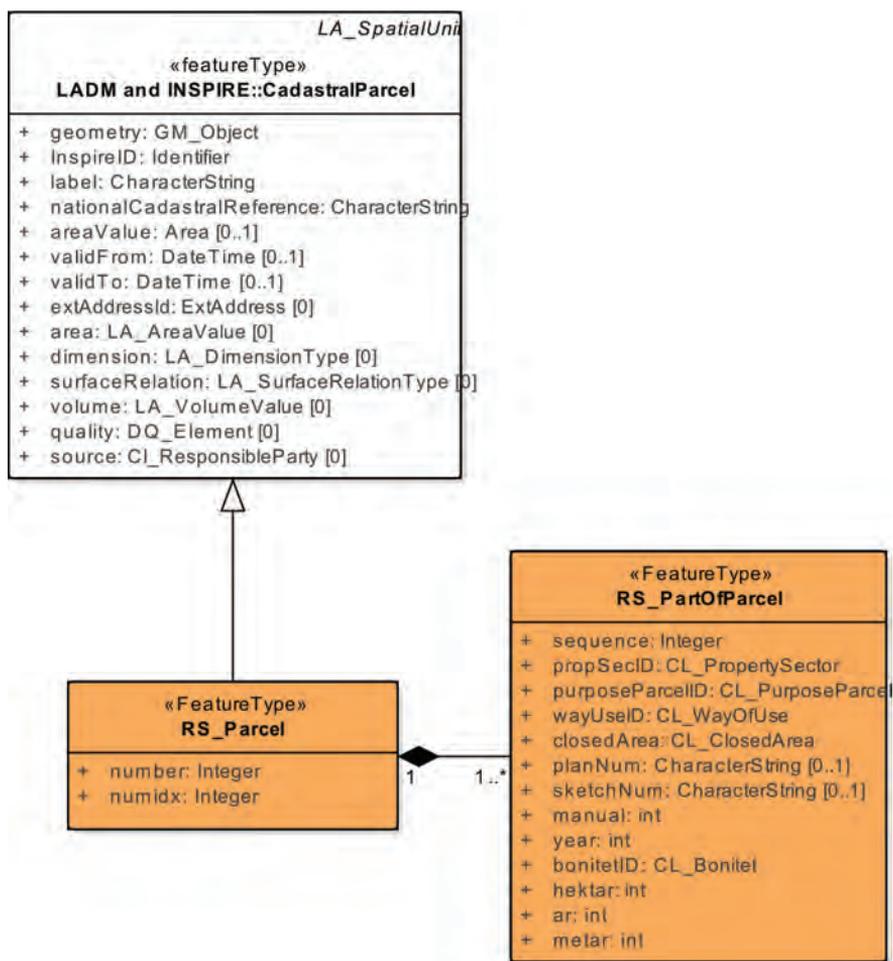

Figure 3:   Extension of the cadastral parcel.

The main extension of the LPIS core model containing spatial classes is shown on Figure 4. First, a new prototype class is created for each of LPIS spatial classes (Physical Block, Agricultural Parcel, Sub Parcel, Topographic Block and Farmer Block) and represented in the blue colour with a prefix RS. The reason that each of the classes is represented is that there still hasn't been an official decision on which of the classes to use. Therefore, the system may serve as a way for experts from other fields to decide on which to use.

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 60 |

The definitions are shown in Table 3. Each of the prototype classes extends the classes defined by the standard. Although in this iteration of the system new attributes were not added to the prototype classes, their purpose of creation is because of expanding the system in the future and because of inheritance from multiple classes. The class **RS_SubParcel** additionally inherits the cadastral **RS_PartOfParcel** because, conceptually, they are the same. The only difference **RS_PartOfParcel** is used in the cadastral system to represent land ownership of one part of a parcel and the **RS_SubParcel** is used in the LPIS to represent farming entitlements and ownership of a part of the parcel.
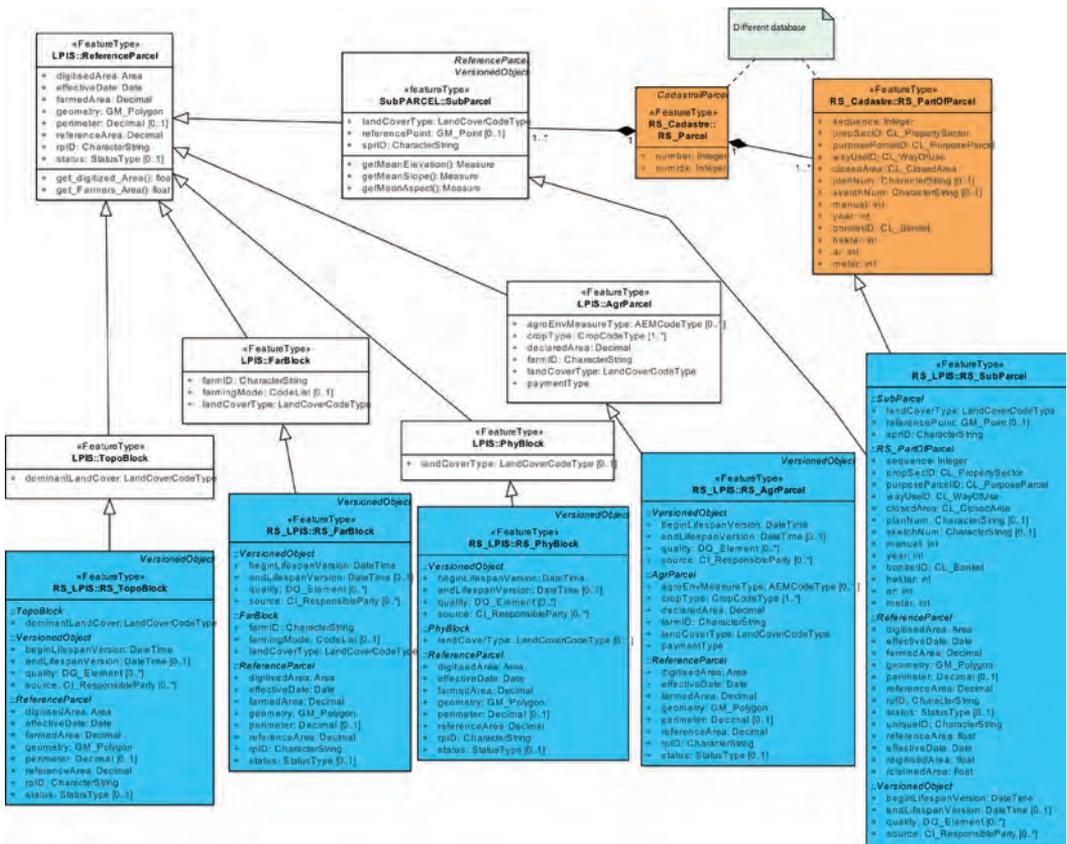

Figure 4:   Extension of the LPIS core model.

Lastly, the connections were made between the classes of the agricultural holding and LPIS core classes (Figure 6). The class **RS_AgrParcel** is connected to the Crop class with the type Composition. This implies that **RS_AgrParcel** cannot exist without a **Crop** class from a holding, which means that the LPIS with the reference parcel of Agricultural Parcel would be strongly connected to the registry of agricultural holdings. Other classes are connected to the **Holding** class but do not have to necessarily rely on the system of agricultural holdings because the definitions are different. The class **SubParcel** is not connected in the current iteration to the **Holding** class because administrative classes must be accounted for in both the cadastral system and registry system, although a future connection may be possible.

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 61 |

Figure 5: Connection between the registry of agricultural holdings classes and LPIS model classes.

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN
AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 62 |

Table 3: Classes for the parcels in the LPIS system (adopted from Sagris and Devos, 2009).

Class	Definition
Reference Parcel - **ReferenceParcel**	Basic spatial unit for the administration and geographical localization of agricultural parcels. May contain one or more declared agricultural parcels in IACS and may be cultivated by one or more farmers (or producers' association).
Sub Parcel - **SubParcel**	Unit of agricultural or non-agricultural land cover inside of cadastral parcel. Class has topological relation with extCadParcel, which compose from one or many CadSubParcel-s.
Agricultural Parcel – **AgrParcel**	Reference parcel containing only one production unit/agricultural parcel - continuous area of agricultural land on which a single crop group is cultivated by a single farmer.
Farmer Block - **FarBlock**	Reference parcel - continuous area of agricultural land grouping together a number of neighbouring agricultural parcels cultivated by the same farmer. In other words, production block, which contains several adjacent production units of the farmer.
Topographic Block - **TopoBlock**	Reference parcel known as 'Physical block', but NOT satisfying criteria of production block with following characteristic: – 100% subdivision of national territory to the blocks, which allows 'water', 'road', 'residence area' blocks; – delineated by most stable boundaries, – can compose of mixture of land cover classes; -agricultural land cultivated by one or more farmer(s).
Physical Block - **PhyBlock**	Reference parcel known as 'Physical block' - a continuous area of agricultural land (production block) grouping together several neighbouring agricultural parcels (production units) cultivated by one or more farmer(s) and delineated by most stable boundaries.

3.2 Verification

The implementation of the conceptual model was created using an open-source solution PostgreSQL[11] with PostGIS[12]. Additionally, triggers were created for further implementation of requirements and standards. These include algorithms that check (1) if the parcels are overlapping, because overlaps are not allowed (Sagris and Devos, 2009), and prevent the user from entering the data; (2) calculate area and store it in a column immediately after digitizing; (3) check whether the **SubParcel** is contained within the parcel and (4) check if the data exists in the Crop table before digitizing a new Agricultural Parcel. The triggers were created in the Procedural Language for PostgreSQL (PL/pgSQL)[13].

The test area chosen for verification was the rural area around the city of Ruma, Serbia. The base imagery used for digitizing was obtained from the RapidEye platform, as well as supplementary data like Google Earth and Bing Aerial Imagery. The test data was created in a GIS environment and migrated for verification of the database structure. This is only test data and does not completely represent the real data. The reason for this is the lack of spatial, agricultural open-data, pay-to-use cadastral data and lack of communication with the authority. PostgreSQL with PostGIS were used for the database, and

[11] *https://www.postgresql.org/*
[12] *http://postgis.net/*
[13] *https://www.postgresql.org/docs/8.3/static/plpgsql.html*

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 63 |

QGIS[14] was used for digitizing the test data for the test area.

The initial verification was carried out by digitizing parcels with visible boundaries, so that the triggers and constraints might be verified. After this verification was performed, the test data were published trough a Geoserver[15]. Geoserver is an open-source server solution designed for interoperability, data discovery, dissemination of spatial data using open standards.

A local Geoportal Web application was created to simulate a real-world example for further verification. Geoportals are World Wide Web gateways that organize content and services such as directories, search tools, community information, support resources, data and applications (Maguire and Longley, 2005). It was created using html, css, javascript, php, and the OpenLayers[16] javascript library for creating Web maps. The design includes user accounts, three tier architecture with a middleware for data dissemination, a database with a Database Management System (DBMS) for storage and management and end users which interface the data through a Web browser. The geoserver implements the WMS, WFS, possibilities of styling, etc. Besides the geoserver a php Web application was created to handle user accounts, registration and display of user data. The Client does not access the data directly from the database, but through the geoserver. The user interface is presented on Figure 6.
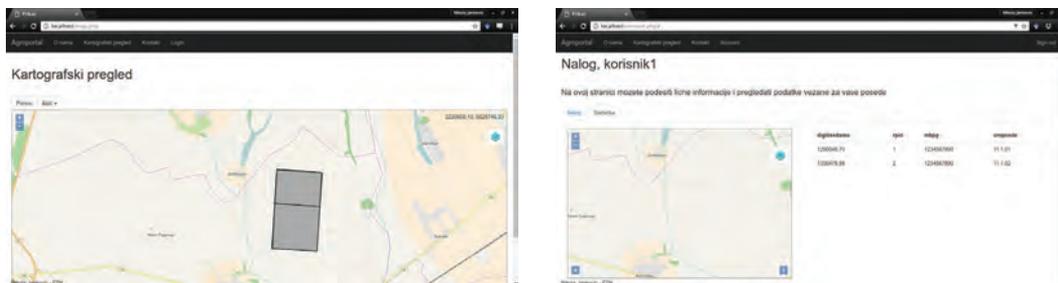

Figure 6: Cartographic overview (left) and User account page (right).

The main page shows a main cartographic preview of all the layers and the data. From here users can also download the data or log in and see more information (Figure 6a). Additionally, the user, when logged in, may preview the basic information of their land such as the area, the type of land, the crop groups. The user may also visualize their land separately from the main cartographic preview on a separate interface (Figure 6b).

The possibility of downloading layers with *GetMap* or *GetFeature* requests has been included. The *GetMap* requests that are available are as OpenLayers, or raster files. The *GetFeature* requests made available shapefile and GML. Alternatively, the users can check which of the layers and which formats are available with a *GetCapabilities* request. Examples of *GetMap* and *GetFeature* are shown on Fig 7.

---

[14]   http://www.qgis.org/
[15]   http://geoserver.org/
[16]   https://openlayers.org/

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 64 |

Figure 7: *GetMap* request (left) and *GetFeature* request right).

4 CONCLUSION AND DISCUSSION

The paper outlines state of the art regulations and work done so far on the domain model as a proposal for an agricultural information system. We can conclude that the agricultural domain can be modelled using standards and specifications laid out by ISO, EU, INSPIRE. In the end, the model was verified using a geoportal Web app as a means of simulating a real-world use case. The different cases of EU countries show which kinds of systems are implemented and how the member states solved different problems. All the member states already have a system in place for EU requirements, and such a system must be implemented in the Republic of Serbia as a part of EU accession. Other reasons include setting up a framework for better management of agricultural data by which agricultural subsidies are given and for providing aid to farmers.

We can conclude that this system has certain advantages:

– Conforms to standards and fulfils some of the technical requirements;
– Increases transparency, because of the openness of the data and the system itself;
– Enables scalability, which means the system can be expanded in the future;
– Contributes to farmers for data viewing and opens possibilities for aid in the future;
– Makes some tasks easier for the administration.

We can also conclude that it is possible to create a system using open-source software. Open-source software is free of cost and the source code is provided so that it is known how it works, therefore any misuse may be spotted. However further work is required to test the performance of this kind of a solution.

The main work covers the domain model with regards to spatial information. Much remains to be done in the future, to achieve a complete system such as the inclusion of other auxiliary standards, e. g. INSPIRE – Agricultural and Aquaculture Facilities (INSPIRE, 2013). This standard has the entity and class called **Holding** that defines agricultural activities. Furthermore, a new CAP model and website[17] are being built currently for the period of 2015–2020.

From this research it is not possible to conclude, which of the land use parcels would be the best for the Republic of Serbia, and more research from the agricultural experts is needed. It may be necessary to determine which of the parcels would be the best to use in this system according to state of the current registry, the status of the cadastral system and available technologies. It is also necessary to synchronize the spatial and administrative parts of the system. Extension of the geoportal Web app is also necessary for more functionality, such as user input of geometries, data security, permissions, more detailed

---

[17] *https://marswiki.jrc.ec.europa.eu/wikicap/index.php/Main_Page*

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 65 |

statistical data and analysis. Furthermore, the test data used is the best case, created in lab conditions for testing, and further research using real data and other commercial and open-source software can be done to ensure the best possible solution.

Literature and references:

Arcotrass GmbH (2006). Serbia Country Report. ARCOTRASS - Consortium, (December). http://ec.europa.eu/agriculture/sites/agriculture/files/external-studies/2006/applicant/serbia_en.pdf, accessed on March 31, 2017.

Booch, G., Rumbaugh, J., Jacobson, I. (1998). The Unified Modeling Language User Guide, Addison Wesley Longman, Inc.

Ciolkowska, M., Kosakowski, J., Mróz, M. (2003). The integrated use of digital aerial orthophotos, satellite images and cadastral data in aid applications control in the frame of Polish IACS, pp.339–342.

European Commission (2014a). Agriculture "The EU's common agricultural policy (CAP): for our food, for our countryside, for our environment." Office of the European Union, pp.1–8.

European Commission (2014b). EU Common Agricultural Policy Model. http://lpis.jrc.ec.europa.eu/CAP_IACS/index.htm, accessed on March 31, 2017.

European Commission (2017). Integrated Administration and Control System (IACS). https://ec.europa.eu/agriculture/direct-support/iacs_en, accessed on March 31, 2017.

European Commission (2007). Managing the Agriculture Budget Wisely. Office of the European Union. http://ec.europa.eu/agriculture/sites/agriculture/files/publi/fact/clear/2007_en.pdf, accessed on March 31, 2017.

European Commission (2013a). REGULATION (EU) No 1306/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0549:0607:EN:PDF, accessed on November 16, 2017.

European Commission (2013b). REGULATION (EU) No 1307/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0608:0670:en:PDF, accessed on November 16, 2017.

INSPIRE (2007). Data Specification on Cadastral Parcels – Technical Guidelines, pp.1–26.

INSPIRE (2013). INSPIRE data specification on Agricultural and Aquaculture Facilities – Technical Guidelines, pp.1–134.

ISO/TC211 (2014). ISO 19101 Geographic information -- Reference model -- Part 1: Fundamentals. ISO International Standard Organisation.

ISO/TC211 (2015a). ISO 19103 Geographic information -- Conceptual schema language. ISO International Standard Organisation.

ISO/TC211 (2015b). ISO 19109 Geographic information -- Rules for application schema. ISO International Standard Organisation.

ISO/TC211 (2012). ISO 19152 Geographic information -- Land Administration Domain Model (LADM). ISO International Standard Organisation.

MAEP (2010). Law on agriculture and rural development. Official gazette of the Republic of Serbia. http://www.mpzzs.gov.rs/download/Zakoni/poljoprivreda1(2).pdf, accessed on March 31, 2017.

MAEP (2011). Rulebook of the means and conditions for the agricultural holdings in the registry of agricultural holdings with required documentation. Official gazette of the Republic of Serbia. http://uap.gov.rs/wp-content/uploads/2011/12/Pravilnik-o-načinu-i-uslovima-upisa-i-vodjenja-registra-poljoprivrednih-gazdinstava.pdf, accessed on March 31, 2017.

MAEP (2013). Law on subsidies in agriculture and rural development. Official gazette of the Republic of Serbia. http://www.mpzzs.gov.rs/download/Zakoni/3197-16.pdf, accessed on March 31, 2017.

MAEP (2014). Strategy of agriculture and rural development of the Republic of Serbia for the period of 2014-2024. Official gazette of the Republic of Serbia. http://uap.gov.rs/wp-content/uploads/2016/05/STRATEGIJA-2014-2020-.pdf, accessed on March 31, 2017.

Maguire, D. J., Longley, P. A. (2005). The emergence of geoportals and their role in spatial data infrastructures. Computers, Environment and Urban Systems, 29 (1 SPEC.ISS.), 3–14. DOI: https://doi.org/10.1016/s0198-9715(04)00045-6 D

Milenov, P., Kay, S. (2006). Status of the implementation of LPIS in the EU member states. In 12th MARS PAC Annual Conference, pp. 41–47.

Ozcelik, A. E., Nisanci, R. (2015). Building of geo-spatial data model for tea agricultural crop-lands compliance with LPIS Core Model (LCM) based land administration domain standards. Computers and Electronics in Agriculture, 117, 8–21. DOI: https://doi.org/10.1016/j.compag.2015.07.008

Radulovic, A., Sladić, D., Govedarica, M., Jovanović, D. (2015). Extended LPIS domain model for Serbia. Research Journal of Agricultural Science, 47 (2), 62–168.

Radulović, A. (2015). Model domena i servisa u geoinformacionom sistemu katastra nepokretnosti. University of Novi Sad.

Republic Geodetic Authority (2015). Law on state survey and cadastre. Official gazette of the Republic of Serbia. http://www.rgz.gov.rs/upload/web/zakon-o-drzavnom-premeru-i-katastru-2009.zip, accessed on October 3, 2017.

Sagris, V., Devos, W. (2009). LPIS Core Conceptual Model (LCM). http://ies-webarchive-ext.jrc.it/mars/mars/content/download/1676/9118/file/10272pubsy.pdf, accessed on March 31, 2017.

Shelestov, A. Y., Kravchenko, A., N., Skakun, S. V., Voloshin, S. V., Kussul, N. N. (2013). Geospatial Information System for Agricultural Monitoring. Cybernetics and Systems Analysis, 49 (1), 124–132. DOI: https://doi.org/10.1007/s10559-013-9492-5

Czech LPIS (2004). Czech LPIS - A soluteon for the 3rd millennium. http://www.lpis.eu/down/CZLPIS_case_study_EN.pdf, accessed on March 31, 2017.

Tóth, K., Kučas, A. (2016). Spatial information in European agricultural data management. Requirements and interoperability supported by a domain model. Land Use Policy, 57, 64–79. DOI: https://doi.org/10.1016/j.landusepol.2016.05.023

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 66 |

Dipl.-Ing. Nikola Janković
TU Vienna, Department of Geodesy and Geoinformation
Gusshausstrasse 27-29
A-1040 Vienna, Austria
e-mail: nikola.jankovic@geo.tuwien.ac.at

Prof. Miro Govedarica, Ph.D.
University of Novi Sad, Faculty of Technical Sciences
Trg Dositeja Obradovica 6
SRB-21101 Novi Sad, Serbia
e-mail: miro@uns.ac.rs

Priv. Doz. Gerhard Navratil, Ph.D.
TU Vienna, Department of Geodesy and Geoinformation
Gusshausstrasse 27-29
A-1040 Vienna, Austria
e-mail: gerhard.navratil@geo.tuwien.ac.at

Dipl.-Ing. Paolo Fogliaroni, Ph.D.
TU Vienna, Department of Geodesy and Geoinformation
Gusshausstrasse 27-29
A-1040 Vienna, Austria
e-mail: paolo@geoinfo.tuwien.ac.at

Nikola Janković, Miro Govedarica, Gerhard Navratil, Paolo Fogliaroni | MODEL DOMENE KMETIJSKEGA INFORMACIJSKEGA SISTEMA, UTEMELJENEGA NA STANDARDIH | DOMAIN MODEL OF AN AGRICULTURAL INFORMATION SYSTEM BASED ON STANDARDS | 51-67 |

| 67 |