Associating External Land Use/Cover Information with LADM's Spatial Unit

Halil Ibrahim INAN, Turkey

Key words: Land Use/Cover, Spatial Unit, Data Model

SUMMARY

In the LADM design, any specification is not presented on the association of land use/cover information with LADM classes but for the defined association relations between LA_SpatialUnit class and external land use/cover classes. There are many severe obstacles against defining such specifications which are applicable to all cases. In this context, there are many different types of land use/cover classification systems for different purposes in different data quality and content which is either designed internationally or nationally. CORINE land cover, INSPIRE land use/cover themes, land use capability classification and LPIS are a few international examples.

In this study, based on natural spatial relation between land use/cover types in an external data source and spatial units of land (land parcels) in a Land Administration System, management of land use/cover data in association with land parcels (spatial units in LADM) was studied in a pilot study area in Turkey. In this context, association of information as attribute data to land parcels and also as subdivision of land parcels (sub-parcels) were studied. Land use/cover data used in this study was specifically produced for this study with an LPIS like digitization method because of unavailability of similar external data sources. Before the processing of the data, both data sets are checked and properly corrected against topological errors. For the association of land use/cover data as attribute information a basic overlay operation without any cluster or XY tolerances was carried out. Attribute table of the product of this operation was used as associated land use/cover data of land parcels, and geographic data produced with this operation was used for the analysis of data consistency and accordingly errors. For the association of land use/cover data as spatial subdivision of land parcels, a special overlay operation with predefined XY tolerances was carried out. Data consistency between the produced data set and land parcels and also errors was analysed by comparing the two method. Together with these data processing and analysis work, LADM modelling abstraction, availability and data quality issues of external land use/cover data, updating and maintenance issues were also discussed accordingly.

Associating External Land Use/Cover Information with LADM's Spatial Unit

Halil Ibrahim INAN, Turkey

1. INTRODUCTION

In the LADM design, any specification is not presented on the association of land use/cover information with LADM classes but for the defined association relations between LA_SpatialUnit class and external land use/cover classes (see ISO 19152, 2012, p.104) because the LADM is a basic/generic domain model focussed on Land Administration which may be called as the legal aspect of land. Land Use/Cover Information, Land Use Planning and Land Valuation are important concepts in Land Management (see Enemark 2005, p.5) which may be called as the technical aspect of the land. Therefore, it is natural that detailed specifications are not defined within the LADM.

Unavailability of land use/cover data in any external source is a major problem all over the world with some exceptions in developed countries. In the case of availability, none-standardized production is one problem and production of with different purposes in different data quality is the other. In fact, land use and land cover data are confused by the majority of spatial data users or even producers. In some cases, they are mixed up to come up with a specific purpose classification. In this context, there are many different types of land use/cover classification systems for different purposes in different data quality and content which is either designed internationally or nationally. CORINE land cover (EC, 1995), INSPIRE land use/cover theme (INSPIRE D2.3, 2007; INSPIRE D2.8.II.2, 2013), land use capability classification (Soil Survey Staff, 1999) are a few international examples. Large Scale Topographic Mapping in developed European countries (Cete, 2008) and Land Parcel Identification Systems (LPIS) (JRC, 2001; Kay and Milenov, 2006; Goeman et al., 2007; Inan, 2010; Sagris et al., 2013) within the framework of the European Agricultural Policy may also be presented as examples although their primary aim is not the production of land use/cover data. International standardisation initiatives (Di Gregorio and Jansen, 1998; ISO 19144-2, 2012) aim at contributing harmonisation in a standardised production for the same purpose. In Turkey, in addition to these, different agricultural land classification based on soil and topographic properties (TUGEM, 2008), classification of land by the type of ownership (state land, forest, meadows, shores and private land), classification of land as a mixture of land use, cover and included attachments (man-made extensions) within Land Administration System are a few different purpose common examples.

Depending on the aim, geographic extent, data quality and relation with land administration or management, some of external land use/cover data sources are not intended to associate with land administration (land registry and cadastre) data. However, in some cases this need arises. This study focusses on defining specifications on associating external land use/cover data with LADM's basic spatial unit (land parcel) and discussing related issues in conjunction with a pilot application in the Province of Kayseri, Turkey. The pilot study is planned as a component of a national scientific project (funded by the Turkish Scientific and Technical

Studies Foundation:TUBITAK), which focusses on the development and application of a data model for a standardised management of farmer, farm land and agricultural product data. The external land use/cover data used for this study was produced specifically for this study by using an LPIS like method. Two methods were used for the association of land use/cover data with land parcels. One is producing land use/cover data as attribute information to be linked to each land parcel and the other is producing sub-divisions of land parcels by overlaying with land/use cover data.

2. LAND USE/COVER DATA REPRESENTATION IN LADM

In LADM data model ExtLandUse and ExtLandCover classes were simply associated with LA_SpatialUnit (see Figure 1). This association may be accepted as a representation of natural spatial relation between land parcels and land use or cover data. For the application, this relation is not the case because of the fact that a land parcel may not completely/geographically coincide with one or more instances of land use or cover classes. Yet, land parcels are dependent on external data for land use or cover information. So, one of dependency, use, data flow or any other dynamic relation may be appropriate to represent the natural relation between the two data sets. However, this association may be true after processing land use/cover data by an overlay operation with land parcels data set.

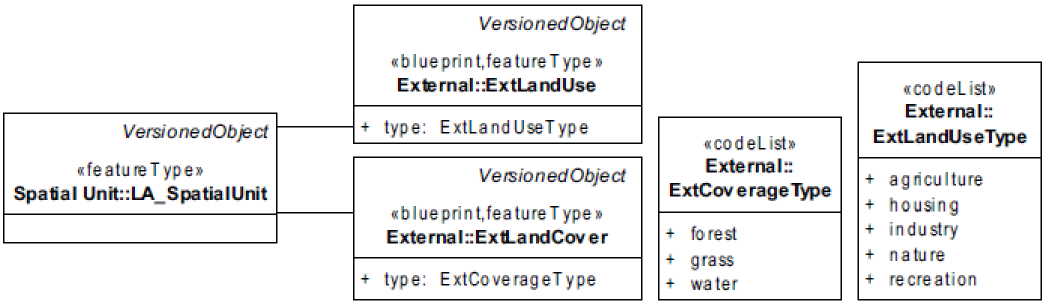

Figure 1. External land use and land cover in LADM

ExtLandUse and ExtLandCover classes were defined with their type attributes. Data types of these attributes are defined as extensible land use or cover classes which mean that they are dependent on the content of external data source.

3. MATERIAL AND METHOD

Two districts namely Elagoz and Karahoyuk (see Figure 1) of Kayseri Metropolitan Municipality in Turkey were selected as study areas for this study. Total area of the two districts is approximately 1700 hectares. Elagoz has 1137 land (cadastral) parcels and Karahoyuk has 740 (see Figure 3 for cadastral parcel maps).

Cadastral land parcel data was obtained form Land Registry and Cadastre Directorate in Kayseri. Land Use/Cover data for two districts were produced for this study. A methodology which is similar to LPIS data creation done in the absence of cadastral information was used. Land use/cover classes were digitised on very high resolution satellite imagery. Physical blocks of different land use/cover (fertile land, meadow or grazing land, built area or building, woody/bushy area) identifiable with their boundaries on satellite imagery were digitised as polygon features (see Figure 2 for land use/cover classes and Figure 3 for land use/cover boundaries).

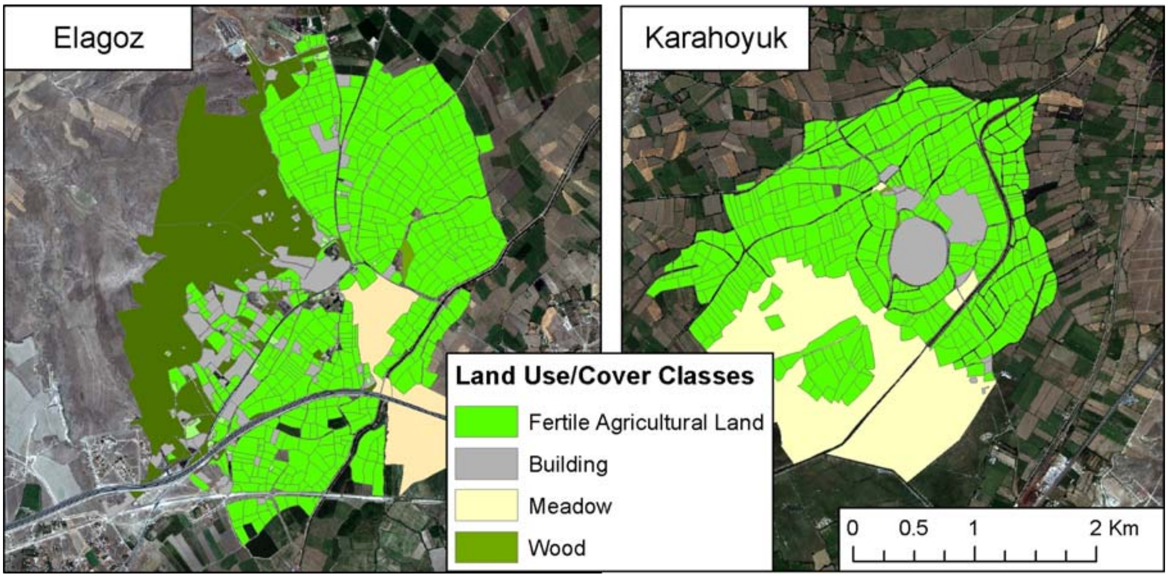

Figure 2. Digitised land use/cover classes of two districts

Unlike many other external land use/cover data sets, land use/cover data sets of two districts include inner identifiable (on satellite imagery) farm boundaries and any other similar boundaries in the same land use/cover class which are not required for land use/classification but required for LPIS implementation or similar purposes. In this context, land use/cover data produced for this study may be regarded as a special type of land use/cover data and in terms of boundaries it has many common characteristics with cadastral land parcel data (see overlapped data in Figure 3).

Before studying the association of land parcels with land use/cover data. Both type of data sets were checked and corrected against structural and topological errors. No structural errors was encountered thank to software support during data creation and maintenance. Yet, thousands of topological errors were corrected, which means that adequate software support may not be provided for topological consistency. Common topological errors were small polygons on large polygons and small linear overlaps through polygon boundaries.

For the association of land parcels with land use/cover data, two basic methods were used. One is associating land use/cover information as attribute information by applying a so called seamless overlay operation without any cluster or XY tolerances, which produces a table of land use/cover information to be linked land parcel data set by unique land parcel identifiers.

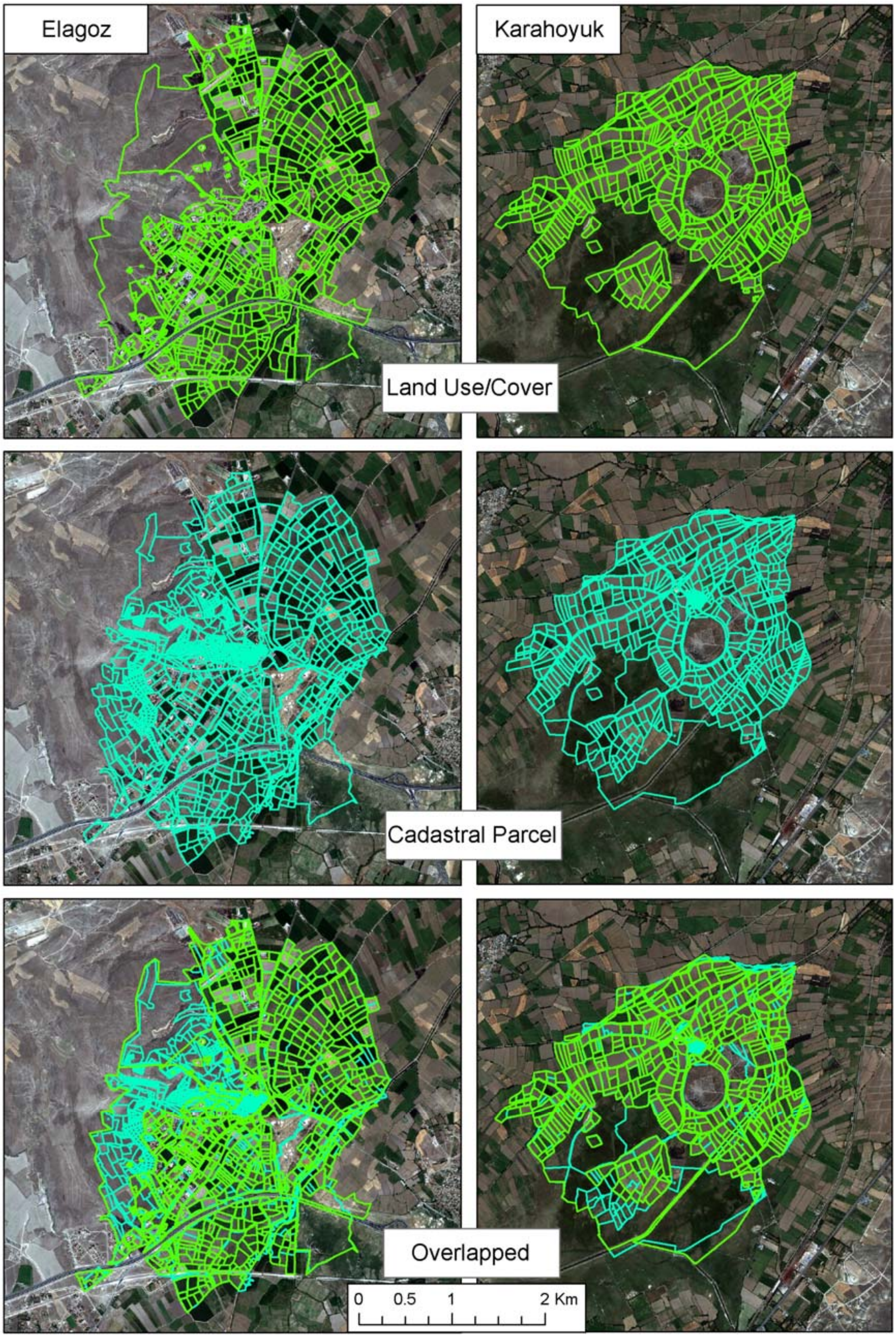

Figure 3. Land use/cover and cadastral data of two districts

The other is associating land use cover information as subdivision of land parcels by applying a special overlay operation with 2m XY tolerance, which produces a data set of sub-parcels with land use/cover information. The 2m XY tolerance is a pre determined approximate value which was approximated considering the accuracy of satellite imagery and digitisation process of land use/cover boundaries by visual interpretation.

4. ASSOCIATION OF LAND USE/COVER DATA WITH LAND PARCEL

Land parcel data without any up-to-data land use/cover information in a Land Administration System cannot provide information other than area of land. Even the owner (right holder) information may be out-dated. So, for a possible contribution of any land management activity the type and more specifically the type of land use/cover of a land parcel should be produced with using external up-to-date sources. In this context, depending on data requirement of land management activity, the original source for the production of land use/cover classes, production method, the type of land use/cover classification in external data sources, their data quality and updateness are very important qualities. Therefore, many sources of land use/cover data may not be used for this purpose. Land use/cover data used for this study was produced with a spatial data quality equivalent to large scale topographic maps at scales 1/5,000 – 1/10,000. Use of CORINE land cover data produced with data quality of a 1/100,000 scale map for this purpose may only contribute to some specific land management activities.

It is evident naturally that any type of land use/cover is spatially related to land parcel (and so LADM's LA_SpatialUnit class) in the case of a full partition data structure. In other cases, there may be some exceptions, yet this relation prevails. This relation is required for all types of Land Management activities such as land use planning and application, environmental protection schemes, rural development schemes and de-coupled payment schemes for farming land. That is to say, Land Administration should facilitate Land Management activities which is related to land ownership, land use rights or merely land parcel boundaries. In this study, a special type of land use/cover data produced within the framework of LPIS was associated to land parcels which are represented by LA_SpatialUnit class in LADM.

The natural spatial relation between land use/cover types and spatial units of land may be specified as an attribute information or alternatively as a spatial sub-division. Attribute information may be defined as an homogeneous single attribute of a whole spatial unit (land parcel) or it may be as multiple attributes coming from spatially coinciding land use/cover classes with the same spatial unit. Similarly spatial sub-divisions may be the exact product of the operation of overlaying land use/cover data with spatial unit data or the final product may be corrected against geometrical and topological inconsistencies. They may be generalised versions of external land use/cover data or they may be refined (in spatial accuracy, in further classification or in the stability of land use/cover boundaries in time) versions of external ones. In this study, these alternatives were studied and discussed.

A special overlay operation (identity) which preserves the geographic extent of land parcels and causes some unnecessary land use/cover data to be removed from the product of the overlay operation were used in this study. Errors caused by land use/cover data with farm boundary information was handled properly by defining XY tolerance.

4.1 Associating land use/cover as attribute information

The basic idea behind associating land use/cover information as attribute data is the identification of up-to-data land parcel type which can not be updated in land administration systems periodically or any other way which is not dependent on procedures to be completed by the land owner or right holder. Land use/cover types with their area/proportion information in a land parcel may also be used for the application of coupled or de-coupled payments within agricultural policy implementation. In fact, this one is the real cause facilitating this and other similar studies.

4.1.1 Pilot application on the association of land use/cover data as attribute information

Association of land use/cover data with land parcel data should be done through a seamless overlay operation done by the software used. Instead of this, for this research, it is done through a real overlay operation which produces both geographic and also attribute information in order to analyse and discuss the underlying data processing issues.

As a result of the overlay operation for Karahoyuk district, 2309 attribute information records were created. Due to geographic coverage differences (some of which are caused by harmonisation problems through shared outer boundaries) in the two data sets, 439 of these records have no land use/cover information. For evaluation purposes, it is also determined that 407 of them have an area of equal to or smaller than 10 m^2, and 1152 of them have an area of equal to or smaller than 100 m^2 (see Figure 4). With the help of associated geographic coverage, it is observed that the first group (equal to or smaller than 10 m^2) of records were completely caused by shared boundary errors and that the majority of second group were also caused by similar errors. Exceptions may be a small strip of woody or infertile area through boundaries or small land parcels. As for Elagoz district, 3574 attribute information records were created. Records with no land use/cover information were 425. In accordance with Karahoyuk district, the number of first group of records was 558, and the second group was 1501 (see Figure 4).

Attribute records produced in this step are associated with geographic sub-parcels, which is only intended for study purposes. They should be further processed for each land parcel which is defined with a unique land parcel identifier in order to merge the same type of land use/cover classes regardless of geographic adjacency, which may further reduces the number of attribute information records to be associated with only land parcels, not with sub-parcels.

Figure 4. Linear and/or small area errors on overlapped data (with no/default XY tolerance): All errors within whole data in two districts (above), errors in specific areas (below).

4.1.2 Updating and maintenance issues in the case of attribute information

All small errors reported in the previous section and represented in Figure 4 are in fact seamless to user in the case of associating land use/cover data as attribute information to land parcels. However, the attribute (land use/cover) information cannot be checked for its updateness. So, for the whole data set, a periodic update operation is essential. In the case of need in a variety of occasions, this update need may be troublesome. Methods for updating a specified land parcel may be developed to overcome this.

4.2 Associating land use/cover as spatial subdivision

This type of spatial association by subdividing land by their land use/cover type may be used for all type of land management activities dependent on spatial information. Planning engineering structures, environmental conservation, land use planning, agricultural land use planning and similar land management activities may be done in this context. Yet, agricultural policy implementation together with LADM implementation was the major triggering factor for this study.

4.2.1 Pilot application on the association of land use/cover data as spatial subdivision

A similar overlay operation with 2 m XY tolerance was used for the production of sub-parcels with land use/cover information. For Karahoyuk, 1198 subdivisions of parcels (sub-parcels) were produced. 271 of sub-parcels with no land use/cover information were determined. There were no sub-parcels with an area of equal to or smaller than 10 m^2, and there were 212 sub-parcels equal to or smaller than 100 m^2. As for Elagoz district, 2110 subdivisions of parcels (sub-parcels) were produced. 260 of sub-parcels with no land use/cover information were determined. There were no sub-parcels with an area of equal to or smaller than 10 m^2, and there were 268 sub-parcels equal to or smaller than 100 m^2.

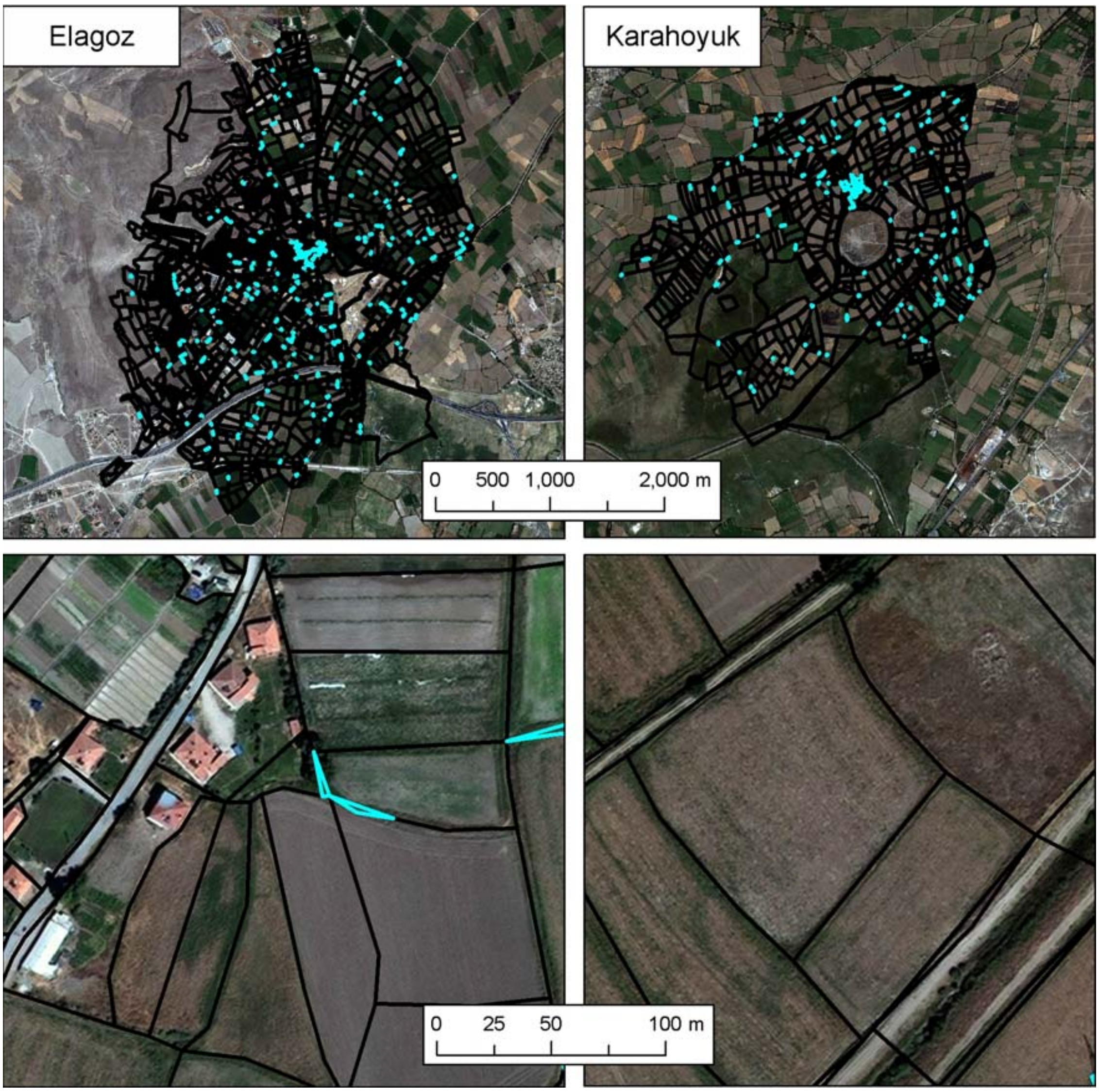

Figure 5. Linear and/or small area errors on overlapped data (with 2m XY tolerance): all errors within whole data in two districts (above), errors in specific areas (below).

When compared with the overlay operation with no XY tolerance carried out in the previous section 4.1, percentages of number of sub-parcels (or records) are 52% in Karahoyuk and 59% in Elagoz. Similar figures for sub-parcels with no land use/cover information are 62% in Karahoyuk and 61% in Elagoz, for sub-parcels equal or smaller than 10 m^2 is 0% for both districts, and for sub-parcels equal or smaller than 100 m^2 is 18% for both districts. It is evident from this comparison that there were a considerable decline in the number of errors. In fact, 48% decrease in the percentage of sub-parcels with no land use/cover information indicates that a vast amount of them were caused by errors. Similarly, the disappearance of sub-parcels with an area of equal or smaller than 10 m^2, and also a vast decline in the percentage of sub-parcels (82%) with an area of equal or smaller than 100 m^2 may be considered as an indication of errors as a result of an overlay operation without any tolerances. See Figure 5 for the representation of decreased number of errors.

4.2.2 Updating and maintenance issues in the case of spatial subdivision

Updateness of land use/cover of sub-parcels may be visually checked by using an appropriate underlying satellite imagery or any other similar cartographic material. In this context, land use/cover information or inner boundaries of sub-parcels may be updated depending on external land use/cover data. In case of outdateness of external land use/cover data, a special update operation may be done manually using the underlying cartographic material which should be up-to-date.

5. DISCUSSION AND CONCLUSION

Association of land use/cover data sets with land parcels is required for any related land management activity. In fact, external land use/cover data sets have their updating cycle which must be done periodically – once in a year or so. Therefore, checking the updateness of associated land use/cover data with other external data sources – a satellite image or similar cartographic material is an important aspect. In this context, association of land use/cover information as sub-parcel data may be an appropriate solution. However, the content of external data sources in terms of land use/cover classification may require a generalisation process before processing the data for the association. In case of a general land use/cover classification within external data, it may not be possible specialising land use/cover classes without using any additional external data – satellite imagery or similar cartographic material.

An error free association of land use/cover data with land parcels are not possible. However, eliminating some errors may be possible by using appropriate data processing methods. In the case of associating as attribute information, many errors are seamless to users. Accordingly, details of land use/cover in a land parcel are also seamless. Only an area information for each type of land use/cover within a land parcel may be provided. Updating may only be possible without checking changes and relaying on external data. For the case of associating as sub-parcels, all details of land use/cover information may be provided, checked for errors, updated independently from a specific external data source. However, errors caused by spatial inconsistencies are inevitable. For this study removing farm or any other type of inner boundaries by merging the same type of land use/cover classes before associating land parcels with land use/cover data may resolve some boundary inconsistencies. A data model with topology rules in order for data harmonisation before any overlay operation may be an alternative. This model is intended to correct boundary inconsistencies by urging external land use/cover boundaries to harmonise with land parcel boundaries by using tolerances defined in the model. Such a data model is planned to be studied within the project this study was conducted.

ACKNOWLEDGEMENTS

This study is accomplished as a component of a national scientific project (No 112Y027 and titled “A Spatial Data Model Design and its Application for the Management of Farmer and Agricultural Land”) funded by the Turkish Scientific and Technical Studies Foundation (TUBITAK). I would like to thank to Mr Ismail DURSUN who contributed to this study by digitising land use/cover data of two districts as part of his duty within the project.

REFERENCES

Cete, M., 2008. Turkiye icin bir arazi idare sistemi yaklasimi (PhD thesis in Turkish with English abstract). Institute of Applied and Natural Sciences, Karadeniz Technical University, Trabzon, Turkey.

Di Gregorio, A. and Jansen, L.J.M, 1998. Land Cover Classification System (LCCS): Classification Concepts and User Manual, Food and Agriculture Organization of the United Nations, Rome, http://www.birdlist.org/downloads/ecology/lccs_user_guide.pdf, 15 August 2013.

EC (European Commission), 1995. CORINE Land Cover.
http://www.eea.europa.eu/publications/COR0-landcover, 15 August 2013.

Enemark, S., 2005. Understanding the Land Management Paradigm, FIG COM 7 Symposium on Innovative Technologies for Land Administration, 19-25 June, Madison, Wisconsin, USA. https://www.fig.net/council/enemark_papers/madison_2005.pdf, 15 August 2013.

Goeman, D., Kantor, C., Printzios, V., Zloty A. and Mercimek, E., 2007. Final Report for Technical Assistance for the Ministry of Agriculture and Rural Affairs for the Design of a Functioning Integrated Administration and Control System (IACS) and a Land Parcel Identification System (LPIS) in Turkey, The European Union’s TR0402.08/002 Programme for Turkey, Ankara, 162 s.

Inan, H.I., 2010. Arazi idare sisteminin tarim bileseni olarak konumsal veri modeli gelistirilmesi (PhD thesis in Turkish with English abstract). Institute of Applied and Natural Sciences, Karadeniz Technical University, Trabzon, Turkey.

INSPIRE D2.3, 2007. Drafting Team "Data Specifications" - deliverable D2.3: Definition of Annex Themes and Scope, version 2.0 2007-04-06.

http://www.ec-gis.org/inspire/reports/ImplementingRules/inspireDataspecD2_3v2.0.pdf, 14 July 2013.

INSPIRE D2.8.II.2, 2013. Data Specification on Land cover – Draft Technical Guidelines. http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_LC_v3.0rc3.pdf, 21 July 2013.

ISO 19144-2, 2012. Geographic information — Classification systems — Part 2: Land Cover Meta Language (LCML)

ISO 19152, 2012. Geographic information -- Land Administration Domain Model (LADM). http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51206, 15 August 2013.

JRC (European Commission Directorate General Joint Research Centre), 2001. Land Parcel Identification Systems in the Frame of Regulation (EC) 1593/2000 Version 1.4 (Discussion Paper).

http://mars.jrc.ec.europa.eu/mars/content/download/991/6092/file/2580DiscLPISv1.4.pdf, 15 August 2013.

Kay, S. and Milenov, P., 2006. Status of the Implementation of LPIS in the EU Member States, 12th MARS PAC Annual Conference, November, Toulouse, France.

Sagris V., Wojda P., Milenov P. and Devos W., 2013. The harmonised data model for assessing Land Parcel Identification Systems compliance with requirements of direct aid and agri-environmental schemes of the CAP, Journal of Environmental Management 118 (2013) 40-48.

Soil Survey Staff, 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys, Natural Resources Conservation Service, U. S. Department of Agriculture Handbook 436.

TUGEM (Ministry of Agriculture and Rural Affairs, General Directorate of Agricultural Production and Development), 2008. Toprak ve Arazi Sınıflaması Standartları Teknik Talimatı ve Ilgili Mevzuat, Ankara, 192 pp.

BIOGRAPHICAL NOTES

Halil Ibrahim Inan works for Geomatics Engineering Department, Faculty of Engineering, Erciyes University, Kayseri, Turkey with the academic title of Asst. Prof. Dr. He got his BSc, MSc and PhD degrees from the Department of Geomatics Engineering at Karadeniz Technical University in 2000, 2004 and 2010 respectively. He worked as a Guest Researcher at OTB Research Institute for the Built Environment – GIS Technology Section, Delft University of Technology, the Netherlands. His research interests are land administration, rural land management, agricultural policy implementation, related GIS applications and data modelling initiatives.

CONTACTS

Halil Ibrahim Inan
Erciyes University
Faculty of Engineering
Department of Geomatics
38039 Melikgazi
Kayseri
TURKEY
Phone: + 90 352 4374901 / 32656
Fax: + 90 352 4375784
E-mail: hinan@erciyes.edu.tr; hibrahim77@hotmail.com
Website: http://harita.erciyes.edu.tr/en/index.html