Updating and Maintaining Land Parcel Types through Crowd-Sourced Land Use/Cover Classification

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SUMMARY

Modern (Multi-Purpose) Land Administration Systems have difficulty in managing up-to-date land parcel types. Managing external land use/cover information together with land parcels in an integrated manner may be a robust solution to this problem. In this study, inspired from common international land use/cover classification systems (FAO Land Cover Classification System, CORINE land cover and INSPIRE land use/cover theme) and spatial data management issues within agricultural policy implementation both in EU and in Turkey, a new land use/cover classification system was designed and land use/cover data sets was produced for three districts in Kayseri Province of Turkey. Further, rules for the integration of land use/cover data with cadastral land parcel data and accordingly updating/maintenance procedures were defined. Due to complexity of updating and maintenance procedures, use of crowd sourcing techniques with the contribution of related government agencies and also citizens was proposed. The study has been continuing as a component of a national project no 112Y027 that is financially supported by the Scientific and Technological Research Council of Turkey.

ÖZET

Modern (Çok-Amaçlı) Arazi İdare Sistemleri güncel parsel türü/cinsi bilgilerini tam manasıyla yönetememektedirler. Farklı kaynaklardan elde edilen arazi örtüsü/kullanımı bilgilerinin parsellerle birlikte bütünleşik olarak yönetimi bu problem için sağlıklı bir çözüm olabilir. Bu çalışmada, uluslararası alanda yaygın olarak bilinen arazi örtüsü/kullanımı sınıflama sistemlerinden (FAO Arazi Örtüsü Sınıflama Sistemi, CORINE arazi örtüsü ve INSPIRE arazi örtüsü/kullanımı teması) ve Avrupa'da ve Türkiye'deki tarım politikası uygulamalarıyla ilgili konumsal veri yönetimi problemlerinden esinlenilerek yeni bir arazi örtüsü/kullanımı sınıflama sistemi tasarlanmış ve Kayseri ilinde üç mahalle için arazi örtüsü/kullanımı veri setleri üretilmiştir. Buna ilaveten, arazi örtüsü/kullanımı verileri ile kadastro parsel verilerinin bütünleştirilmesi için kurallar ve bu doğrultuda güncelleme ve bakım prosedürleri tanımlanmıştır. Güncelleme ve bakım prosedürlerinin karmaşık olması nedeniyle, ilgili resmi kuruluşların ve halkın da katılımı ile kitlesel temin (crowd sourcing) tekniğinin kullanımı önerilmektedir. Bu çalışma, TÜBİTAK tarafından mali olarak desteklenen 112Y027 numaralı ulusal bir projenin bir bileşeni olarak devam etmektedir.

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1. INTRODUCTION

Within the Turkish Land Administration (Land Registry and Cadastre) System (LAS), land parcel types are formally registered as attribute information. This information may include both the type of land use/cover and also natural and man made features (trees, buildings, wells) (see Uzun and Inan, 2007). This study focusses only on land use/cover information in this respect.

Updating registered land use/cover information within the Turkish LAS relies basically on related personal or governmental procedures (construction permit, subdivision, property tax, farmer support, land readjustment, land consolidation, etc.). Therefore, real time update of land use/cover information is impossible through such procedures. On the other hand, due to the fact that land/use cover type within a land parcel is not always homogeneous, determination of the exact amount of land use/cover is impossible. In fact, the amount information is the spatial component of land use/cover information. So, spatial representation of different land use/cover types within land parcels is the main focus of this study. This problem was previously introduced by Inan et al. (2010).

Incorporating land use/cover information as one of the most important components of modern LASs may be regarded as a basic requirement (see Enemark, 2005). However, such an incorporation depends basically on the availability of land use/cover data. In addition, data quality, type of land use/cover classification (depending on the original production purpose), methodology of incorporation, and updating procedures may be listed as other related issues. This study basically aims at resolving or discussing these issues as part of a national scientific project no 112Y027 financially supported by the Scientific and Technological Research Council of Turkey.

Depending basically on the purpose and data quality, there may be several types of land use/cover classification systems. Internationally well known ones are FAO Land Cover Classification System (LCCS) (Di Gregorio and Jansen, 1998), CORINE land cover (EC, 1995) and INSPIRE land use/cover theme (INSPIRE D2.3, 2007; INSPIRE D2.8.II.2, 2013). Based on FAO LCCS, there has been an international standardization initiative (see ISO 19144-1, 2009; ISO 19144-2, 2012).

Inspired from agricultural policy implementation and related spatial data management issues in Europe (Kay, 2002; Kay and Milenow, 2006; Inan, 2010; Inan et. al., 2010; Sagris et al, 2013) and Turkey (WB, 2005; Goeman et al., 2007; Inan, 2010), in this study, a new land use/cover classification system was developed (see Inan and Dursun, 2014 for preliminary development stage) and incorporated with cadastral land parcels by defining robust geometry and topology rules (the so-called sub-parcel data model). Further, inspired from emerging crowd sourcing (McLaren, 2011) techniques in land administration and related fields, in order to update related land parcel and spatially associated land use/cover information, work on multi-tier updating strategies with the contribution of related governmental institutions and also citizens has been continuing. Apart from its original development aim, the study will be presented, in the following sections, in terms of its contribution to the management of spatial land parcel types (incorporated land use/cover information).

2. MATERIALS and METHODOLOGY

Pilot application of this study has been carried out in three districts (Elagoz, Karahoyuk and Vatan) in Kocasinan county of Kayseri province, Turkey.

For the production of land use/cover data, at the first stage, a tree level special classification system was developed. Number of designed classes is two, nine and eighteen in the first, second and third levels respectively (see Section 3 for classes). At the second stage, land use/cover classes were digitized using visual interpretation techniques on Very High Resolution (VHR) satellite imagery (WorldView-2). To assist in visual interpretation, VHR images of two different years (2010 and 2013) were used. Unchanged land use/cover information (fixed boundaries) where digitized and changes over years were also considered in accordance with the rules for digitization procedure. Sub-parcel data structure (see Inan et al., 2010) was used as part of digitization procedure. To implement this data structure, cadastral land parcel boundaries data sets of three districts were used. As a result, using a total of 3640 land parcels (as spatial template) in three districts, a total of 6811 spatial sub divisions of land parcels were produced as spatial land parcel types (land use/cover classes).

Digitization process was done by trained operators. Later, at the data quality control stage, digitization and classification control processes were carried out by an expert. At the last stage of control procedure, topology control and accordingly semi-automated correction procedures were applied by a database specialist. In this stage, two topology rules namely “Must Not Overlap” and “Must Not Have Gaps” were utilized within an ESRI ArcGIS geodatabase, and as a result hundreds of topological errors were corrected.

The digitization process was carried out by using a static (un-changed) data structure. That is to say no updates to cadastral land parcels and similarly to sub-parcels have been applied. In fact, dynamic structures of these two data sets must be considered. To realize this fact, study on the integration of produced sub-parcel data set with an online cadastral land parcel data set by using WFS web service provided by the General Directorate of Land Registry and Cadastre (GDLRC) has been continuing. Similarly, to be able to update dynamic changes on sub parcels, study on serving this data set together with cadastral land parcels and background VHR images to related users via WMS and/or WFS has also been continuing.

These users may be representatives of governmental institutions and also citizens who engaged in agricultural land use. Some of these users are planned to be data providers in different levels for dynamic updata procedures via croud sourcing techniques.

3. RESULTS and DISCUSSION

3.1 Land Use/Cover Classes

Inspired from agricultural policy implementation and related spatial data management issues in Europe and Turkey, in this study, a new land use/cover classification system was developed (see Inan and Dursun, 2014 for preliminary development stage).

Table 1. Hierarchic levels and classes of proposed land use/cover classification system

Land Use/Cover Classes		
I. Level Classes	**II. Level Classes**	**III. Level Classes**
Agricultural Land (Tarım Potansiyeli Olan)	Cultivated Agricultural (Ekili Tarım)	Fertile (Tarla)
		Protected (Örtü Altı)
		Garden (Bahçe)
	Planted/Perennial Agriculture (Dikili Tarım)	Vineyard (Bağlık)
		Orchard (Meyvelik)
		Olive Grove (Zeytinlik)
		Other Planted (Diğer Dikili)
	Grassland/Pasture (Otlak/Mera)	Pasture (Mera)
		Grassland (Çayır/Otlak)
	Transition Agri. (Geçiş Tarım)	Abandoned (Terk Edilmiş Tarla)
		Uncultivated (Tarım Dışı)
		Immature (Ham Toprak)
	Other Agri. (Diğer Tarım)	Mixed Agri. (Karışık Tarım)
		Uninterpretable (Yorumlanamayan)
Non-Agri-cultural Land (Tarım Potansiyeli Olmayan)	Settlement (Yerleşim)	Settlement
	Built-up (Arsa)	Buit-up
	Infertile (Elverişsiz)	Infertile
	Other (Diğer)	Uninterpretable (Yorumlanamayan)

In the development stage, possible use of internationally well known classification systems namely FAO Land Cover Classification System (LCCS) (Di Gregorio and Jansen, 1998), CORINE land cover (EC, 1995) and INSPIRE land use/cover theme (INSPIRE D2.3, 2007; INSPIRE D2.8.II.2, 2013) was considered and some application tests were carried out. However, it was experienced that visual interpretation on VHR is not a practical method for the classification of land outside agricultural areas. Therefore, a new hybrid classification system which classifies agricultural land in detail and classifies rest of the land only in generic classes is required. The developed classification system has classes in three levels. The first level only differentiates the main type of land which has or does not have agricultural potential. The second level includes eight major land use/cover types. The third level includes eighteen land use/cover types, yet focusses only on detailed classification of agricultural land (see Table 1).

3.2 Land Use/Cover Data Sets

In land use/cover production stage, by using a total of 3640 land parcels (as spatial template) in three districts, a total of 6811 spatial sub divisions of land parcels were produced as spatial land parcel types (land use/cover classes) (see Fig. 1).

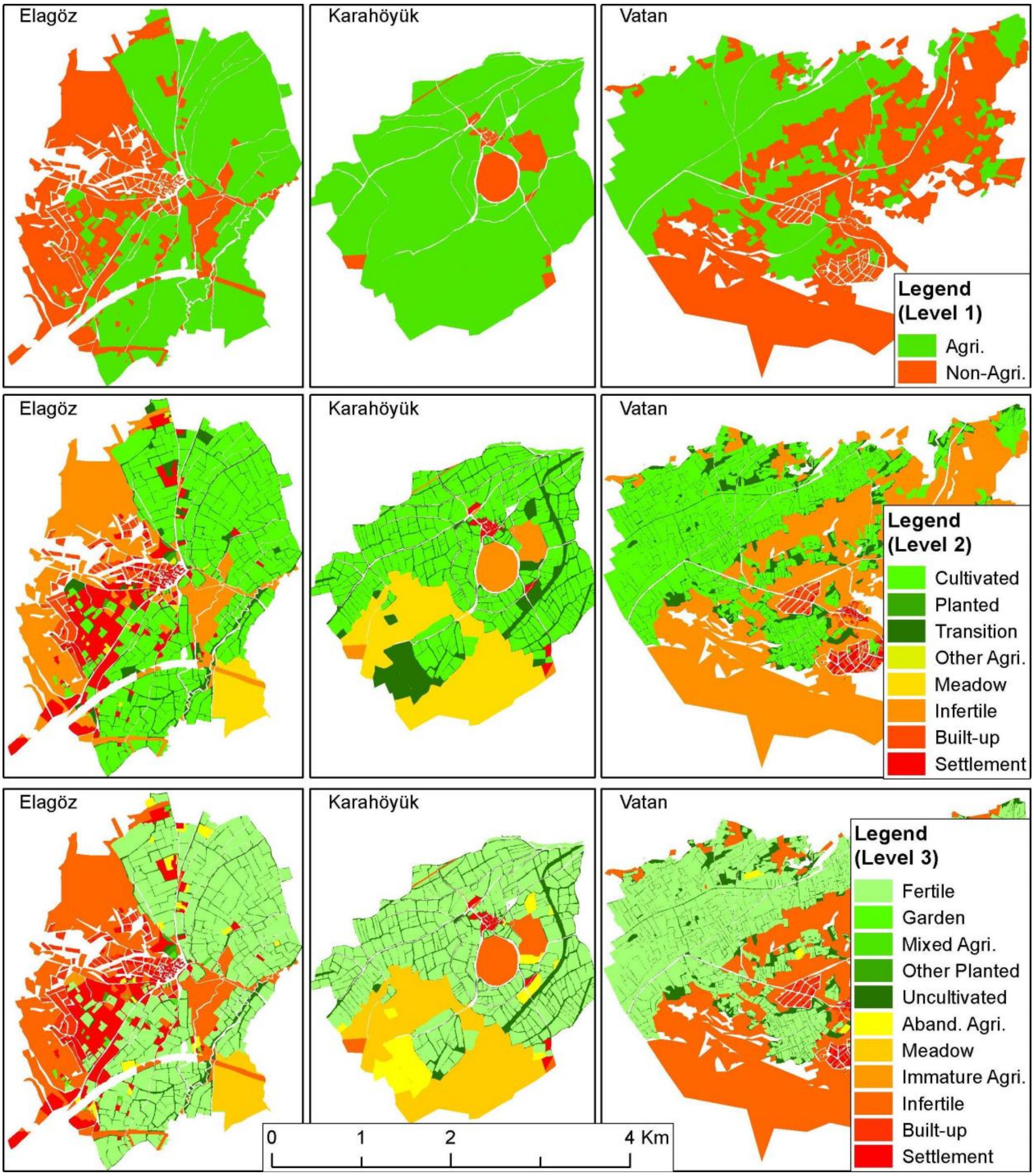

Fig. 1. Land use/cover data and three levels of classification in pilot application areas

In the production of land use/cover data sets, the main focus is the production of the most detailed Level 3 data. Data in lower levels are generalized versions of Level 3 data. Because instances of all classes designed in Level 3 (see Table 1) are absent in three application areas, the number of classes in Level 2 and 3 are not far different in Fig. 1.

3.3 Integrity of Cadastral Land Parcels and Land Use/Cover Data

3.3.1 Data Structure

Sub-parcel data structure (see Inan et al., 2010) was used for the integrity between cadastral land parcels and land use/cover data. This data model requires the use of robust geometry and topology rules. Basic rules are as follows. A land use/cover unit (sub-parcel) must geometrically be a sub set of the specially coinciding cadastral land parcel. Similarly, data quality of cadastral land parcels must be used for shared boundaries although spatial data quality of cadastral land parcels and land use/cover units may be different. Land use/cover units within a cadastral land parcel must not overlap and may not have gaps only for exceptional cases. The produced data sets were checked and corrected against all these basic rules.

During implementation, these basic rules combined with updating and maintenance rules will always be implemented. The implementation strategy may differ depending on the type of process. Possible processes may be updating cadastral parcel boundaries and related land use/cover units, simply updating land use/cover units within a cadastral land parcel, a regular maintenance operation, a crowd source contribution with real geometry or only a spot indicating some sort of change etc. Study on these issues has been continuing.

3.3.2 Updating and Maintenance by Crowdsourcing

Cadastral land parcels lives (updated) legally depending on land administration procedures. On the other hand, changes of land use cover information on cadastral land parcels can not always be traced legally. This may only be possible in planned urban areas where all land use activity especially construction activities are legally monitored. For the majority of unplanned rural areas this is not the case. Therefore, this study focusses on classifying, updating and maintaining land use/cover data in rural areas. However, real time update of land use/cover data in such areas is almost impossible. Updating strategies proposed with this study concentrates basically on increasing the number of related legal (by adding the domain of agricultural policy) or illegal (well organized) procedures by sharing data all related parties (who have a potential contribution by crowdsourcing).

Updating of cadastral land parcels, in this study, is fully dependent on the WFS web service which provide the most up-to-date digital information about cadastral land parcels. For land use/cover information updates, the classification and visual interpretation methodology which reflects easily understandable fixed or clearly identifiable land use/cover boundaries makes the development of a robust updating methodology. Another advantage is that land use/cover information in three levels has the potential to serve for a vast variety of disciplines. In fact, changes of fixed or clear boundaries on VHR images or alternatively by field visits may be identified easily even in the absence of an expert. Therefore, contribution by expert or non-expert crowdsourcing will be possible (This is called as multi-tier updating in this study). Yet, the key development for the implementation of such a task is serving related data to the users in an easy and convenient way. In this context, web services usable on desktop, tablet and mobile devices will be developed both for data share and contribution by crowd sourcing. Software development for this purpose has been continuing. Study on the determination of related foundations and accordingly custodians has partly been completed.

Due to the robust data structure which must be maintained by only experts, crowd sourcing can not be the first order source for updating. It must be at later orders depending on the expertise of the data provider. It must only be used as supporting evidence for updating procedures. For the management of such a complex, multi-tier updating strategy, management of metadata must have a crucial role.

Apart from crowd sourcing, some periodical update operations may be required. These may be done using VHR images and/or aerial photography. In the absence of up-to-date imagery or photography, field visits may also be another alternative. However, during visits, identification of changes may not be possible, and accordingly measurement of all (suspected) land use/cover boundaries may not be possible. Yet, a rapid field survey without boundary surveying may be useful for the determination of the need for imagery/photography update.

4. CONCLUSIONS

As part of modern land administration which serves not only for land market but also for other related disciplines (agricultural policy implementation in this study), management of up-to-date land parcel type information is of utmost importance. Similarly, instead of causing burden to related land administration foundations, using interoperable data structures/models (e.g. sub-parcel data structure) maintained in close collaboration with related foundations or even citizens is also required. However, management of conventional land parcel type information which is not capable of representing amount of land use/cover type spatially is not a convenient way. Instead, in terms of developing effective updating and maintenance procedures, using a well defined land use/cover classification system may be a robust solution. For the effectiveness of such multi-tier maintenance procedures, storing and managing related metadata about contributors, equipment used and also methodology of data acquisition are strictly required.

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BIOGRAPHICAL NOTES

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