Cadastral Map Data Quality in Turkey and Methods Used for Updating its

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Key words: Cadastral Renovation, Cadastral Updating, Cadastre, Land Management, Digitization

SUMMARY

Approximately 57.4 million cadastral parcels have been produced in Turkey since its establishment. In this period, it was used different methods in the produced of these parcels. Therefore, the cadastral data are not all of the same standard in quality. According to the data of the General Directorate of Land Registry and Cadastre (GDLRC), there are approximately 34 million parcels which have been harmonized with the ground. The remaining parcels have temporary coordinates in terms of data quality. Also, only 27 million of these parcels are in the ıtf 96 datum. Turkey has been carrying out important work towards modernizing the technical cadastral infrastructure for a long time. GDLRC has declareted that it will updated 22 million parcels in the near future. Acording to Cadastre Law, there are three different methods in updating of cadastral maps in Turkey. These are basic technical error correction, digitization and updating methods. The aim of these methods is to improve the quality of cadastral maps, to provide its harmony with ground and to convert them to a common reference system (ITRF: International Terresterial Reference Frame). Technical error correction is applied in one or more parcels. The digitization method is mostly carried out on the cadastral block or village/neighborhood scale in urban areas. The updating method is preferred when the input of a local expert-witness is needed in rural areas. After legislative regulations, the content and scope of the updating method, which is called initially cadastral renovation has been expanded and transformed into an updating method. In this study, it will focus on the current status of Turkish cadastre data quality and the cadastral updating methods applied there. In addition, the role of the private sector in the implementation of these methods will be discussed.

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1. INTRODUCTION

Cadastre, which determines the geometric status and property rights of the immovable properties, is the most basic component of land administration systems (Luo et al., 2017). An effective cadastral system guarantess property rights to support agricultural productivity, land market, poverty and other national development (Williamson, 1997). However, unfortunately, only 30% of the world population can reach official cadastral systems. The high accuracy of these systems is undoubtedly an expensive process (Enemark and et al. 2014). Using traditional ground-based cadastral surveying techniques, high positional accuracy cadastral mapping and registration took decades (Zevenbergen, 2009 / a; Enemark and et al. 2014). Despite this, some cadastral systems could not be preserved, this situation lead to outdated cadastral maps (Fetai et al. 2019). For this reason, while developing countries are seeking to accelerate cadastral mapping efforts to guarantee their land rights (Zevenbergen, 2004; Simbizi et al 2014), developed countries strive to keep the established cadastral systems updated (Zevenbergen, 2009 / a). Since 1990s, efforts to increase the efficiency of cadastral systems have been carried out in the world under the name of cadastral update, upgrade and renovation (Effenberg and et al., 1999; Effenberg 2001; Hope and et al. 2008; Döner 2015; Yildiz and et al. 2015).

Data collection, which has high spatial accuracy for establishment of cadastral systems requires a lot of cost and time. For this reason, it was started to be discussed in the developing countries in the early 2000s that instead of high accuracy cadastral systems, each country should have cadastral system quality, which has sufficient meet their own needs. This idea was called the Fit-For-Purpose Land Administration (FFPLA) in the international agenda (Bennet and et al. 2008; Enemark and et al. 2014; Enemark 2016).

Developing the positional accuracy in photogrammetric methods over time has provided important advantages in the establishment and updating of cadastral systems. Unmanned Aerial Vehicles (UAVs), high resolution satellite images are some of these developments. Today, UAVs are gaining increasing attention in the establishment and updating of cadastral systems (Ramadhani et al. 2018; Volkmann et al. 2014; Crommelinck et al., 2016). Beside this, there is workings exploring semi-automatically extract cadastral boundaries in rural areas based on the land cover information from WorldView-2 satellite images (Wassie and et al., 2018).

When it comes to Turkish cadastral data; approximately 57.4 million cadastral parcels have been produced in Turkey since its establishment. In this period, it was used different methods in the produced of these parcels. Therefore, the cadastral data are not all of the same standard in quality. According to the data of the General Directorate of Land Registry and Cadastre (GDLRC), there are approximately 34 million parcels which have been harmonized with the ground. The remaining parcels have temporary coordinates in terms of data quality. Also, only 27 million of these parcels are in the ıtf 96 datum. Turkey has been carrying out important work towards modernizing the technical cadastral infrastructure for a long time. GDLRC has declareted that it will updated 22 million parcels in the near future.

In this study, updating studies in the Turkish cadastre system will be discussed in parallel with international developments. In the first part, the quality of cadastral maps, in the second part, the methods used in the update phase will be presented.

2. QUALITY OF CADASTRE MAPS in TURKEY

Turkey cadastre, technically, are dealt with in three periods, including writteen, linear and numerical. Written cadastral period title records do not have a geometrical equivalent. Cadastral maps produced in the linear cadastral period constitute an important part of the archive. In this period, cadastral maps were produced by using various map materials at various scales. In addition, while some of these maps do not have a coordinate system, some of them used local or ED50 datum. These maps consist of graphic, photo-plan, photogrammetric and classic maps. Classic maps are produced by prismatic and tacheometric survey methods. Changing cadastral surveying methods led to the beginning of the numerical cadastre period after the 1980s.

Table 1. Turkish cadastre technical archive and their accuracy

Cadastre Map Type	Scale	Datum	Linear / Numerical	Material type	Spatial Accuracy (m)	Rate in archives (%)
Graphic Maps	1/500, 1/1000, 1/2000, 1/2500, 1/5000, 1/10000	None	Linear	Cardboard	0.5-5.0	17.6
Photoplan Maps	Miscellaneous	None	Linear	Cardboard	-	0.3
Photogrammetric Maps	1/5000	ED50	Linear	Astrolone	1.5	15.6
Classic Maps	1/500, 1/1000, 1/2000, 1/5000	Local ED50	Linear	Astrolone, Aluminum	0.25-1.73	36.2
Digital Maps	1/500, 1/1000	ED50 ITRF96	Numerical	Astrolone etc..	0.08	29.5

Table 1 shows that the spatial accuracy of the cadastral maps ranges from 0.08 m to 1.73 m depending on the cadastral map type and its scale. This accuracy expresses the error limit of that map. The error limit is defined in the Official Gazette (2006) as the acceptable difference between the boundary of the real estate on the ground and the map values calculated according to the production method and scale of the cadastral maps. Briefly, the error limit of a cadastral map is the error circle of the spatial data obtained from this map.

The maximum spatial error (error limit) of the detail points varies according to the measurement method used and the scale of the cadastral map. Error amounts in cadastral maps produced with prismatic and tachometric method are presented in Table 2 (GDLRC, 2012).

Table 2. Spatial accuracy of classic cadastral map sheets

Method	Prismatic Method $M_ö = 0.21$ m		Tacheometric Method $M_ö = 1.00$ m		
M *(Scale)*	1/500	1/1000	1/2000	1/2500	1/5000
ds_{max} *(m)*	0.25	0.35	1.15	1.22	1.73

Error amounts in cadastral maps produced by the photogrammetric method are calculated from the following equation.

$$ds_{max} = 0.0003 \text{ m} \times M$$

Since the scales of the photogrammetric cadastral maps are 1/5000, the maximum spatial error is calculated as 1.5 m according to the above equation (GDLRC, 2012). If the cadastral spatial data is generated by the numerical method, the maximum spatial error should be less than 8 cm (Official Gazette, 2005a). It is difficult to state precisely the spatial data accuracy in graphic maps. In a pilot field study conducted by Coruhlu (2007), it was found that the spatial accuracy of graphic maps ranged from 0.5 m to 5.0 m (Demir and Coruhlu 2008).

There are various concepts of error in the production of cadastral maps beyond the error limit mentioned above. These errors can be summarized as measurement, drawing, area and boundary errors originate in human and other measuring instruments.

3. METHODS USED TO IMPROVE CADASTRAL MAPS

There are three methods for the improvement of cadastral maps in Turkey. These are correction of the cadastral map error, digitization, and updating. These three methods are different from each other in terms of application. But, their aims are common (Fig. 2). The common objectives of these methods are: (i) to improve the quality of cadastral map sheets, (ii) to improve map-ground alignment, and (iii) to convert existing maps to a common reference system (Datum ITRF96) (Yildiz, 2015).

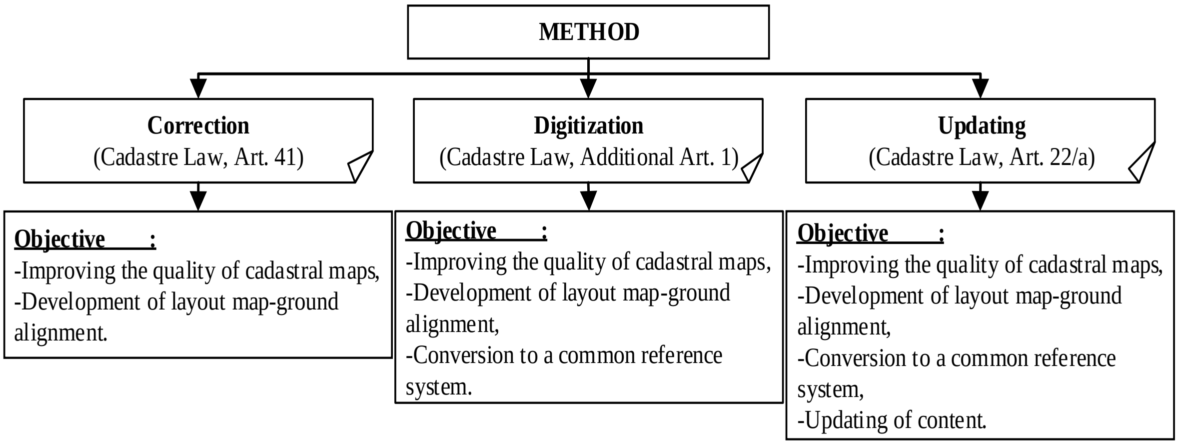

Figure 1. Methods used to improve cadastral maps

Technical error correction method (Cadastre Law, Art. 41) is applied in correction of errors such as drawing, calculation, limitation in cadastral map. Under this method, all parcel owners affected by the correction process are required to be notified. Therefore, this method is not preferred where technical errors are common in cadastral maps, but rather for narrow-scale correction operations which mostly concern one or more parcels.

The digitization method (Cadastre Law, Additional Art. 1) is summarized as follows: Firstly the temporary coordinates of the cadastral maps are calculated in accordance with the original technical documents. In the field, fixed boundaries are measured under the current reference system. Then, both sets of data are overlapped in a computer environment. If there is a difference within the error limit between the temporary coordinates and the coordinates of the fixed boundaries obtained from the field, the coordinates obtained from the field are taken directly into account. If there is a difference between the temporary coordinates and the coordinates obtained from the ground exceeding the error limit, this indicates a technical error (error of measurement, drawing, calculation, etc.). If such errors are detected, they are reported and corrected. The results of the investigation are announced via posted notices. Under this method, local expert-witness support is not taken for the measurement of fixed points in the field, and thus, it is mostly applied in urban areas.

Cadastral updating method (Cadastre Law, Art. 22/a), in general, is similar to classic cadastral work. For example, the basic stages of classic cadastral work include procedures such as cadastre Project area notification, expert-witness selection, cadastral block notification, demarcation and surveying studies, information notification, commission works, general posting of notices, and registration. Property determination is the most important element in which the updating method differs from the classic cadastre. With the updating method it is not possible to determine the ownership rights for a parcel undergoing cadastre. With this method, initially called the “renovation” method, the aim is to improve the ground alignment of the cadastral maps and to convert them to a common reference system. However, the jurisdiction of this method was expanded with the 2018 amendment of the regulation (Official Gazette, 2006a). After that date it began to be called the “updating” method. Accordingly, apart from the main purposes mentioned above, external transactions and subdivisions, transfers, etc. were included in the process for an area declared to be updated.

The most important phase of the updating method consists of the demarcation, surveying and evaluation steps. At this stage parcel boundaries are created and boundary sketches are prepared. Various boundary concepts have been developed for this application (Yildiz, et al., 2015). These boundary types (Official Gazette, 2006a; GDRLC, 2018) are fixed, indeterminate/General, disputed, non-fixed/Changeable, valid, considered as valid and post-earthquake boundaries. In order to establish these limits, all or some of the data layers presented in Figure 2 must be combined. Cadastral updates cannot be made without raster cadastral map, temporary digitization results and current land measurements belonging to fixed borders.

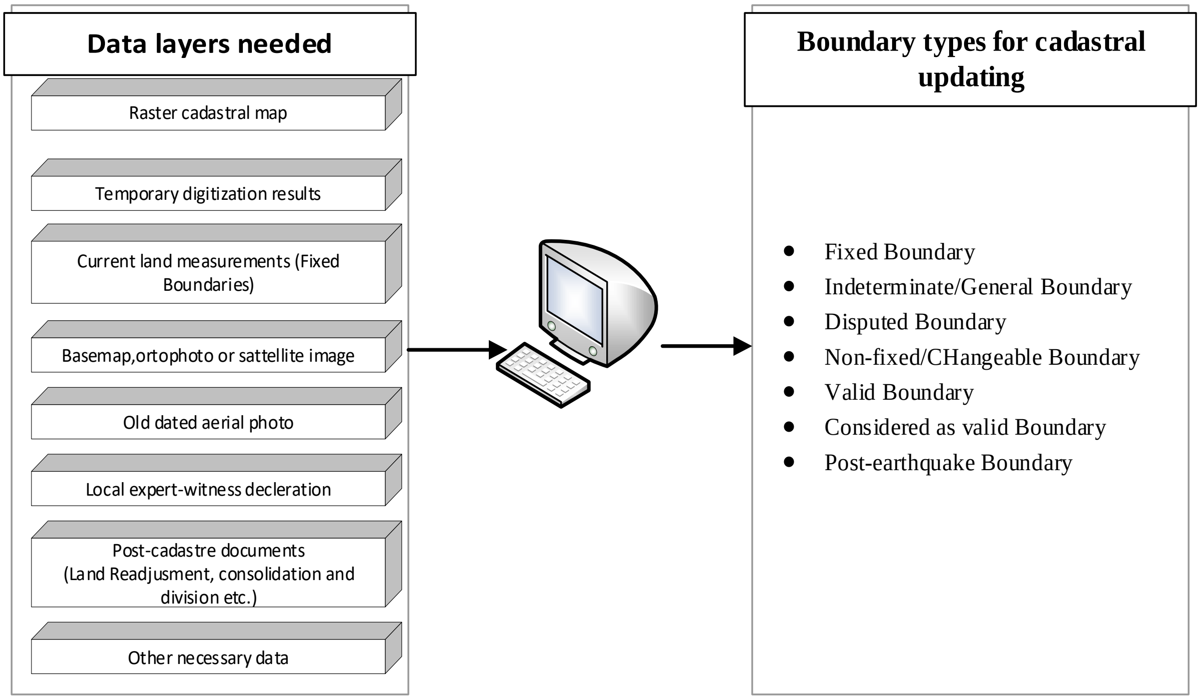

Figure 2. Necessary data layers and new boundaries in cadastral update

4. DISCUSSİON and CONCLUSION

Today, as presented in the paper, three methods are used to improve cadastral maps. The application steps of these methods differ from time to time. We can summarize the possible application areas of these three methods as follows. Article 41 of the Cadastral Law. Application is simple technical error correction. It is a method applied in border corrections involving one or more parcels. Digitization method is the method applied on the scale of the village/neighborhood (sometimes applicable on the basis of cadastral block). In this method, the geodetic infrastructure is reconsidered and all the parcels are converted into digital format. Thus, cadastral map-ground compatibility is provided. The third method is updating method.
The way of applying the digitization and updating methods and the areas where it is applied are different. Digitization studies are carried out in areas where cadastral map-ground compatibility are relatively good and in areas where local expert-witness is not required. The updating method, on the other hand, is a preferred method in areas where errors exceeding the limit of error are common and where a local expert-witness is needed in the field. Choosing the right method will save considerable time and money in studies.

Turkey, in the process of completing cadastral spanning the last century, is made of the total production of 57.7 million parcels until today. 33 million (57%) of these plots are numerical format parcels with ground compatibility. However, 24.7 (43%) parcels have been temporarily converted to digital format.

When the cadastral technical archive is classified according to the geodetic reference system, the following results are obtained: 25.5 million parcels in ITRF96 Datum (23%), 23 million parcels in ED50 Datum (40%), 6.70 million parcels in Local Datum (12%), 2.50 million parcels (4%) (URL-1, 2019). Despite these conditions, GDLRC first submitted its written land registry information to the e-government service through the Land Registry and Cadastre Information System (in Turkish TAKBİS). Then collected the linear/digital cadastral maps with the Spatial Real Estate System (in Turkish MEGSİS) in a central system and matched them with the land registry data. However, during this process, the linear map dates that form part of the technical archive have been temporarily digitized and presented to e-government service as presented above (Official Gazette, 2006; Yıldız, 2013).

On the other hand, it continues to intensely improve the cadastral system. The most important of these is the Land Registry and Cadastre Modernization Project. With the project, which has a budget of 135 million Euros, the renovation process of approximately 4 million parcels was completed between 2008 and 2013. The process of improving the cadastre system, which has intensified since the beginning of the 2000s, continues increasingly. The methods used in this process have changed constantly. Finally, in the statement made by GDLRC (GDLRC, 2018), it was announced that the updating of 22.3 million parcels will be completed within three years and the modernization process will be completed. It is considered that the goal can be realized by strong surveying private sector (Yildiz and Coruhlu, 2017) in Turkey .

REFERENCES

Bennett, R., Wallace, J., & Williamson, I. (2008). Organising land information for sustainable land administration. Land Use Policy, 25(1), 126–138. http://doi.org/10.1016/j.landusepol.2007.03.006

Coruhlu, Y.E., 2007. Grafik Kadastro Sorunu ve Çözüm Olanaklarının Araştırılması: Trabzon Örneği [The Graphic Cadastre Problem and Investigation of Solution Opportunities: The Case of Trabzon]. Master’s thesis, Karadeniz Technical University Institute of Science and Technology, Trabzon.

Crommelinck, S., Bennett, R., Gerke, M., Nex, F., Yang, M. Y., & Vosselman, G. (2016). Review of automatic feature extraction from high-resolution optical sensor data for UAV-based cadastral mapping. Remote Sensing, 8(8), 689.

Demir, O., & Çoruhlu, Y. 2008. The graphical cadastre problem in Turkey: the case of Trabzon province. *Sensors*, *8*(9), 5560-5575

Döner, F. (2015). Evaluation of cadastre renovation studies in Turkey. Survey review, 47(341), 141-152.

Effenberg, W. W., Enemark, S., & Williamson, I. P. (1999). Framework for Discussion of digital spatial data flow within cadastral systems. *Australian surveyor*, *44*(1), 35-43.

Effenberg, W. (2001). *Spatial cadastral information systems: the maintenance of digital cadastral maps* (Doctoral dissertation).

Enemark, S., Bell, K. C., Lemmen, C. H. J., & McLaren, R. (2014). Fit-for-purpose land administration. International Federation of Surveyors (FIG).

Enemark, S., (2016). Fit-for-purpose Land Administration for Sustainable Development, *Gim International-The Worldwide Magazine For Geomatics*, 30(8), 16-19.

GDLRC, 2018. Cadastre Update Studies Application Circular, Circular No: 1792 (2018/13).

Hope, S., Gordini, C., & Kealy, A. (2008). Positional accuracy improvement: lessons learned from regional Victoria, Australia. Survey Review, 40(307), 29-42.

Fetai, B., Oštir, K., Kosmatin Fras, M., & Lisec, A. (2019). Extraction of Visible Boundaries for Cadastral Mapping Based on UAV Imagery. Remote Sensing, 11(13).

GDLRC, 2012. Digitization of Cadastral Maps, Circular No: 1737 (2012/15).

Luo, X., Bennett, R. M., Koeva, M., & Lemmen, C. (2017). Investigating semi-automated cadastral boundaries extraction from airborne laser scanned data. Land, 6(3), 60.

Official Gazette, 2006. Implementing Regulation on the Digitization of Cadastral Maps, (No. 26356), date: 24.11.2006.

Official Gazette 2006a, Kadastro Güncelleme Yönetmeliği [Cadastre Update Regulation], (No. 26361), date: 29.11.2006.

Ramadhani, S. A., Bennett, R. M., & Nex, F. C. (2018). Exploring UAV in Indonesian cadastral boundary data acquisition. Earth science informatics, 11(1), 129-146.

Simbizi, M. C. D., Bennett, R. M., & Zevenbergen, J. (2014). Land tenure security: Revisiting and refining the concept for Sub-Saharan Africa's rural poor. Land use policy, 36, 231-238.

URL-1 http://cbs.GDLRC.gov.tr/istatistik/ParselEnvanter.aspx, Accessed: July 9, 2019.

Volkmann, W., & Barnes, G. (2014, June). Virtual surveying: Mapping and modeling cadastral boundaries using Unmanned Aerial Systems (UAS). In Proceedings of the FIG Congress: Engaging the Challenges—Enhancing the Relevance, Kuala Lumpur, Malaysia (pp. 16-21).

Wassie, Y. A., Koeva, M. N., Bennett, R. M., & Lemmen, C. H. J. (2018). A procedure for semi-automated cadastral boundary feature extraction from high-resolution satellite imagery. Journal of spatial science, 63(1), 75-92.

Williamson, I. (1997). The justification of cadastral systems in developing countries. Geomatica, 51(1), 21-36.

Yildiz, O., 2013. New Approaches of Turkey Cadastre to the Current Situation and the Multipurpose Cadastre, Doctoral thesis, Karadeniz Technical University Institute of Science and Technology, Trabzon.

Yildiz, O., Coruhlu, Y. E., & Demir, O. (2015). A visional overview to renovation concept on cadastral works in turkey. Sigma: Journal of Engineering & Natural Sciences, 33(4).

Yildiz, O., & Coruhlu, Y. E. (2017). the Turkish Surveying Private Sector. *Fresenius Environmental Bulletin*, *26*(12A), 8008-8022.

Zevenbergen, J.A. (2009/a) Land Administration: To See the Change from Day to Day; ITC: Enschede, The Netherlands, 2009; ISBN 978-90-6164-274-9

Zevenbergen, J. (2004). A systems approach to land registration and cadastre. Nordic journal of surveying and real estate research, 1(1).

BIOGRAPHICAL NOTES

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