DIGITAL PHOTOGRAMMETRIC MAPS AND ORTHOIMAGES FOR CADASTRE RENOVATION STUDIES

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Abstract

The old cadastral sheets can no longer be used in the face of developing technology, or because of wear, tear or loss. The sheets which are inadequate due to the technical reasons, which have lost or are seen the lankness of the application feature, and which are determined the incompatibilities between them and the ground are renovated to eliminate the restriction, surveying, drawing and calculation errors. Therefore the cadastre renovation studies are needed and started in Turkey. The renovation applications are realized by using classical surveying methods. In this paper the usage of orthoimages and digital photogrammetric maps for cadastral renovation studies are compared. Hendek in Sakarya city in Turkey is selected as a case study.

Key words: Surveying, IKONOS, image, photography, test.

1. Introduction

In Turkey the cadastral studies at the national level are under the responsibility of General Directorate of Land Registry and Cadastre (GDLRC) affiliated with Ministry of Environment and Urbanism after The Decree-Law on Organization and Duties of Ministry of Environment and Urbanism come into force on 04.07.2011 with Official Gazette numbered as 27984 (URL1). The main responsibility of this general directorate is to organize implementation of land registry and cadastre works. It carries out this duty with 22 District Directorate, 81 Cadastre Directorates (Offices) and Land Registry Directorates (Offices). Until 2000 not much more than 85% of the country land was surveyed and registered by GDLRC. Webpage of GDLRC indicates that "cadastral studies of 96,9% of the villages, cadastral studies of 99,3% of the districts and cadastral studies of 97,7% of all units are completed." (GDLRC, 2011). The remaining land has the most problematic areas and the studies are continuing.

In Turkey the cadastral studies have been started with local-based works in 1924 and speeded up after 1950's. After 1980's the computerization of the cadastral works began. With

The Project of Land Registry and Cadastre, the problems of the cadastre and the requirements for solving these issues have been identified in detail. As a result of these studies The Project of Land Registry and Cadastre Information System was started in 1990's. It can be said that the important requirements have been determined to digitize the cadastral maps. One of them is the constitution of all cadastral bases in a national coordinate system. In Turkish cadastral system there are different surveying methods, coordinate systems, scales and sheets used. The production methods of cadastral maps are graphic, polar, orthogonal, photogrammetric and digital. There are 10 different scales from 1/200 to 1/10000. The existing cadastral maps with respect to sheet bases are transparent, aluminum and paper-cartoon. (Demir and Cete, 2004). This diversity brings out the incompatibilities in the context of field, sheets and surveys. Also cadastral sheets may be insufficient in the face of developing technology in time because of technical reasons, lose application feature and may be seen the lack of application feature. Additionally the restriction, surveying, drawing and calculation errors during the cadastral studies or change operations may cause the sheets to lose their application features. On the other hand the incompatibilities between the sheets and the ground may be encountered because of the landslides or the earthquakes. These incompatibilities are seen especially on Application Processes. Application Processes are not only the demonstration of the places, but also the processes of separation, combining, abandonment to road and type change of the places. This is very important especially during the expropriation processes. When the expropriation line of the ground is tried to show on its sheet, this line may meet different parcels of the land. It is sure that this kind of problems causes the loss of benefit. Therefore these incompatible sheets need to be renovated with the current contemporary techniques.

As a natural result of the crustal movements in Kocaeli, Sakarya and Yalova (three cities of Turkey) the incompatibilities are seen between the cadastral sheets that are subject to the ownership and the ground. Therefore it is needed to improve the land registry and cadastre information and documents. Then the technical studies such as digitization and renovation are started. For the base of cadastral renovation studies digital vector photogrammetric maps in scale 1/1000 are produced. Also the satellite images are used to control and check the cadastral renovation studies. As a result both aerial photos and the satellite images are used for the cadastral renovation study area.

In Turkey there are some academic studies on cadastre renovation. For example while Inam et al. are presenting reasons and project results of cadastre renovation, Cagla et al. give an example for Konya in Turkey. However Alkan and Solak (2010) give another study by

selecting Taskopru in Kastamonu in Turkey as a study area to investigate 1:5000 scale photogrammetric data for cadastral mapping uses. They present 1:5000 scale photogrammetric maps are generally useful for cadastral mapping in rural and forest areas, but the 1:5000 scale is not accurate enough for city mapping. Therefore 1:2000 or 1:1000 scale photogrammetric maps should be used for surveys of urban areas.

In this paper the digital photogrammetric maps and the othoimages are compared if they are favorable for the renovation or not. This paper is also a further investigation of satellite images and aerial photos for cadastral renovation over two papers that are presented at International Symposium of Photogrammetry and Remote Sensing in 2004 and 2008 (Sahin et al. 2004, Bakici et al. 2008).

2. The Legal Infrastructure of The Cadastre Renovation Studies

"Insufficient Sheets" is one of the main reasons of the cadastral renovation. Because of some reasons cadastral sheets may not be used in desired degree:

- some restriction, surveying, drawing and calculation errors during cadastral studies,
- development of more sensitive surveying and drawing techniques because of continuous developing technology
- defacement, laceration, rupture and loss on/about old sheets.

The above-mentioned reasons may cause difficulties and problems during application processes or especially expropriation processes, for example the ground and the sheet of expropriated site may not be overlapped.

Because of all these reasons it is decided to start cadastral renovation studies. In 1983 The Law on Land Registration and Cadastre Renovation numbered as 2859 was released to update them but the required efficiency was not obtained. In 2005 The Cadastre Law numbered as 3402 had a change on the twenty_second article (22/a) with the law numbered as 5304. These are two of The Cadastre Renovation Legislation. All is listed as below:

- "The Cadastre Law" numbered as 3402 changing with the law numbered as 5304 (Artcle 22/a)
- "The Law on The Renovation of the Cadastral Sheets" numbered as 2859

- The Decree-Law on “Adding Some Articles to The Law on The Renovation of the Cadastral Sheets” numbered as 590 (Official Gazette Date: 08.02.2000, Official Gazette No: 23958).
- The Regulation on “The Principles and The Procedures about Rearrangement of the Cadastral Maps and Corrections on Title Deeds” (Related to 3402_22/a) (Official Gazette Date:29/11/2006, Official Gazette No:26531).
- The Regulation of “Registration and Renovation of The Cadastral Sheets” (Related to 2859).
- The Implementing Regulation on Articles Appendix1 and Appendix2 added to The Law numbered as 2896 with The Decree Law numbered as 590.
- The Regulation of Large Scale Maps and Map_related Information Production (Official Gazette Date: 15.05.2005, Official Gazette No: 25876)
- The Regulations issued in accordance with The Cadastre Law numbered as 3402.
- The Control Directive and Application of The Regulation on Renovation of The Cadastral Sheets and Making Required Corrections on Title Deeds (Circular 2007/10)
- The Control Directive on Cadastral Map Production (Circular 2007/12)
- The Directive on Control and Application of Renewal Studies (Circular 2004/12)
- The Circular of Type Change on Renovation Studies (Circular 3003/2) (Kocak, 2009).

Article 22/a and its regulation has less scope and wider and new developments than The Renovation Law and its regulation. All of these arrangements have the same aim and the essence of the studies is the same: to create new sheets (maps) using old ones.

3. Test Area

Test area is approximately 800 m2 area, which contains both renovation and initial cadastre area, in Hendek (the town) of Sakarya (the city). Figure 1 shows the center of Hendek with “A” and Figure 2 shows the location of Hendek on Turkey map with “B” letter. The coordinates of the lower left corner of the project area is North:40° 34’ 50” East:30° 29’ 50” and the coordinates of the upper right corner of the project area is North:40° 55’ 05” East:30° 58’ 20”.

4. Test Data and Processes for Test Area

The cadastral parcels with Ground Control Points (GCPs) and Tie Points (TPs) in Hendek are surveyed with classical methods for cadastral renovation as a normal procedure. Then the satellite images and aerial photos are provided to calculate same GCPs and TPs.

4.1 Satellite images for Test Area

The satellite images of the test area are provided for The Project of Usage of IKONOS Images in the concept of Rural Cadastre Base for General Directorate of Land Registry and Cadastre. The aim is to test the usability of IKONOS images for rural cadastre and agricultural projects in Turkey. Normally the project area is 1100 km2.

The satellite images are pan-sharpened color images that have less than 1m. resolution. The orthorectified images have +/-1,0m. (RMSE[1]) resolution and +/-1,5m. (RMSE) coordinate accuracy. The projection system is Universal Transverse Mercator (UTM) with 3° slice and the geographic coordinates of the images are in World Geodetic System of 1984 (WGS-84) ellipsoid and the European Datum 1950 (ED-50). The products delivered are in GeoTIFF format. The cloud cover is less than 10% and the north is the initial angle for the image. The sun angle is bigger than 15° and image angle is bigger than 70°. Digital Elevation Model (DEM) for orthorectification is provided from YUKPAF[2] data at General Command of Mapping (GCM) in Turkey.

The steps of the project are: to mark the ground control points with the white plates sized 1*1 m. and to survey the coordinates, to take the satellite images, to produce DEM from 1/5000 scale maps, to produce DEM from YUKPAF, to orthorectify IKONOS images using the points surveyed and DEMs produced.

In the concept of the project thirty-three (33) triangulation points are surveyed on the test area. Software Pinnacle 1.0 is used for the evaluation, adjustment and transformation of Global Positioning System (GPS) observations.

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[1] RMSE: Root Mean Squared Error: The RMSE is a quadratic scoring rule which measures the average magnitude of the error. The equation for the RMSE is given in both of the references. Expressing the formula in words, the difference between forecast and corresponding observed values are each squared and then averaged over the sample. Finally, the square root of the average is taken. Since the errors are squared before they are averaged, the RMSE gives a relatively high weight to large errors. This means the RMSE is most useful when large errors are particularly undesirable.

[2] YUKPAF: The file that contains Digital Elevation Models from 1/25000 scale maps.

The orthorectification is presented in the standard of the scale 1/5000. PCI OrthoEngine is used for orthorectification. For the test area a block of six (6) images is formed. On average seven (7) GCPs are distributed for each image. Thirty-nine (39) GPCs (as C1, C2 and C3 degree) are established, twenty-five (25) of them are at C3 degree[3]. TPs between images are determined for colons and models; however two (2) GCPs (G25S0034 and G25S0048) cannot be read (evaluated) because of the clouds. The orientation results for Image Pictures numbered as 14363, 14364, 14365, 14366, 14367, and 14368 are showed on Figure 3, Figure 4, Figure 5, Figure 6, Figure 7 and Figure 8 respectively. On the other hand the result of the block adjustment are adjusted with the results of the adjustment of GCPs and TPs to control and check by selecting the comparison points. The result of the block adjustment which belongs to the six images is presented as Table 1. As a result RMSE X= 0,64 m. RMSE Y= 0,55 m. for 42 GCPs, RMSE X= 0,22m RMSE Y=0,07m. for 24 TPs. To determine the absolute accuracy some GCPs are selected as comparison points and the adjusted coordinates are compared with the coordinates calculated geodetically (Table 2). As the result of the block comparison adjustment, RMSE X= 0,66 m. RMS Y= 0,57 m. for 33 GCPs, RMSE X= 0,64 m. RMSE Y= 0,60 m. for 9 comparison points, RMSE X= 0,22 m. RMSE Y= 0,07 m. for 24 TPs.

4.2 Aerial photos for Test Area

The Project of the Production of Digital Photogrammetric Maps at Urban Areas in Scale 1/1000 covers Sakarya, Kocaeli and Yalova cities and 600 km2. For Digital Photogrammetric Map Production eight (8) Black/White aerial photos in 1/4000 scale are used.

For test area GCPs are established, surveyed and calculated, also Photogrammetric Points are established, GCPs are marked. All control points which have C1 and C2 degrees are used in the project. New control points are established around the block, at least six (6) photogrammetric points in each km2 are set homogeneously. While surveying GCPs geodetic GPS receivers which have double- and single-frequency, capable of simultaneously recording at least six (6) satellites are used with the static and fast method. Table 3 shows number of all

[3] What are C1, C2 and C3? C1:The points that are based on the high degree of networks and have 15-20 km base length between them. C2: The points that are based on the high degree of networks and have 5 km average edge length between them. C3: The points that are based on the high degree of networks and have 3 km average edge length between them.

points established in the area with columns “Number of Points on Sheets”, “Number of GCPs”, “Number of Photogrammetric Points” and “Number of Cadastral Points”.

Black/White (B/W) aerial films are scanned at 14 microns pixel size. Each picture scanned is checked in the view of the distribution of grey tone, and brightness and sharpness adjustments then the problematic photos are re-scanned. In the test area 910 aerial photos in Yalova, 850 aerial photos in Kocaeli, 913 aerial photos in Sakarya, totally 2673 aerial photos are scanned. PHODIS PAT software is used for aerial triangulation and measurements. The measurements are adjusted by PATB-GPS software. Inner orientation results, the distribution of model and colon tie points, internal and external reliability measures are examined. Generally inner orientation values are less than 5 microns.

DEM is created by using MATCH-T software. All DTM points edited are inserted in required format to produce orthophotos. For the production “pixel by pixel” method for geometry, “bicubic” method for radiometry and 1/1000 output scale are selected.

5. Evaluation of the orthoimages and the digital photogrammetric maps with the cadastral surveys

8 ones of 913 Black/White aerial photos in 1/4000 scale in Sakarya city of The Marmara Region are used for Hendek (district of Sakarya) to test. On the other hand IKONOS satellite images are provided. While orthoimages are produced in 1/5000 scale from IKONOS images the digital photogrammetric maps are produced in 1/1000 scale at 10 m. Ground Sample Distance (GSD) from aerial photos. Then the orthophotos (orthoimages) derived from satellite images, digital photogrammetric maps and actual cadastral surveys are compared. Check points and the coordinates on actual cadastral surveys, actual digital photogrammetric maps and IKONOS orthophoto maps are shown in Table 4. Then the comparison of “Cadastral Survey and Actual Photogrammetric Map”, “Cadastral Survey and Satellite Orthophoto” and “Actual Photogrammetric Map and Satellite Orthophoto” are presented in Table 5, Table 6 and Table 7 respectively.

The basic aim in this paper is to compare the satellite images and the digital photogrammetric maps with the cadastral surveys for cadastral renovation. Therefore especially the results of Table 5 and Table 6 are much more important. As seen at Table 5,

Table 6 and Table 7 the least RMSE value belongs to the comparison of Cadastral Survey and Actual Photogrammetric Map with values Dy=-0,05 Dx=-0,16 Ds=0,67.

It means that digital photogrammetric maps, in other words aerial photos, have closer measurement value to the desired measurement result than the satellite images have.

6. Conclusion

Cadastral data is important for decision making and it is basic for many computer_based spatial applications. Therefore it should have the required accuracy and actuality. In Turkey the cadastre has different processes such as textually, graphically and digitally, also different methods, sheet types, coordinate systems and location accuracies. Today some cadastral bases, except orthogonally and digitally produced ones, have lost their actualities. It means that there are important conflicts between sheets and fields. In the scope of the legal arrangements the renovation of the cadastral measurements is needed and the studies are started in Turkey. It is possible and useful to combine modern technologies such as GPS/DGPS, digital orthophoto production from aerial or satellite images, geodatabases, and even mobile technology for cadastre. This paper aims to present an alternative solution versus field surveying for cadastre renovation: The first method is photogrammetric techniques and the second one is satellite images. Hendek in Sakarya is selected as a case study. Finally it is researched whether if the digital photogrammetric maps and satellite images are usable or unusable for the production of the cadastral maps.

As a result the detail measurement accuracy on orthophotos from IKONOS is the value between +/-2 m. and +/-3 m. RMSE. It means that IKONOS satellite images are not suitable for 1:1000 and 1:5000 scale map production standards in Turkey. Therefore IKONOS satellite images (orthoimages-orthophotos) are not suitable for cadastral renovation by vectorization of orthoimages. This method can be used for quality control of cadastral renovation and decision making. But also it is tested that 1:1000 scale vector maps derived from aerial photos which have 10 m. GSD are suitable for cadastral renovation and quality control of cadastral data.

This study addresses that the aerial photos, which have GSD of 10 m. resolution are usable for cadastre renovation. To use orthophotos for renovation can be a useful way through the accuracy, applicable, reliable and cost of orthophoto. Therefore it helps the studies on the way of “fast cadastre” or “mobile cadastre”. Photogrammetric maps will save time and cost

for field surveying. Orthophotos and true orthophotos[4] can be produced for cadastral applications. Also they are useful to update and maintain cadastral GIS (geographic information system) databases because the reliable cadastral data is the basic of the land management policies and sustainable development.

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[4] True orthophoto: is an orthophoto with geometric corrections applied to position the buildings and other features in their exact geographic locations.

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