MULTIPURPOSE USE OF ORTHOPHOTO MAPS FORMING BASIS TO DIGITAL CADASTRE DATA AND THE VISION OF THE GENERAL DIRECTORATE OF LAND REGISTRY AND CADASTRE

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ABSTRACT

The General Directorate of Land Registry and Cadastre (GDLRC) has started 1/5000 scale standard topographic map production by aerial image acquisition and photogrammetry in 1955 in order to complete initial cadastre within a short time in rural areas. Aerial photographs taken and 1/5000 scale standard topographic maps produced since 1955 have made a great contribution to the completion of Turkish Cadastre and have been used by public institutions and organizations at engineering services and applications. The aerial photographs of approximately 480.000 km² out of 500.000 km² area, whose 1/5000 scale maps are intended to be produced with respect to the development plans, were taken between 1955–2007 and 1/5000 scale standard topographic map production was completed belonging to that area. The aerial photographs located in the achieve of the General Directorate of Land Registry and Cadastre were taken in an approximate scale of 1/16.000 and with 60% forward & 30% side laps stereoscopically with the purpose of 1/5000 scale standard topographic map production and identification in order to complete initial cadastre rapidly. The aerial photographs covering this 480.000 km² area consist of about 1600 rolls and 150.000 photographs. The GDLRC is an institution that produces, manages and improves the important parts of Turkish National Geographic Information System's main spatial basis such as geodesy, cadastre, metadata and orthophoto and provides services to another institutions and organizations. In this context, satellite images and aerial photographs forming one of the essential layers of spatial information systems, acquired by remote sensing instruments have a great importance taking the necessity of image base into consideration. The GDLRC, which conducts valuable projects in this area, has actualized the Orthophoto Information System. The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera purchased in 2009, 1/5000 scale digital colored orthophoto map production of an area of approximately 310.000 km^2 was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works. In this study, the use areas of orthophoto maps produced and the vision of GDLRC related to the production/use of the orthophoto are discussed.

KEY WORDS: Aerial Photograph, Orthophoto, Photogrammetry, Decision-Support, Quality-Integrity Control, Geographic Information System

INTRODUCTION

The demand for geographic/spatial information in Turkey and World is increasing day by day. As a result, geographic information in various qualities is produced by different organizations and institutions using different sources with different methods. The GDLRC is an institution that produces, manages and improves the important parts of Turkish National Geographic Information System's main spatial basis such as geodesy, cadastre, metadata and orthophoto and provides services to another institutions and organizations. In this context, satellite images and aerial photographs forming one of the essential layer of spatial information systems, acquired by remote sensing instruments have a great importance taking the necessity of image base into consideration. The GDLRC, which conducts valuable projects in this subject, has actualized the Orthophoto Information System. The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera purchased in 2009, 1/5000 scale digital colored orthophoto map production of an area of 305.700 km^2 was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.

ORTHOPHOTO AND ORTHOPHOTO MAP

An orthophoto, orthophotograph or orthoimage is an aerial photograph geometrically corrected (orthorectified) such that the scale is uniform; the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt. An orthophoto map can be defined as an orthophoto having cartographic information on it and produced with respect a certain map sheet system. An orthomosaic is obtained by combining more than one orthophoto on a single base.

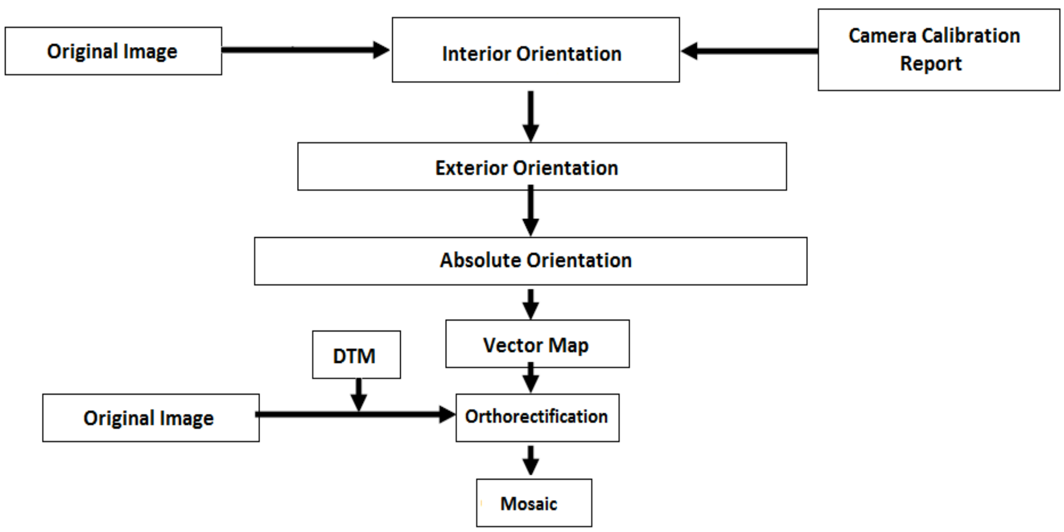

Figure 1. Orthophoto Flow Diagram

True Ortofoto

The term true orthophoto is generally used for an orthophoto where surface elements that are not included in the digital terrain model are also rectified to the orthogonal projection. Those elements are usually buildings and bridges. Even though the GDLRC has the capability to produce true orthophoto, this kind of production is not performed with respect to the institution policy.

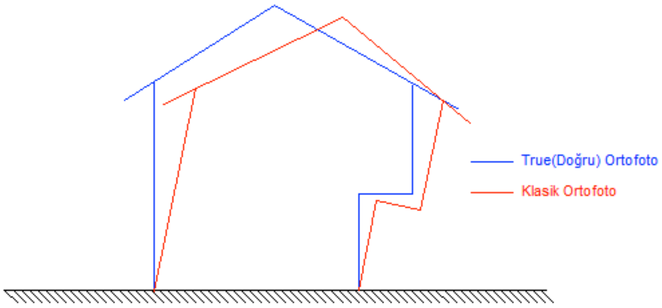

Figure 2. True vs. Classic Orthophoto

Near Infrared (NIR) Orthophoto

Color contrast is quite high in infrared orthophotos. Therefore, they are used effectively in vegetation classification, tree classification and health status determination.

Figure 3. RGB & NIR Orthophoto

Image base requirement for national spatial database

One of the main components of spatial information systems is image layer, which includes satellite images and aerial photographs obtained by remote sensing instruments. According to the researches done for determining the usability of aerial photographs against satellite images, it was found out that aerial photographs are fast and reliable source for establishing image basis. Besides, their production cost is lower than satellite data.

Moreover, the investigations done for meeting the requirements of different organizations and institutions showed that aerial photographs are the most reliable source since they provide more accurate, up-to-date and cloudless information.

Orthophoto production in the GDLRC

In order to complete first cadastre within a short time, 1/5000 scaled base map production has been carried out over 480.000 km^2 area since 1955 by photogrammetric method meaning map production from aerial photography, and digital colored orthophoto production has been carried out since 2009 for the purposes of decision-support, quality control and establishing legal basis within the context of renewal and update Works.

Hardware and Technology

Flight services for aerial image acquisition are provided by 1 airplane with special equipment in the institution. Apart from institution's own need, service for map production is given to private sector as well against remuneration set by Circulating Capital Enterprise.

Figure 4. Airplane of GDLRC

In 2009, ZI/DMC Digital Aerial Camera was purchased for the purpose of digital orthophoto production.

Figure 5. DMC Digital Aerial Camera

Digital aerial camera was mounted on the institution's ISLANDER BN-2T airplane. It performs aerial image acquisition of approximately 60.000 – 70.000 km^2 area per year.

With this system, photogrammetric map production costs have been decreased 26% and the opportunity of high quality digital service has been provided.

In the institution, there are two storage units to store the raw flight data and orthophotos. Besides, hardware and software for flight planning, GPS/IMU calculations, digital image processing, stereo assessment and orthophoto production are present.

Figure 6. Photogrammetric Hardware and Software

Digital Colored Orthophoto Production Studies in the GDLRC

The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera taken in 2009, 1/5000 scale digital colored orthophoto map production of an area of approximately 310.000 km^2 was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.

Figure 7. 1/5000 Scale Digital Colored Orthophoto Production Areas

Products and Quality Works

The Digital Mapping Camera (DMC) has eight cameras. There are four panchromatic cameras with a 7.000 x 4.000 pixel array and four multi-spectral cameras with a 3.000 x 2.000 pixel array. The raw data for each of the cameras is stored in separate partitions on the FDS units. The final output from the post processing are high resolution panchromatic, color, and color infrared images with a 12 micron resolution and an image size of 7.680 x 13.824 pixels.

The spectral sensitivity in images is 400-580 nm for blue band, 500-650 nm for green band and 675-850 nm for red band. The radiometric resolution is 12 bits.

The Ground Sampling Distance (GSD) of the images is 30 cm, which means the image acquisition is performed from 3.000 m above the terrain. The images are 99,9% cloudless, which are gathered between May and October.

CORS-TR data is used at geodetic works and GPS/INS assessments. The ground control points have 1-2 cm positional accuracy. Within this context, the positional accuracy in photogrammetric triangulation is approximately 1/4 of the pixel size, whereas height accuracy is about 1/3 of the pixel size.

The positional accuracy of orthophotos is around 1 - 1,5 pixel size. From the sectoral priorities point of view, the maps produced are infrastructure investment service for developing agriculture, education, health, technological research, transportation, irrigation, e-state and information & communication technologies. From the regional priorities point of view, the maps produced are used as an effective tool for reducing interregional development levels.

GEO-METADATA WEB PORTAL

The purpose of establishing Geo-Metadata Web Portal is collecting all kind of map information from different sources under a single roof, combining it in a portal structure and presenting this information to users. After completing the project in 07.07.2008, announcing it to the related public institutions and organizations and providing online service from the website of http://hbb.tkgm.gov.tr/metadata/;

- Producing duplicate maps by different public institutions and organizations is prevented.
- Final numbers for ground control points are started to be given from a single center. So, duplicate numbering and duplicate geodetic point establishment are prevented.
- Geodetic point analyze can be done before going to field, approximate coordinates can be seen and planning can be done accordingly.
- Existence of any 1/5000 scale maps can be queried. If a 1/5000 scale map has been produced, the producing institution can be identified.
- Queries can be performed such as when, where and what kind of maps were produced by any institution and detailed information can be reached.
- Since it is not necessary to come to the institution to get information and learn all these things, time and cost saving is provided.

It is a Spatial Information System in portal structure developed for enabling relevant institutions to access online, update and present metadata relating to information and documents of maps produced by mapping agencies and institutions and preventing waste of resources caused by duplicate map production as a result.

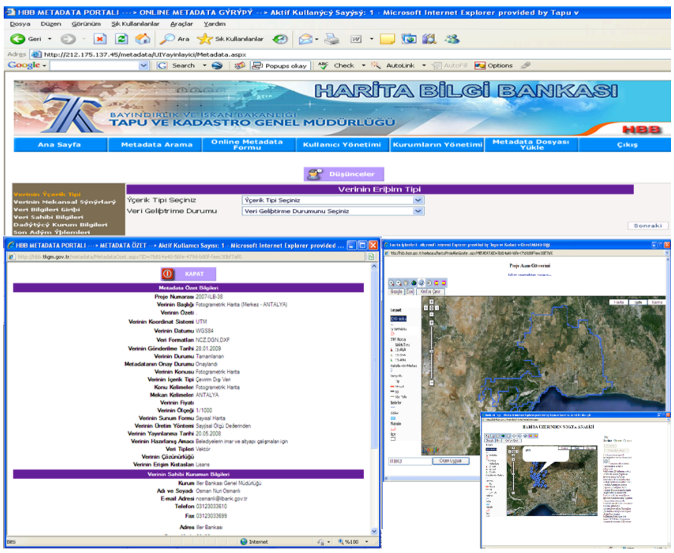

Figure 8. Geo-metadata Web Portal

ARCHIving and web services

The General Directorate of Land Registry and Cadastre has started a test project in 2010 in order to share digital orthophoto maps on web, which are produced regarding to the institutional requirements and taken from other institutions with the protocols done.

The test project for presentation of 1/5000 scale orthophoto/base maps on http://www.tucbs.gov.tr still continues, which are produced to be used in decision-making processes, quality-integrity controls and base for legal aspects in digital cadastre works and other institutions' large scale engineering projects.

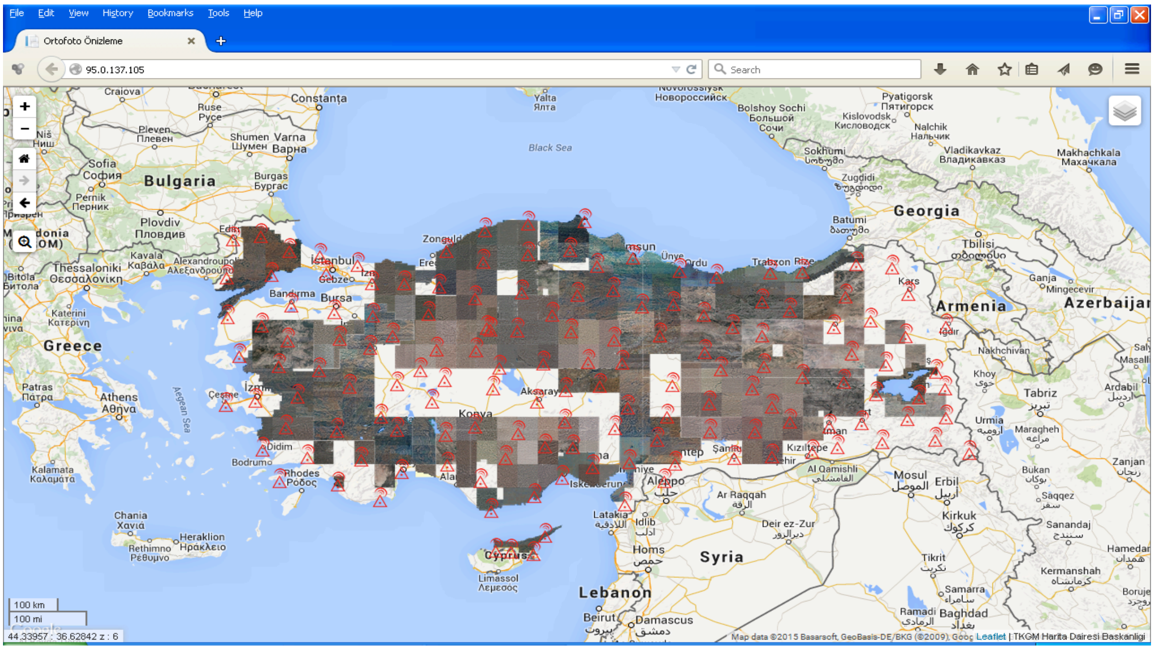

Figure 9. Orthophoto WEB Services

Besides, existing orthophotos produced by other institutions are taken as services and in magnetic environments. The obtained orthophoto maps and services are presented as WMS/TMS/WMTS.

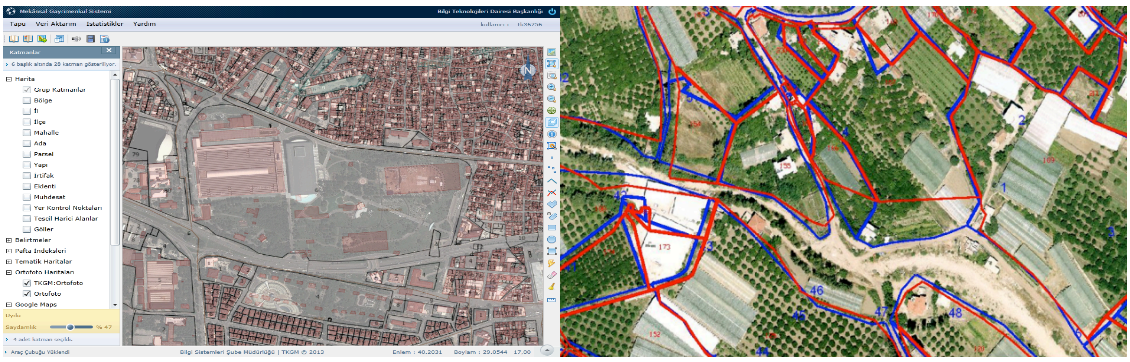

Figure 10. a) Orthophoto Web Service b) Superimposition of Parcel Data on Orthophoto

Produced and provided orthophoto maps are opened to the use of our directorates by giving services to the one of the most important projects of our institution namely Land Registry and Cadastre Information System (TAKBİS). In this context, web services of orthophoto maps produced by both our institution and other institutions were created. Web services are also provided to the use of institutional users outside the General Directorate of Land Registry and Cadastre.

PROJECT OF ORTHOPHOTO PRODUCTION WITH APPROXIMATE ACCURACY FROM OLD-DATED AERIAL PHOTOGRAPHS

Production of Digital Orthophoto with approximate accuracy from old-dated aerial photographs in order to establish basis for decision support processes before and during renewal; accuracy & integrity checks after renewal; and legal aspect of renewal at works of renewal and update of cadastral maps.

Figure 11. Scanned Aerial Photograph

Old-dated aerial photographs within the archive of the GDLRC and the General Command of Mapping (GCM), whose orthophotos were not produced, are demanded and used by Cadastre Directorates at renewal and update of cadastral maps.

It is quite hard to use these images at cadastral works, which are not in orthophoto format, having no coordinates & scale and including errors arising from field slope.

Black/white orthophoto map production with approximate accuracy from old-dated aerial photographs of total 55.000 km^2 area including the city borders of Istanbul (5.000 km^2) and Ankara (50.000 km^2) was carried out by service procurement in 2012 and delivered to Cadastre Directorates.

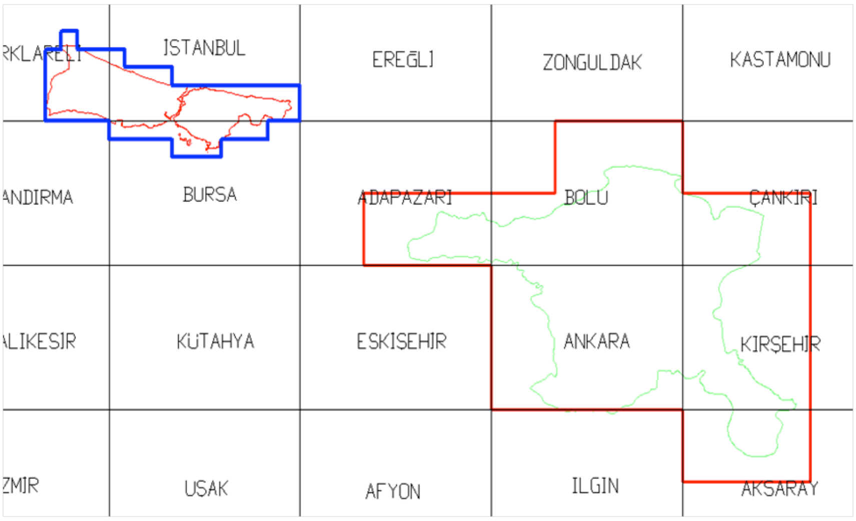

Figure 12. Pilot Projects

TURKISH NATIONAL GEOGRAPHIC INFORMATION SYSTEM (TUCBS)

The Feasibility Etude Report of Geographic Information System Infrastructure Establishment operated under the responsibility of the General Directorate of Land Registry and Cadastre was prepared and submitted to the Ministry of Development (Secretariat of the State Planning Organization) in 27.01.2011.

Since the mission of establishment and improvement of National Geographic Information System was given to the General Directorate of Geographic Information Systems, which was founded regarding to the statutory decree numbered 644, the related studies are carried out by the General Directorate of Geographic Information Systems.

"Geographic Information Infrastructure Establishment Project" was performed under the responsibility of the General Directorate of Land Registry and Cadastre with respect to the action no 75 in action plan under the topic of Modernization of Information Society Strategy in Public Administration, published in official gazette dated 28/07/2006 & numbered 26242 proposing the presentation of information from the place where it is produced.

Turkish National Geographic Information System is an e-state project that aims to establish Geographic Information System infrastructure complying with national level technological advancements and INSPIRE Directive, to create web portal with the purpose of presenting geographic information under the responsibility of public institutions and organizations to the users through a joint infrastructure and to define the standards of content for geographic information as meeting the requirements of all user institutions.

RESULTS

In order to complete first cadastre within a short time, 1/5000 scaled base map production has been carried out over 480.000 km^2 area since 1955 by photogrammetric method meaning map production from aerial photography.

The GDLRC follows the latest technological improvements in the world closely and acts as a locomotive in the sector successfully. With the digital aerial camera purchased in 2009, 1/5000 scale digital colored orthophoto map production of an area of approximately 310.000 km^2 was done throughout the country. These products are to be used for the purposes of decision-support, quality-integrity control and establishing legal basis within the context of renewal and update works.

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TÜRKİYE'DE TRUE ORTOFOTO ÜRETİMİ PROJESİ

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ÖZET

Doğal Afet Sigortaları Kurumu (DASK) tarafından ihalesi yapılan ve Teknik Koordin rlüğü Çevre ve Şehircilik Bakanlığı (ÇŞB) Coğrafi Bilgi Sistemleri Genel Müdürlüğü (CBSGM) tarafından yürütülen "Gerçek (True) Ort ğrafi Veri Üretimi" projesi Türkiye'nin tüm il ve ilçelerini kapsamaktadır. Kapsam bakımından dünyada ilk olan çalışmalar içinde yer lan proje kentlerin yerleşim ve gelişim alanlarını kapsayacak şekilde yüksek çözünürlüklü ortofoto üretimi, bina envanterinin çıkart ve güncel yol bilgilerinin elde edilmesini sağlayacaktır. Proje; mevcut ve yeni kurulan büyükşehir belediyeleri merkez ve ilçele ri, tüm il ve ilçe merkezlerini, yerleşim potansiyeline sahip olan tüm kıyı bölgelerini, yatırım ve turizm potansiyeli olan alanları ve öncelikli afet bölgelerini kapsamaktadır. Bilgi sistemleri kapsamında yapılan proje incelemelerinde, birbirleri ile ilişkisi bulunm ayan, kendi bağımsız katı bürokrasisi içinde üretimlerin tekrarlı olarak gerçekleştirilmiş olduğu belirlenmiştir. Buna göre ortofoto ve ini 12 bakanlık 73 farklı iş ve projede, coğrafi bina verilerini 11 bakanlık 76 farklı iş ve projede 42 farklı mevzuat çerçevesinde üretmekte ve/veya kullanmaktadır. Proje, programına uygun olarak devam etmekte, Eylül-Ekim aylarında yaklaşık olarak 15 ilin merkez ve ilçe merkezlerine ait havadan görüntü alımı tamamlanmıştır. Gelişen ve değişen Türkiye'de, planlara altlık olacak üretimi gerçekleştirilen yüksek çözünürlüklü ortofoto üretimi zaman ve maliyet açısından da yerel yönetimlerin çalışmalarında fayda sağlamaktadır. Bu çalışmada projenin Türkiye'de kullanımı, şehirlerde yapılan kadastro yenileme projelerindeki karar-destek temine katkısı ve çevre ülkelerde yapılacak bu tür çalışmalarda model olacak öneriler anlatılmaktadır.

**Full paper is not submitted.*

STUDY OF USABILITY OF ORTHOPHOTO AND HIGH RESOLUTION SATELLITE IMAGES IN CADASTRE RENEWAL WORKS IN TURKEY

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ABSTRACT

The fact that cadastre is a living phenomenon and it needs to be updated constantly has become even more apparent with recent technological developments. If the usability of especially orthophoto and high resolution satellite images in cadastre renewal works is ensured, the state cadastre can be maintaned constantly updated. For this purpose, 3 pilot areas in Konya, Adana and Şanlıurfa were selected. In these areas detail acquisition was made with Cors method by using GPS. The coordinates were obtained by using orthophotos of 1/1000 and 1/2000 scale in Konya, orthophotos of 1/5000 scale in Adana and WorldView-2 high resolution satellite images of 1/5000 scale in Şanlıurfa in Erdas program. The positional accuracy of the data obtained from digital orthophoto and area accuracy in comparison with cadastral areas were attempted to be established by presuming that geodesic coordinates were accurate. Moreover, cost analyses of all three methods were carried out. In light of the discovered results, comments on the usability of orthophoto and high definiton satellite images in renewal cadastre were made.

Keywords: Cadastre, renewal, orthophoto, high definiton satellite images

INTRODUCTION

Cadastre, in its simplest sense, is the establishment and demonstration of the geometric and legal status of real estates. International Cadastre Association (FIG) defines cadastre as; “The information system which has a key function in the fulfillment of societal, cultural and economic development, guarantees the constitutional security of land and realty property rights, ensures the protection of various information on land and buildings.” (Anonymous, 2006).

In the 2014 cadastral report which has been adapted by all countries, the explanation “Cadastre is systematically organized public inventories of proprietary data of a state or an area boundaries of which have been established based on a scale. Legal land objects are systematically established with different indication meanings. This land object is defined by public or private law. The outlines of the real estate, meaning the properties, size, value and legal rights of each descriptive land object, are demonstrated by special data and limitations associated with land objects" was given as a definition (Yomralıoğlu et. al, 2003).

The amendment made in Law no. 5304 has not been implemented in accordance with the purpose aimed in 22-a implementations. With the amendment to the "a" clause of the 22th article, in this section which starts with the word "However" the fact that provision of the first subclause shall not be applied in registered and cadastred places to eliminate errors arising from limitation measurements, illustrations and calculations on "land registration" cadastre or amendment process, with the purpose of re-arranging and ensuring the necessary corrections are made in land registry of cadastral maps which have lost the implementation characteristics, are insufficient due to technical reasons, are deemed to be lacking and have been established to be inaccurate in terms of ground boundaries has been stated and an exceptional case has been indicated (Sarı, 2009).

The aim of the thesis is to put forth whether orthophoto and high resolution satellite images can be used in cadastre renewal works or not.

With this purpose and purpose of comparing cost and area data, test areas were created. The details of test areas, Adana / Karataş/ Çakıören and Gökçeli districts (villages), Şanlıurfa/Akçakale/Deniz ve Aydınlı districts (villages) and Konya /Selçuklu/ Dokuz and Aşağıpınarbaşı districts (villages) were measured with GPS (CORS method).

As the cadastre works in Turkey are generally done in rural areas, selected areas are also of rural nature. The lands selected in Adana / Karataş / Gökçeli and Çakıören are partially orange groves. Moreover, they are wetlands and have changed shape due to drainage works. The districts of Konya /Selçuklu/ Dokuz and Aşağıpınarbaşı are near to Selçuk University campus and are in a zone which is open to the influence of urbanization. Whereas Şanlıurfa /Akçakale / Deniz and Aydınlı are in a zone which borders on Syria and of which agricultural activities and land values have increased, along with its irrigation activities, with Southeastern Anatolia Project (GAP).

Cadastral sheets of 1/1000, 1/2000 and 1/5000 scales were digitized, geodesic ground measurement was made, orthophoto vector data of 1/5000 scale and 1/5000 orthophoto 50 cm resolution satellite images (worldwiev -2) were worked with. Analyses were made by presuming geodesic measurements as accurate, comparing the data obtained with this method and data obtained from other methods and taking cadastre renewal and Large Scale Map and Map Information Production Regulation.

MATERIAL METHOD

Implemention zones in 3 different areas were selected to put forth whether orthophoto and high resolution satellite images can be used in cadastre renewal works. These zones;

1- Adana province Karataş county Çakıören and Gökçeli districts
2- Şanlıurfa province Akçakale county Deniz and Aydınlı districts
3- Konya province center county Dokuz and Aşağı Pınarbaşı districts

areas in the size of blocks were selected.
About these zones:

1- Cadastral map sheets and scientific files were procured from Adana, Şanlıurfa and Konya Land Registry and Cadastre Directorates..
2- Orthophoto images of 1/5000 scale and vector maps of Adana-Karataş Area obtained from photogrammetric flights, orthophoto images of both 1/1000 and 1/2000 scale and vector map data of Konya-Selçuklu Area obtained from photogrammetric flights and orthophoto images of 1/5000 scale and vector map data of Şanlıurfa-Akçakale obtained from satellite images were used.

ADANA – KARATAŞ - GÖKÇELİ AND ÇAKIRÖREN DISTRICT STUDY AREA

Gökçeli and Çakırören villages are residential areas which have been transformed into district status in the boundaries of Karataş municipality with the metropolitan Law no. 6360 while they were formerly villages of Karataş county in Adana.

These villages are located on the highway of Adana-Karataş. Cadastral sheets no. MERSİN O34-c-13-D and MERSİN O34-c-02-b (in 1/5000 scale) and scientific files of our study area Adana province Karataş county were procured from Adana Cadastre Directorate. The cadastral works in the aformentioned villages were carried out photogrammetrically in 1970 by the General Directorate of Land Registry and Cadastre.

The selected area in Çakırören village is located on the west of Adana-Karataş highway. The land is used as a field. As the ground water level is high, many drainage works have been carried out and drainage channels have been opened.

Gökçeli village is also located on Adana-Karataş highway. This highway divides our study area. The land is used more as an orange grove and partially as a field. A big channel runs through our study area and drainage channels were also installed in this area.

Vector data and orthophoto images of 1/5000 scale which contain Çakırören and Gökçeli Districts were procured from General Directorate of Agricultural Reform.

2.2 ŞANLIURFA – AKÇAKALE - AYDINLI and DENİZ DISTRICT STUDY AREA

Şanlıurfa province, Akçakale county, Aydınlı and Deniz Districts are in a zone which is very close to the Syrian border. Uğurtaş village became Deniz village by being divided later on. It is an area to be irrigated in the scope of GAP project and irrigation facility constructions by General Directorate of State Hydraulic Works still continue.

Again cadastral sheets no. SURUÇ O41-a-14-b, SURUÇ O41-a-14-C, SURUÇ O41-a-08-d and scientific files of Şanlıurfa province Akçakale County was procured. The cadastral works in the aformentioned villages were carried out photogrammetrically in 1973 by the General Directorate of Land Registry and Cadastre.

Orthophoto images and vector data of O41-a-14 –b, O41-a-14-c and O41-a-08-d 1/5000 scale were procured from General Directorate of Agricultural Reform.

KONYA – SELÇUKLU - DOKUZ AND AŞAĞI PINARBAŞI DISTRICT STUDY AREA

Dokuz and Aşağıpınarbaşı Districts are residential areas within the boundaries of Selçuklu county in Konya Metropolitan region. These villages are located on the 25th kilometer of Konya-Ankara highway. Transportation is provided by public transport buses of Konya Metropolitan Municipality. The villages are generally dominated by faming and animal husbandry is also the main source of income in the villages. Residential units in the villages largely consist of single-storey mudbrick buildings. The farm lands of the village have a flat geography and agricultural irrigation is ensured with the wells located on land. Facility cadastre of the village was completed in 1952 for the village and in 1957 for the agricultural area.

Cadastral sheets of Konya Province Selçuklu County Dokuz District was procured from Konya Cadastre Directorate.

Scientific files of Dokuz and Aşağıpınarbaşı villages were procured from Konya Cadastre Directorate.

Orthophoto images and vector data of L29-d-21-a-2-c, L29-d-21-a-3-b, L29-d-21-a-3-c, L29-d-21-a-1-d, L29-d-21-a-4-a and L29-d-21-a-4-d, 1/1000 scale were procured from Konya Metropolitan Municipality.

Orthophoto images belonging to sheets no. L29-D-21-B-1 ve L29-D21-B-4 of 1/2000 scale were produced as Ground Sampling Interval = 20 cm from Leica Photogrammetric System (CPS) software.

IMPLEMENTATION

Areas in the size of blocks in Adana province Karataş county Çakırören and Gökçeli villages, Şanlıurfa province Akçakale county Deniz and Geldiğen villages, and Konya province center county Dokuz and Aşağıpınarbaşı villages were selected as implementation sites.

Detail measurements of our study areas were carried out with TUSAGA active system by utilizing Cors TR reference stations. Utilized TUSAGA active points are ADAN station for Adana Karataş, SURF station for Şanlıurfa Akçakale and KNYA station for Konya.

In detail measurements, a mobile receiver GNSS of SOUTH brand was used. In mobile receiver, data collection interval was at 1 sec. and satellite elevation angle was set at 10^{o}.

ADANA –KARATAŞ- ÇAKIRÖREN AND GÖKÇELİ DISTRICTS STUDY AREA

Transformation of the cadastral sheets no. MERSİN O34-c-13-d and MERSİN O34-c-02-b of our Study Area Çakırören and Gökçeli districts was made in NETCAD program. As the result of affine transformation, root mean square error was obtained as 0.29 m for O34-c-13-d sheet and as 0.29 for O34-c-02-b sheet. Vector data was obtained from the transformed sheets.

An area of one block consisting of 166 to 207 parcels and 231 to 256 parcels selected in Çakıören village was measured with cors method with South 582 GNSS Rover GPS device. For utilized TUSAGA active points Adana Karataş, ADAN station was used.

44, 45, 48, 57, 58, 62, 64, 65, 117 to 121 and 137 to 165 parcels, and their sub-parcels selected in the determined Study Area of Gökçeli village were measured with cors method with South 582 GNSS Rover GPS device.

Cadastral sheet was digitized. Transformation to ITRF system was made bu using the transformation parameters.

Parcel amalgamations were made with the help of Netcad program by transferring land measurement values obtained from GPS measuring device. After the transformation of the cadastral sheets, of which vector maps were made, to ITRF DATUM, they were superposed with land data. Cadastral sheet and ground measurement were superposed (Figure 3.1).

Figure 3.1 : Adana Province Karataş County Gökçeli District land and cadastral status

Area measurements of parcels no. 160, 166, 167, 168, 169, 174, 207, 219, 229, 231, 232, 243, 244, 245, 246, 257, 258, 259, 260, 262 in O34-c-13-d sheet of Çakıören District were made by using NETCAD software.

Area measurement was made by digitizing the cadastral sheet no. O34-c-13-d obtained from Adana Cadastre Directorate.

The coordinate values of parcels no. 207, 219, 232, 231, 230, 229, 227, 262, 260, 259, 258, 257, 246, 245, 244, 243, 174, 160, 169, 168, 167, 166, 161, 196 in O34-c-13-d sheet of Çakırören District were obtained in Erdas 8.1 software and area measurement was made from orthophoto.

Area measurements were made after transferring the coordinates of points belonging to the parcels to NETCAD media and forming the shape of the parcel.

Area measurement was made by digitizing the cadastral sheet no. O34-c-13-d obtained from Adana Cadastre Directorate.

Areas which were measured in the land belonging to the parcels in the study area, were registered in land records, were obtained from orthophoto and vector drawing and areas which were obtained as the result of the digitization of cadastral sheet were compared. Tolerance margin quantity (df), M scaling denominator, F; an area in m2 unit was calculated with:
df = 0,013 * (M.F)1/2 + 0,0003 * F (Table 3.1) .

Table 3.1 : Adana Province Karataş County Gökçeli District Area Measurement

BÖLGE ADI	PARSEL NO	ARAZİ ALANI	TAPU ALANI	KADASTRO ALANI	ORTOFOTO ALANI	VEKTÖR ALANI	FARK	TECVİZ SINIRI	TECVİZİN 3 KATI	SONUÇ
Adana İli - Karataş İlçesi - Gökçeli Mahallesi	48	15605.79	14900	14666.87	15606.42	14934.88	705.79	116.68	350.04	RED
	53	23524.64	24200	20034.85	23525.58	26580.87	675.36	150.26	450.78	RED
	57	13265.48	17500	13642.63	13361.08	13786.33	4234.52	126.85	380.55	RED
	52	8369.18	8450	8391.09	9223.23	8229.45	80.82	87.04	261.12	KABUL
	64	20681.41	19400	21071.67	22357.58	22064.29	1281.41	133.86	401.58	RED
	65	12435.57	11400	13447.55	10878.33	10738.92	1035.57	101.57	304.71	RED
	117	25976.93	26990	26786.86	26359.79	26499.77	1013.07	159.12	477.36	RED
	118	27006.5	26990	26139.69	26915.46	30006.6	16.50	159.12	477.36	KABUL
	119	29662.45	26990	29841.61	30359.82	31361.83	2672.45	159.12	477.36	RED
	120	26368.13	26990	25099.43	26595.65	24440.84	621.87	159.12	477.36	RED
	121	27492.75	26990	25365.11	27493.85	27712.98	502.75	159.12	477.36	RED
	146	21829.04	21274.5	22903.53	20278.46	20721.96	554.55	140.46	421.38	RED
	147	11828.17	11741.9	12462.26	12005.87	12621.78	86.24	103.13	309.39	KABUL
	148	15209.89	14228.4	15265.72	16479.18	14768.85	981.52	113.92	341.76	RED
	155	164914.28	165200	155703.51	176267.57	171423.37	285.72	423.18	1269.54	KABUL
	156	43167.79	43500	43364.61	43169.51	42625.06	332.21	204.77	614.31	KABUL
	157	195402.83	199800	199681.04	196163.93	195357.3	4397.17	470.83	1412.49	RED
	158	47202.89	48400	48348.66	46578.13	48823.54	1197.11	216.75	650.25	RED
	163	23312.46	22300	22329.11	23617.94	20315.32	1012.46	143.96	431.88	RED
	164	22501.55	22300	23246.08	22202.22	23849.59	201.55	143.96	431.88	KABUL
	165	43106.6	42760	42686.64	42796.27	41346.89	346.60	202.91	608.73	KABUL

ŞANLIURFA-AKÇAKALE-DENİZ AND AYDINLI DISTRICTS STUDY AREA

Cadastral sheets no. SURUÇ O-41-a-14-b, SURUÇ O-41-a-14-C, SURUÇ O-41-a-08-d of Şanlıurfa province Akçakale County were obtained from Şanlıurfa Cadastre Directorate and digitized.

Akçakale county Aydınlı district parcels of 137 to 180 and Deniz district parcels of 81, 127 to 129, 132 to 145 were measured with with cors method with South 582 GNSS Rover GPS device. For utilized TUSAGA active points Şanlıurfa Akçakale, SURF station was used.

Digitized cadastral sheet coordinates were transformed from UTM coordinates to ITRF coordinates. Area measurement was made by using Netcad program.
Area measurement was made by digitizing the cadastral sheets no. O41-a-08-d, O41-a-14-b and O41-a-14-c obtained from Şanlıurfa Cadastre Directorate.
Area measurement was made from digitized satellite images.
Area measurement was made from the vector map obtained from the General Directorate of Agricultural Reform.

Land title area and land area, areas obtained from orthophoto, areas obtained from vector orthophoto and areas obtained from cadastral sheet were compared. Tolerance margin was measured according to scale of 1/5000 and parcels in and out of the tolerance margin were determined.

By taking the cadastral sheet scale of parcel areas into consideration with the purpose of control and measuring the surface areas with graphic method, the surface area in the land title and its usage status in the land, parcel areas digitized from orthophoto and parcel areas obtained from vector orthophoto were compared. Tolerance margin quantity (df), M scaling denominator, F; an area in m2 unit was calculated with:

df = 0,013 * (M.F)1/2 + 0,0003 * F

Konya- CENTER –Dokuz AND A.pınarbaşı DISTRICT STUDY AREA

Cadastral sheets of no. Konya L29-d-21-a-2-c, L29-d-21-a-3-b, L29-d-21-a-3-c, L29-d-21-b-1-d, L29-d-21-b-4-a, L29-d-21-b-4-d, L29-d-21-b-1, L29-d-21-b-4 belonging to Dokuz and Aşağıpınarbaşı districts, which were our implemetation areas, were digitized. These sheets are within the scope of 1/5000 L29-d-21-a ve L29-d-21-b cadastral sheet.

Cadastral sheets of 1/5000 scale were porduced by the General Directorate of Land Registry and Cadastre in 1978 with Aerial Photogrammetry method.

The aerial photos of this area were taken between 19.05.2005 and 30.05.2005. The photography was carried out analogously with ZEISS RMK TOP 30 aerial camera. Photography scale is 1/4000. Scanning process was conducted with işlemleri ZEISS SCAI Photogrammetry scanner. Pixel size directly from negative roll film was actualized as 14 micron and radiometric resolution was provided as 8 bit (256 gray scale).

In orthophoto of 1/1000 scale, ground sampling interval was produced to be 10 cm and in orthophoto of 1/2000 scale, ground sampling interval was produced to be 20 cm.

Cadastral sheets which were digitized by using transformation data were transformed from ED_50 datum and ITRF datum.

Our study area was measured with cors method with South 582 GNSS Rover Gps device.
For utilized TUSAGA active points Konya, KNYA station was used. Area measurement was carried out by using Netcad program.

Digitized cadastral sheets were superposed with land data after being transformed into ITRF.
Area measurements of Konya province Selçuklu county Aşağıpınarbaşı district ve Dokuz district were made.

EVALUATION

Evaluation Of Parcels In Study Areas

Adana Province Karataş County Çakırören District

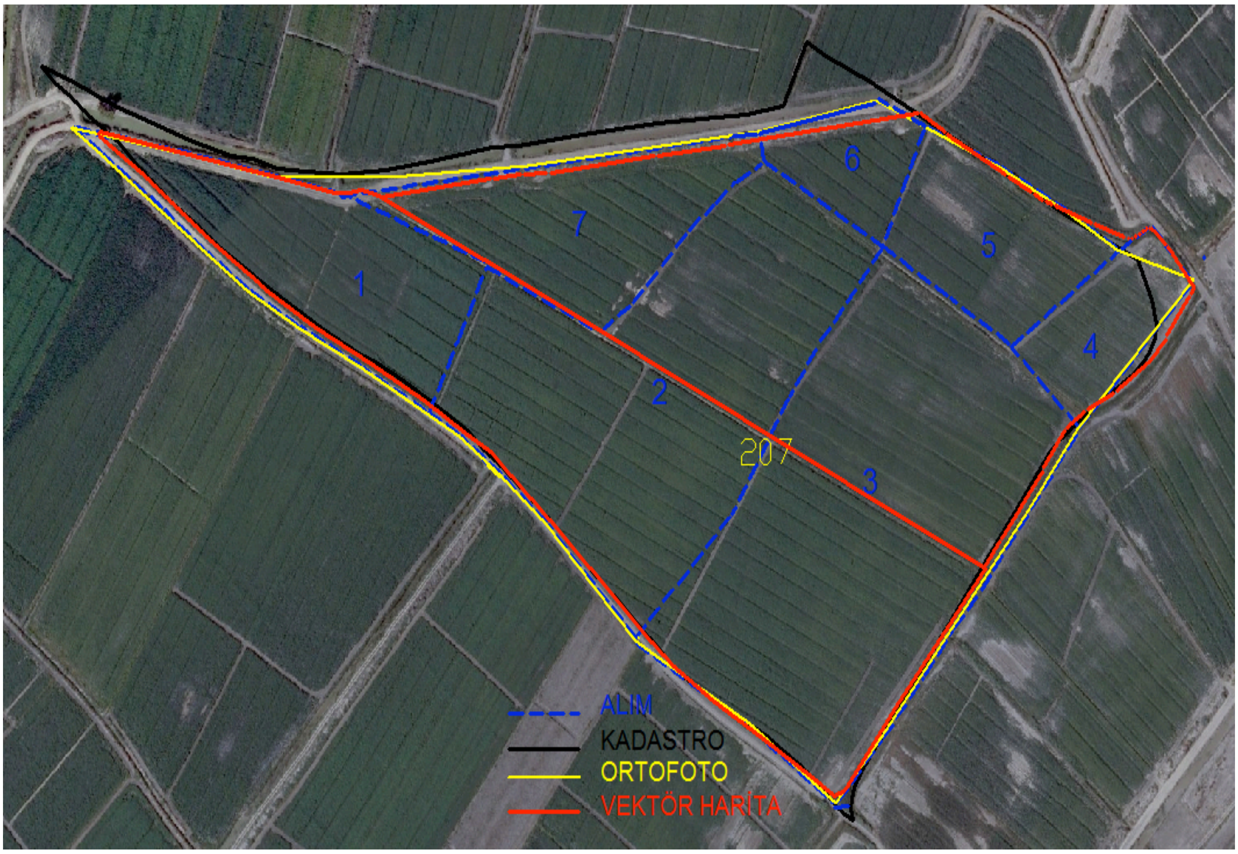

Figure 4.1: Adana Province Karataş County Çakırören District evaluation of parcel no. 207

Cadastral area of parcel no. 207 Adana province Karataş county Çakırören district (village) is 158050,74 m2 while its land title area is158000m2. In the first cadastre, area measurement was carried out by encircling with planimeter. As the result of land measurement, area value was obtained as 155518,95 m2. While in the area measurement carried out from orthophoto this value was 155796,07 m2. Vector map area was obtained as 158570,04 m2. Tolerance limit calculated according to 1/5000 sheet was calculated as 412,79 m2. In this case, its divergence from land area was 2481,05 m2 and 2203,93 m2 from orthophoto. Orthophoto measurement and land measurement area values are excluded from tolerance limit. The reason why they are excluded from tolerance limits is the fact that parcel no. 207 is divided into 7 parcels in land usage. Area of 207/1 is 18958,11 m2, area of 207/2 is 44421,50 m2, area of 207/3 is 50932,15 m2, area of 207/4 is 7246,56 m2, area of 207/5 is 11391,80 m2, area of 207/6 is 6198,34 m2 and area of 207/7 is 16370,49 m2. It was found that sections such as roads and channels were formed outside the parcel due to the land in use being wetlands and, moreover, there is a road on the north of the parcel while there is none on cadastre and this road was divided from the parcel. Boundaries of which land measurement was detected to not have changed with Cadastral Sheet were established in accordance with the fixed boundary definition in renewal legislation.

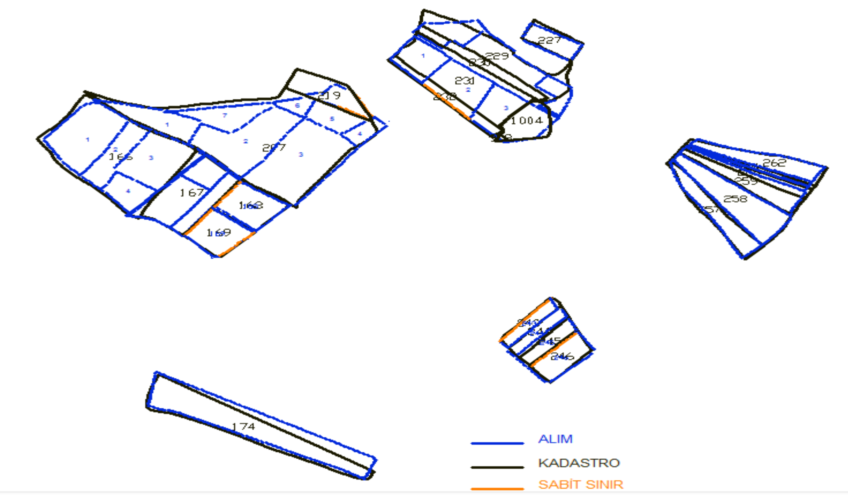

Figure 4.2 : Adana Province Karataş County Çakırören District Fixed boundaries

Table 4.1 : Adana Province Karataş County Çakırören District skewness status

BÖLGE ADI	PARSEL NO	KAYIKLIK	
		EN AZ (m)	EN ÇOK (m)
ADANA İLİ - KARATAŞ İLÇESİ ÇAKIRÖREN MAHALLESİ	160	0.73	12.25
	166	1.86	16.59
	167	0.02	40.12
	168	0.3	6.88
	169	1.2	11.2
	174	4.5	45
	207	0.79	29.3
	219	0.97	101.91
	227	1	9.28
	229	1.7	31.4
	230	3.04	16.76
	231	4.24	113.24
	232	1.01	46.6
	243	1.22	11.77
	244	1.88	8.9
	245	0.65	8.21
	246	0.71	5.1
	257	0.67	8.77
	258	1.03	11.18
	259	3.2	24.64
	260	0.85	24.64
	262	0.27	13.92

Digitized cadastral status in Adana Province Karataş County Çakırören District and land status was compared frontally. In this comparison, the least and most skewness quantities were established and presented in the table (Table 4.1)

COST ANALYSIS OF METHODS

Table 4.2 : Cost Analysis of Methods

Yöntemler	Maliyet (1 ha)	
	TL	$
GZK GPS	26.28	11.58
1/5000 Kıymetlendirme ile Beraber Sayısal Ortofoto	2.94	1.29
1/5000 Sayısal Ortofoto	1.41	0.62
1/2000 Kıymetlendirme ile Beraber Sayısal Ortofoto	68.5	39.92
1/2000 Sayısal Ortofoto	19.98	11.35
Uzaktan Algılama (WORLDVİEW-2) Pankromatik Görüntü	3.92	1.73
Uzaktan Algılama (WORLDVİEW-2) Pan-Sharpen Görüntü	3.37	1.48

CONCLUSION AND RECOMMENDATIONS

Adana Province Karataş County Çakırören and Gökçeli Districts, Şanlıurfa Province Akçakale County Aydınlı and Deniz Districts and Konya Province Selçuklu County Dokuz and Aşağıpınarbaşı Districts were formed as test areas with the purpose of carrying out cadastre renewal works faster and more economically, and keeping the cadastre constantly updated by renewing it. Coordinates of the detail points within these test areas were measured with GZK GPS (Cors method). With these coordinates orthophoto and vector maps obtained from aerial photographs and satellite images, and areas obtained from land title and land measurements were compared.

In area comparison, rate of being within tolerance limits in Adana/ Karataş/ Çakırören and Gökçeli districts, and Şanlıurfa/Akçakale/Deniz and Aydınlı districts of 1/500 scale is lower than that of Konya/Selçuklu/ Dokuz and Aşağıpınarbaşı districts of 1/2000 scale. In the sheet of 1/5000 scale, the rate of being within tolerance limits is between 15% and 43%. In the sheet of 1/2000 scale, the rate of being within tolerance limits is between 50% and 75%. It is observed that these rates are coherent with İnam 2005 data error limit rates (within error limits 24, not within them 76).

While the rate of area values in land title (calculated with planimeter) and digitized cadastral area values being out of tolerance limits is 10% to 57% in Şanlıurfa/Akçakale/Deniz and Aydınlı districts and Adana/ Karataş/ Çakırören and Gökçeli districts of 1/5000 scale, this rate is 25% in Konya/Selçuklu/ Dokuz and Aşağıpınarbaşı districts of 1/2000 scale.

In our study, cost of CORS GPS method and digital orthophoto cost produced from aerial photograph were compared with orthophoto cost prduced from satellite image (panchromatic and pan-sharpen image).

Finding of Cankurt et. al is coherent with our study as well. Orthophotos of Şanlıurfa region were obtained from Worldview -2 satellite. Orthophotos of Adana region were obtained from aerial photograph. While the cost of one sheet is 2473,10 tl in Adana region, cost of one sheet is 3037,10 tl in Şanlıurfa region.

While the cost of measurement made with CORS GPS method is lower than aerial photogrammetty and satellite imaging for small areas, this advantage lies with aerial photogrammetty and satellite imaging for large areas.

In light of the conlusions and evaluations stated above, the following points are recommended on orthophoto and high resolution satellite images in cadastre renewal works in Turkey:
--- According to fixed (distinct) points; position accuracy in 1/5000 sheet works better in orthophoto than satellite image.
--- Divergence in indistinct points is related to the fact that GPS receiver and mouse cursor could not be hit at the same place and not to a positional error.
--- In the studies conducted, sub-parcels are determined according to first facility cadastre and this subject is lacking in renewal legislation.
--- It was established that some boundaries do not change in land and cadastral sheet and fit the definition of fixed boundary stated in renewal legislation. Other boundaries can be evaluated as indefinite boundary. Therefore, they can be established over orthophoto and sheet with the skill and assistance of experts without going to the area.

In conclusion,
--- Both photogrammetric vector maps and orthophoto maps were analyzed in different scales (1/1000, 1/2000, 1/5000). When area divergences were analyzed, orthophotos and vector maps of 1/5000 scale were observed to be sufficient in cadastre renewal works. It was again concluded that orthophotos and vector maps of 1/5000 scale obtained from high resolution satellite images can be used in cadastre renewal works.
--- Land measurements, photogrammetric vector map and orthophoto map, orthophoto and vector maps obtained from high resolution satellite images were analyzed in terms of cost.
As a significant difference was observed in terms of cadastre renewal works when areas which were obtained from vector maps and orthophoto were analyzed, opting for orthophoto maps with regard to cost will be appropriate.

Orthophotos of 1/5000 scale are recommended in cadastre renewal works in terms of having the ability to be archived, reanalyzed without necessitating extra costs and providing the opportunity to analyze parcels.

In line with requests from Cadastre Directorates, digital vector map and orthophoto of 1/5000 scale production is made or procured by the General Directorate of Land Registry and Cadastre for Cadastre facility, digitization, renewal and update works.
In all these studies;

Medium and small scale maps used with preliminary survey, investigation, planning purposes in digital vector photogrammetric maps of 1/5000 scale or digital colored orthophoto production works and necessitated by the units who need these maps to be used in pre-study planning and preliminary investigations and post-study integrity, completeness and quality controls with the purpose of General Directorate of Land Registry and Cadastre rendering its cadastre-based service in a healthy manner, are of vital importance.

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THE USE OF OBLIQUE PHOTOGRAMMETRY ON LAND ADMINISTRATION

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ABSTRACT

The article 718 of the civil law saying "The ownership on property includes the air above and terrain layers below to an extent providing benefit. The structures, plants and sources are included in the content of this ownership reserving the legal restrictions" and the cadastre law no. 3402 envisage 3D Cadastre. 3D data is required in order to perform 3D cadastre. To meet this requirement, oblique photogrammetry arises as the main data acquisition method. The data obtained by this method is used as base in 3D Cadastre and Land Administration activities. 3D cadastre required in the context of land administration activities in Turkey demands high resolution aerial oblique images to be used in services such as real estate value assessment & marketing in urban areas, urban planning, unlicensed construction monitoring & city administration and making location data (national address data etc.) intelligent.

KEY WORDS: Civil Law, Cadastre, 3D Cadastre, Real Estate Value Assessment, Oblique Photogrammetry

INTRODUCTION

Land Administration

Land is a spatial magnitude, where all living creatures shelter, hold on to life and carry on vital activities throughout the history. It is among the most valuable and indispensible sources for all livings on earth. Since land is an extremely crucial asset, its administration becomes an important issue as well. Land administration is the act of creating, recording and presenting information on ownership, value and use of land and its associated resources (UNECE, 1996). Land administration requires decision making and implementation the decisions about the land. Decisions can be taken either individually or by a group of people. Countries provide their existing lands to be managed with respect to requests, requirements and laws depending to the technological advancements. The key point is the establishment of land administration for sustainable development. The modern land administration depends on the land management paradigm (Williamson et al., 2010). In this approach, land administration functions including land tenure, land use, land value and land development are treated as inseparable parts.

Sustainable development consists of economic, social and environmental components and the basis of the paradigm is the Institutional Arrangements depending on the country context.

This basis can be defined by the three legs, which are Land Policies, Land Information Infrastructures and Land Administration Functions for sake of sustainable development. Land Policy can be defined as the purposes set by the governments to cope with land issues. These issues include economic development, social justice and equity and political stability. Land policies may differ from country to country regarding to social, economical and cultural aspects. Land Administration Functions is the operational component of the paradigm, which enables fair implementation of rights, restrictions and responsibilities about the land and its associated resources. As already mentioned, these functions are land tenure meaning securing and transferring rights in land, land use meaning planning and control of the land and properties, land value meaning valuation and taxation of land and properties and land development meaning implementing utilities, infrastructure and construction planning (Enemark, 2004). In order to serve these functions, solid Land Information Infrastructures are required, which include reliable cadastral and topographic data and gain access to thorough and updated information on artificial and natural environment. To sum up, the land management paradigm is required by modern land administration theory to make systems overcoming the land related right, restriction and responsibility issues for providing sustainable development (Williamson et al., 2010).

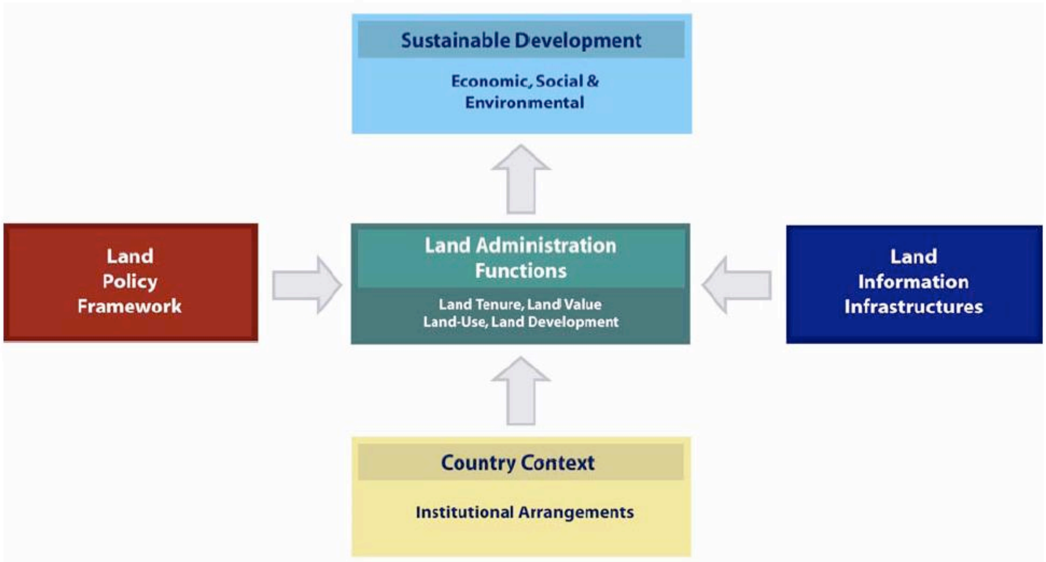

Figure 1. The land management paradigm (Enemark, 2004)

Cadastre

In this scenario, cadastre comes up as one of the main components of a successful land administration. It locates at the core of a land administration system enabling spatial integrity and unique identification of land parcels. The statement of International Federation of Surveyors (FIG) on cadastre is given as follows: “A Cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to

assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection" (FIG, 1996).
As indicated in the statement, land information is kept using parcels which use 2D boundaries to identify properties. To assure integrity and consistency, overlaps and gaps should not occur between parcels. However, existing land administration systems adopting 2D parcels have begun to lose their efficiency while coping with rights, restrictions and responsibilities (RRRs) belonging to land which become more complicated day by day. This complexity is mainly caused by overlapping and interlocking constructions appear particularly in urban areas with dense housing. The challenge is how to project these structures onto the surface to obtain 2D parcels in conventional cadastral systems (Stoter, 2003). At this point, the necessity of 3D cadastre concept and 3D property data is confronted.

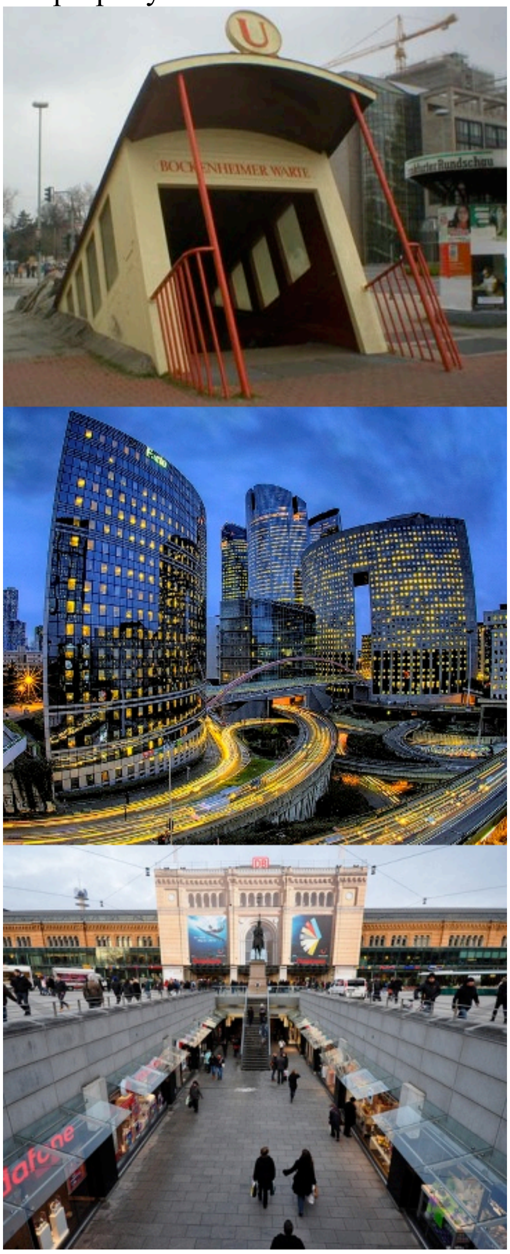

Figure 2. a) Bockenheimer Warte Station, Frankfurt b) La Defense District, Paris c) Subsurface Shopping Places at Central Station, Hannover

The requirement for a 3D cadastral system is triggered by a number of factors (Stoter, 2003):

- a considerable increase in (private) property values
- a considerable increase in the number of tunnels, cables, pipelines, underground metros, parking lots, shopping malls, buildings above roads/railways and other cases of multilevel buildings
- an upcoming 3D approach in other domains (3D GIS, 3D planning) which makes a 3D approach of cadastral registration technologically realizable.

3D CADASTRE

A 3D cadastre is a cadastre which registers and gives insight into rights and restrictions not only on parcels but also on 3D property units (Stoter, 2003). From this point of view, conventional cadastre is required to be adapted to 3D situations for proper registration. FIG Commission 7 – Cadastre and Land Management has come up with a study namely Cadastre 2014 that might take place in 2014 in order to customize the current state of cadastral registration into an approach overcoming the deficiencies. It was an output of a four-year study and has been translated into 27 languages. It has six statements which are (Kaufmann and Steudler, 1998):

- Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions!
- The separation between 'maps' and 'registers' will be abolished!
- The Cadastral mapping will be dead! Long live modeling!
- 'Paper and pencil - cadastre' will have gone!
- Cadastre 2014 will be highly privatized! Public and private sector are working closely together!
- Cadastre 2014 will be cost recovering!

The document emphasizes that the cadastral registration shall not be based on or restricted to 2D cadastral maps in the future. Consequently, 3D rights, restrictions and responsibilities have to be completely registered and access to legal status of multi-level property including 3D spatial information in addition to public law restrictions has to be provided (Stoter, 2003).

Moreover, title deed plans & cadastre map sheets, which are one the primary registers, are indespensible for property law and technical cadastre applications regarding to the article 1003 of Civil Law no 4721 saying “The plan based on official measurement forms the basis for the registration and determination of an immovable property to land registry” and the article 719 saying “...Boundaries of the immovable properties are determined by the title deed plans and boundary signs on the land. Unless they match each other, the actual one is the boundary on the plan...”.

When considered from this point of view, interpretation can be done using building floor space boundary to be obtained from oblique images and state of building in plan. In the case of nadir images, on the other hand, it is not possible to comment by using the display/drawing of building balcony or roof projection and state of building in plan.

At this point, the importance of 3D GIS has risen. This concept requires acquisition of 3D data and creation of objects, visualization and navigation in 3D environment and 3D analyzing and editing.

In recent years, oblique photogrammetry, whose applications are gradually spreading, is used as an effective method for producing 3D data.

OBLIQUE PHOTOGRAMMETRY

Oblique photogrammetry is a photogrammetric method, which combines conventional nadir images together with oblique images acquired at high angles to build 3D city models with texture data obtained from oblique images (Petrie, 2008). Single or multiple camera systems mounted on airplane, helicopter or unmanned air vehicles can be used in this approach. In addition, GPS – IMU integration is adopted as in classical aerial photogrammetry.

In the GDLRC, the project of "Oblique Camera and Environmental Components" was prepared for the purpose of establishing oblique image basis required in 3D Cadastre, Property Evaluation and Marketing studies and it was approved by the Ministry of Environment and Urbanization. The components of the project includes procurement of oblique camera and software, acquisition of 1.000 km^2 oblique imagery annually, production of 3D city models and publish as WMS and integration of produced 3D city models with MEGSIS and other systems.

The advantages of oblique photogrammetry can be grouped as follows (Karbo and Schroth, 2009):

- Imaging all sides of structures and performing their accurate measurements
- Performing distance, height and slop measurements on field
- Exposing blind spots
- Determining objects that are hard to see in orthophotos such as lamp posts, telephone poles etc.
- Integrating with GIS database and visualizing GIS data in 3D.

There are many camera systems used in oblique photogrammetry. As already mentioned, approaches differ from single camera to multiple camera systems. The most preferred and effective system is accepted as the one having vertical and oblique cameras together. Track'Air Aerial Survey Systems - MIDAS, Pictometry - PENTA DigiCam, Hexagon Geosystems - Leica RCD30 and Microsoft - UltraCam Osprey can be given as examples (Petrie, 2008). In this system, oblique cameras are mounted in north, south, east and west directions with an angle of about 40°- 45°. The nadir camera locates in the middle. The average flying height is 1000 m and resolution is approximately 15 cm for nadir images and 12-18 cm for oblique images (Nelson, 2008).

This configuration generally provides minimum 12 and maximum 24 images of a point, which allows the establishment of image libraries by gathering images meeting the quality standards after the completion of photogrammetric processes.

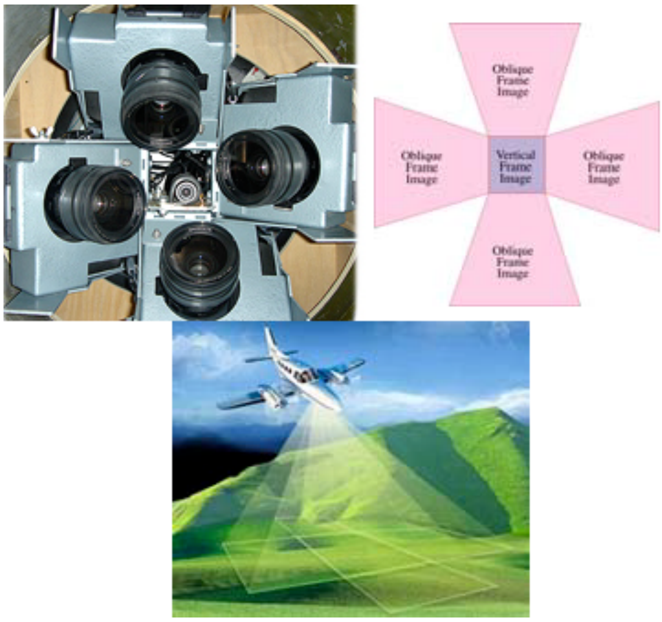

Figure 3. Five camera system (Petrie, 2008)

Figure 4. Five views of a building (Nelson, 2008)

APPLICATIONS

Oblique Photogrammetry is used as a powerful tool in a wide range of applications. Applications can be generally grouped into 5 main topics, which are (Grenzdörffer et al., 2008):

- Tax Assessment & Building Deviation
- Urban and infrastructural planning
- Management of military and security operations
- Critical infrastructural protection
- Cadastral capturing and management.

Since oblique photogrammetry provides accurate measurements of distances, heights and areas, it is exploited for tax assessment effectively. Together with identification and documentation of deviations, raise in tax revenues is obtained.

Powerful measurement capabilities help users to compare buildings and structures for any kinds of planning purposes. In addition, designing pylon construction can be handled easily. Line of sight analyses have an important role at urban and infrastructure planning as well.

Figure 5. Height and distance measurements (Aeromap, 2006)

In terms of military and security operations, oblique photogrammetry strengthens the management by providing accurate and fast information during crisis times. This includes critical site information as well as information on surrounding areas and infrastructure. During crises, access and evacuation routes play a crucial role. Oblique photogrammetry is a great tool to do planning for them in addition to determination of entrances and openings.

Critical infrastructures including airports, harbors, terminal stations, shopping centers, power plants, water resources, military and police facilities, government buildings, hospitals, prisons, dense populated areas, tower blocks, factory premises and industrial areas can be protected using the multi-vision ability of this technology.

Oblique photogrammetry is an effective tool for cadastre projects. As mentioned several times, robust measurements on 3D space make accurate mapping and organization of cadastral activities in rural areas possible (Grenzdörffer et al., 2008). Apart from measurement capabilities, this technology might be used as a support in splitting parcels and parcel formation by preliminary boundary determination (Lemmens et al., 2007).

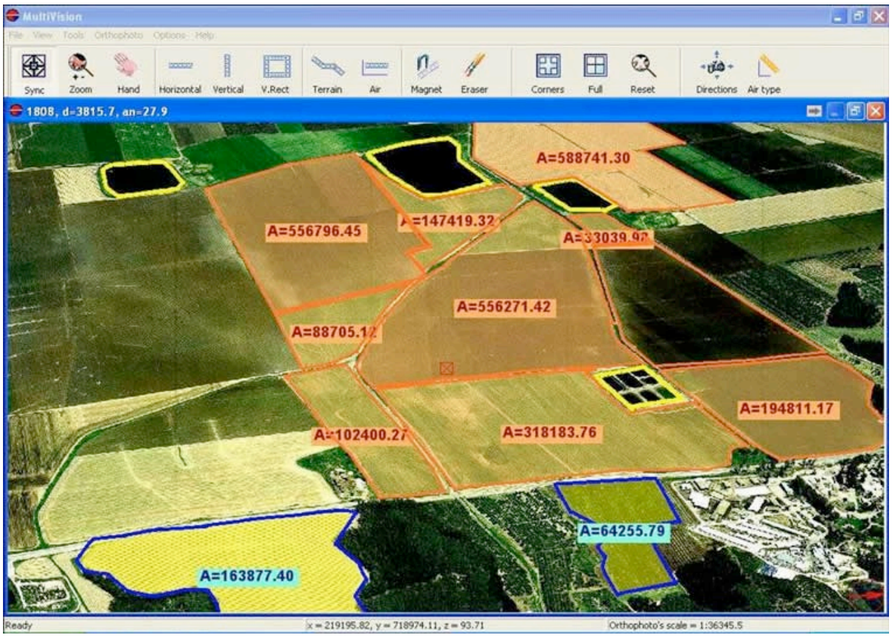

Figure 6. Parcel area measurements (Aeromap, 2006)

Realistic 3D city models obtained by texturing oblique data are used as an important base for 3D cadastre projects and provide convenience in urban planning. Besides, these 3D city models are used to take the environmental factors into account while performing real estate assessment.

Oblique images can be used for getting information, which cannot be obtained using topographic maps and orthophotos in the determination of land use. While it is hard to distinguish poor quality and luxury houses on vertical images, it is possible to get more meaningful data using oblique photogrammetry.

CONCLUSIONS

Intensive use of lands triggered by rapid population increase and complex city structuring enabled by technological advancements have caused existing 2D cadastral registration system to remain inadequate for administrating rights, restrictions and responsibilities (RRRs) belonging to land. To overcome this issue, 3D cadastre approach should be adopted and performed. Thus, healthy and effective land administration can be enabled, which is also the key for obtaining sustainable development.

To be able to realize 3D cadastre, 3D data is required to be gathered. Oblique photogrammetry emerges as a powerful tool to fulfill this requirement. This method can be effectively used as base for 3D Cadastre and Land Administration projects. Besides, it provides a wide range of applications not only in cadastral mapping and management but also in tax assessment & building deviation, urban and infrastructural planning, management of military and security operations and critical infrastructural protection.

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