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LAND USE CHANGE DETECTION USING SATELLITE IMAGES FOR NAJRAN CITY, KINGDOM OF SAUDI ARABIA

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ABSTRACT

Determination of land use changing is an important component of regional planning for applications ranging from urban fringe change detection to monitoring change detection of land use. These data are very useful for natural resources management. On the other hand, the technologies and methods of change detection also have evolved dramatically during the past 20 years. So it has been well recognized that the change detection had become the best method for researching dynamic change of land use by multi-temporal remotely-sensed data. The objective of this paper is to assess, evaluate and monitor land use change surrounding the area of Najran city, Kingdom of Saudi Arabia (KSA) using Landsat images (June 23, 2009) and ETM+ image (June. 21, 2014). The post classification change detection technique was applied. At last, two-time subset images of Najran city are compared on a pixel-by-pixel basis using the post classification comparison method and the from-to change matrix is produced, the land use change information obtained. Three classes were obtained, urban, bare land and agricultural land from unsupervised classification method by using Erdas Imagine and ArcGIS software. Accuracy assessment of classification has been performed before calculating change detection for study area. The obtained accuracy was found between 61% to 87% percent for all the classes. Change detection analysis showed that rapid growth in urban area has been increased by 73.2%, agricultural area has been decreased by 10.5 % and barren area reduced by 7% between 2009 and 2014. The quantitative study indicated that the area of urban class has unchanged by 58.2 km², gained 70.3 km² and lost 16 km². For bare land class 586.4 km² has unchanged, 53.2 km² has gained and 101.5 km² has lost. While agriculture area class, 20.2 km² has unchanged, 31.2 km² has gained and 37.2 km² has lost.

Key words: Land use; Remote sensing; Change detection; Satellite images;

INTRODUCTION

Najran city is located to the south west of the Kingdom of Saudi Arabia (KSA), has been considered as one of the new industrial communities growing rapidly with a planned urban community. The city has witnessed remarkable expansion, growth and developmental activities such as building, road construction and many other activities just like many other cities in KSA. Knowledge of the present distribution and area of such agricultural, bare, and urban lands, as well as information on their changing proportions, is needed by legislators, planners, and State and local governmental officials. If public agencies and private
organizations are to know what is happening, and are to make sound plans for their own future action, then reliable information is critical (2). There are many useful purposes for change detection information:

- to determine better land use policy.
- to project transportation and utility demand.
- to identify future development pressure points and areas to implement effective plans.
- to manage regional development.

Land use information are not only useful to improve the natural resources but also play a vital role in probable natural hazards like flash floods. Observations of the earth (Satellite Images) from space by remote sensing technique provide objective information of human activities and utilization of the landscape. The classified images provide all the information to understand the land use of any study area. There are several methods for mapping land cover changes using remotely sensed data (21) (14) and (16). Many researcher have used remote sensing data for determining change detection, satellite imagery and Markov and cellular automata models were used to predict land cover in 2030 in Al Ain, a city in the Emirate (21). Countries which are suffering from the rapid growth of population, land use is very important be to expected and planned (7).

The objective of this research is to identify the nature and extent of land-cover changes of Najran area through the period from 2009 to 2014. Four of the most commonly used change detection techniques were discussed to detect the nature and extent of the land-cover changes in Najran area using Landsat images. These techniques are;

1. post-classification,
2. image differencing,
3. image rationing, and
4. principal component analysis.

In this study, the post classification method is used. Finally, quantitative evaluations for the results of these techniques were performed to determine the most appropriate change detection technique which will provide the highest accuracy for identifying the nature and extent of land-cover changes in Najran city. In this study several image processing steps were conducted by the aid of Erdas imagine version 2011 (6) and ArcGIS version 10.1 software (8). The obtained results should be examined and checked from errors, therefore, accuracy assessment step should be proceed. Classification accuracy assessment generally include three basic components: sampling design, response design, and estimation and analysis procedures (18). Accuracy assessment allows users to evaluate the utility of a thematic map for their intended applications.

The most widely used method for accuracy assessment may be derived from a confusion or error matrix (17), (5) and (4). The confusion matrix is a simple cross tabulation of the mapped class label against the observed in the ground or reference data for a sample set. Two important information can be derived from the error matrix: errors of omission, or producer’s accuracy, and commission, or user’s accuracy (19). The user’s accuracy of a specific class is the ratio of the correctly classified samples to the total number of samples selected in that class. A Kappa coefficient is commonly used as a measure of the map accuracy (5) and (10).
STUDY AREA AND DATA SET

STUDY AREA

The study area (figure 1), is bounded by coordinates of (219205.660E, 3633792.740N) and (223405.060E, 3637277.540N), an area of approximately 800 square kilometers. It includes various land use activities: urban, desert and road networks.

![Study area location map](image)

Fig. 1 Study area location map.

Two epochs (2009 and 2014) were used for land-cover classification. A total of two scenes of Landsat -7 ETM + images were used. In 2009 epoch; scene of Jun 23, 2009. For 2014 epoch, Jun 21, 2014 were available. The data scene numbers are Path 166 Row 048. Table 1, figure 2 and 3 show the used data sets.

<table>
<thead>
<tr>
<th>Image</th>
<th>Image Type</th>
<th>Image Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat -7 ETM + 2009</td>
<td>Ortho-Products level 1-G</td>
<td>USGS website</td>
</tr>
<tr>
<td>Landsat -7 ETM +2014</td>
<td>Ortho-Products level 1-G</td>
<td>USGS website</td>
</tr>
<tr>
<td>District’s boundary map</td>
<td>shape file</td>
<td>Najran municipality</td>
</tr>
<tr>
<td>Google Earth images</td>
<td>Satellite images</td>
<td>Google Earth website</td>
</tr>
</tbody>
</table>

The used Landsat satellite imagery for the study area is downloaded from the USGS Earth Explorer (http://earthexplorer.usgs.gov/). The images of the two epochs were selected within the dry season of the area, normally between May to October months of a year because generally it is clear sky in the city. In order to remove seasonal sun angle and plant phonological differences images with similar anniversary date were recommended (11).
By using Google Earth (www.GoogleEarth.com) two images for study area are downloaded to be used as reference data for classification accuracy assessment. Google Earth has time slider that allows user to get the historical image records for any study area. Several reasons to use Landsat satellite images in our work. All Landsat data in the U.S. Geological Survey (USGS) archive are now free and have good spectral (seven bands from visible to the infrared spectrum) and spatial characteristics (30 m resolution). ETM+ data are obtained in eight spectral bands simultaneously. Band 6 corresponds to thermal (heat) infrared radiation. ETM+ scene has a spatial resolution of 30 meters for bands 1-5 and 7 while band 6 has a 60-meter spatial resolution and the panchromatic band has a 15-meter spatial resolution.
METHODOLOGY

REVIEW OF CHANGE DETECTION METHODS

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Change detection is the act of comparing two or more satellite images acquired at different times (multi temporal) for the purpose of detecting spectral reflectance differences between the images (15). Over the past years, researchers have used large numbers of change detection techniques of remote sensing image and summarized or classified them from different viewpoints (3) and (13). It has been generally agreed that change detection is a complicated and integrated process. Change detection methods could be listed as following:

- Change detection using write function memory insertion.
- Image algebra change detection.
- Post-classification comparison change detection.
- Multi-date change detection using a binary mask applied to date 2.
- Multi-date change detection using ancillary data source as date 1.
- Manual on-screen digitization of change.
- Spectral change vector analysis.

USED METHODOLOGY

Four of the most commonly used change detection methods were used (13). The most common change detection methods are:

- post-classification
- image differencing
- image rationing, and
- principal components analysis (PCA).

The post classification comparison method is the most preferable by many researchers. In this work, the post classification method is used. The magnitude and location of change were determined for the hole study area. Different software packages were used because each one has strength in certain operations needed for this study. Due to the gaps in the recent Landsat images in and after 2003, focal analysis function in ERDAS Imagine 2011 was used to fill the gaps. ArcGIS version 10.1 was used to produce suitability maps and final maps because of its strength in raster analysis and capabilities in maps production. ERDAS Imagine 2011 was used for classification step. The sequences of operations is schematically shown in figures 4.

POST CLASSIFICATION METHOD

Landsat 7 image includes 7 bands, thermal and panchromatic were excluded for their coarser and finer spatial resolution. Only bands of the same spatial resolution were used in this study. Used two images have the same acquisition date, therefore no need for atmospheric correction. The study area was clipped from two images by clip tool in ArcGIS 10.1 with district boundaries layer.

The main purpose of satellite image classification is the recognition of objects on the earth surface and their presentation in the form of thematic maps. The famous type of classification
technique is the unsupervised classification which doesn’t need a prior knowledge of the area and the supervised classification which needs prior knowledge of the area (12). It seems evident that when one knows what classes are desired and where they occur (at least as a sample), supervised classification strategies are preferable. However, over large areas the distribution of classes is not known a priori. This is compounded by the spatial trends in spectral signatures, resulting in the well-known signature extension problem. These complexities render sample selection very difficult and often arbitrary. Thus, where spatial distribution information is not available, e.g. when mapping a large area previously not well known, unsupervised classification is arguably the better strategy (1), although a supervised method has also been used in such case (9). The post-classification transformation of the classified raster into shape three vectors has been done using ArcGIS 10.1. The obtained shape was converted into a geodata base in order to introduce the change detection analysis.

![Methodology](http://wcadastre.org)

Before this step, it is necessary to make sure that the classification used for the change detection procedure is matching fact in the field using the accuracy assessment technique. By using Erdas Imagine software version 2011, unsupervised classification method is used to classify the images 2009 and 2014. At the beginning, fifty classes are chosen with 50 iteration number and 0.975 conversion threshold value. Finally by using Reclassify function, three classes were obtained urban, bare and agricultural land. The land cover classification maps for both dates are shown in figures 5 and 6. Post-classification refinement was done to improve the accuracy of the classification. The mis-classifications have been mostly corrected manually. The magenta color represents the urban area, green color shows the agricultural area and yellow color shows the barren land.
ACCURACY ASSESSMENT AND ANALYSIS OF THE RESULTS

Evaluation of the classification’s accuracy is calculated by comparing some specific pixels of the classified image and their corresponding reference pixels, which belong to a known class, succeeds the evaluation of the classification. The results of this comparison are the error matrix, the accuracy totals and the kappa statistics. By using data management tools in ArcGIS, 263 random points are created for classification accuracy assessment. The reference data were collected from Google Earth. Table 2 and 3 present design matrix, overall accuracy and Kappa coefficient for used two Landsat images.
Accuracy results for image 2009 show that, the urban class 60%, bare land is 87%, while agriculture area is 63.49%. Overall Accuracy is 76.8% and Kappa coefficient of agreement is 0.77. For image 2014, urban is 61.22%, bare soil is 86.7% and agriculture area is 62.5%. Overall Accuracy is 76% and Kappa coefficient is 0.76. Accuracy results are weak for urban class while, resolution is 30 meter and most of building dimensions less than 30 meter by 30 meter, road width also less than 30 m. Table 4 shows the observed major land cover changes and the area of each land cover class has been given in $km^2$. The urban area has increased from 74.2 to 128.5 $km^2$, the bare land area decreased from 687.8 to 639.6 $km^2$ and agriculture has decreased from 57.5 to 51.4 $km^2$. 

Table 2 Design matrix, overall accuracy and Kappa coefficient for Landsat image 2009.

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Bare</th>
<th>Agriculture</th>
<th>Row total</th>
<th>User's Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>27</td>
<td>11</td>
<td>1</td>
<td>39</td>
<td>69.23%</td>
</tr>
<tr>
<td>Bare</td>
<td>15</td>
<td>135</td>
<td>22</td>
<td>172</td>
<td>78.49%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>3</td>
<td>9</td>
<td>40</td>
<td>52</td>
<td>76.92%</td>
</tr>
<tr>
<td>Column total</td>
<td>45</td>
<td>155</td>
<td>63</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>Producer's accuracy</td>
<td>60.00%</td>
<td>87.10%</td>
<td>63.49%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Accuracy</td>
<td>76.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kappa</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Design matrix, overall accuracy and Kappa coefficient for Landsat image 2009.

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Bare</th>
<th>Agriculture</th>
<th>Row total</th>
<th>User's Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>30</td>
<td>15</td>
<td>4</td>
<td>49</td>
<td>61.22%</td>
</tr>
<tr>
<td>Bare</td>
<td>18</td>
<td>130</td>
<td>20</td>
<td>168</td>
<td>77.38%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1</td>
<td>5</td>
<td>40</td>
<td>46</td>
<td>86.96%</td>
</tr>
<tr>
<td>Column total</td>
<td>49</td>
<td>150</td>
<td>64</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>Producer's accuracy</td>
<td>61.22%</td>
<td>86.67%</td>
<td>62.50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Accuracy</td>
<td>76.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kappa</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Accuracy results for image 2009 show that, the urban class 60%, bare land is 87%, while agriculture area is 63.49%. Overall Accuracy is 76.8% and Kappa coefficient of agreement is 0.77. For image 2014, urban is 61.22%, bare soil is 86.7% and agriculture area is 62.5%. Overall Accuracy is 76% and Kappa coefficient is 0.76. Accuracy results are weak for urban class while, resolution is 30 meter and most of building dimensions less than 30 meter by 30 meter, road width also less than 30 m. Table 4 shows the observed major land cover changes and the area of each land cover class has been given in $km^2$. The urban area has increased from 74.2 to 128.5 $km^2$, the bare land area decreased from 687.8 to 639.6 $km^2$ and agriculture has decreased from 57.5 to 51.4 $km^2$. 

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Table 4 The lands cover changes in \((km^2)\) in 2009 and 2014.

<table>
<thead>
<tr>
<th>Class name</th>
<th>2009 (km^2)</th>
<th>2014 (km^2)</th>
<th>Total change (km^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>74.2</td>
<td>128.5</td>
<td>54.3(, 73.2%)</td>
</tr>
<tr>
<td>Bare</td>
<td>687.8</td>
<td>639.6</td>
<td>-48.2(,-7%)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>57.4</td>
<td>51.4</td>
<td>-6(,-10.5%)</td>
</tr>
<tr>
<td>Total (km^2)</td>
<td>819.4</td>
<td>819.4</td>
<td></td>
</tr>
</tbody>
</table>

The area extent of the three main classes namely were determined from the classified images of 2009 and 2014. Then, the areas of the "from-to" classes were also determined but from the classified change image. These areas of the from-to classes represent the nature and extent of the changes for each of the three main classes. To determine the area of any class whether it is a main class or a from-to class, a bit map was created to code and separate this class from the others. The raster values 1, 2 and 3 has given to urban, bare and agriculture classes respectively. By using raster calculator, the classified image of the year 2009 is multiplied by 10 and then subtract the classified image of the year 2014. The unchanged area of urban class will take raster value 9, unchanged area of bare land will take 18 as a raster value while the unchanged area of agriculture class will take the number 27 as raster value. The lost urban area will take the number 8, while gained area will take the number 19 as shown in figure 7.

![Fig. 7 The changes of land-cover classes between 2009 and 2014 for Najran city KSA.](image)

Table 5 summarizes the area extent of the three main classes in 2009 and 2014 in addition to the types and extent of changes (unchanged, lost, and gained) for each class during the study period.
Table 5 Changes of land-cover classes from 2009 to 2014.

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>%</th>
<th>km²</th>
<th>%</th>
<th>km²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km²</td>
<td></td>
<td>km²</td>
<td></td>
<td>km²</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>74.2</td>
<td>9.1</td>
<td>687.8</td>
<td>83.9</td>
<td>57.4</td>
<td>7</td>
</tr>
<tr>
<td>2014</td>
<td>128.5</td>
<td>15.7</td>
<td>639.6</td>
<td>78.1</td>
<td>51.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Unchanged</td>
<td>58.2</td>
<td>78.4</td>
<td>586.4</td>
<td>85.3</td>
<td>20.2</td>
<td>35.2</td>
</tr>
<tr>
<td>Gained</td>
<td>70.3</td>
<td>94.7</td>
<td>53.2</td>
<td>7.7</td>
<td>31.2</td>
<td>54.4</td>
</tr>
<tr>
<td>Lost</td>
<td>16</td>
<td>21.6</td>
<td>101.5</td>
<td>14.8</td>
<td>37.2</td>
<td>64.8</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The Landsat imagery used in this study proved to be appropriate for distinguishing approximately ten to twenty land cover categories with a spatial resolution of 30 m. After image preprocessing, unsupervised image classification has been performed to classify the images in to different land use categories. Three land use classes have been identified as urban, barren land and agricultural. Classification accuracy is also estimated using the field knowledge obtained from Google earth images. The obtained accuracy is between 61% to 87% percent for all the classes. Change detection analysis showed that Built-up area has been increased by 73.2%, agricultural area has been decreased by 10.5 % and barren area reduced by 7% during time from 2009 to 2014. The quantitative study indicated that the area of urban class has unchanged by $58.2\text{km}^2$, gained $70.3 \text{km}^2$ and lost $16 \text{km}^2$. For bare land class $586.4\text{km}^2$ has unchanged, $53.2\text{km}^2$ has gained and $101.5\text{km}^2$ has lost. While agriculture area class, $20.2\text{km}^2$ has unchanged, $31.2\text{km}^2$ has gained and $37.2\text{km}^2$ has lost.

REFERENCES

INVESTIGATION OF AVAILABILITY REMOTE SENSED DATA IN CADASTRAL WORKS

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ABSTRACT

In cadastral applications, quality of data is important all over the world for land ownership and border. Country which need to high precision for cadastre works as Turkey, data production and application process require to more time, labor and cost. Developing technology leave a positive impression to type and quality of the data used in Geomatics. Remotely sensed data such as aerial orthophotos and satellite images has been used widely with modern technology in studies that require precision. Therefore, it is necessary to investigate the availability of remotely sensed data in cadastral works. In the cadastral works, objects as parcel boundaries, buildings, roads, fountains, transformers etc. which is a subject to real property needs to be survey. In this study, extraction of objects which needs to be surveyed during cadastral works, directly by orthophotos and satellite images examined. For this reason, manual digitizing, object and pixel based classification techniques used for the extraction of real property objects from images. Accuracy of results determined by comparing with field surveys and current cadastre data on Aksaray city. At the end of the coordinate based statistical analysis, object based classification method and manual digitizing method were determined that it’s gave the closest value to cadastral data.

Key words: Remote sensed data, Cadastre, Image classification, Precision

ÖZET

INTRODUCTION

Cadastre, which is defined legal status and rights specifying the boundaries of the immovable property on the land and map is very important in relation to property (Kadastro Kanunu, 1987). In countries like Turkey that require high precision, in cadastral survey data used in the cadastral work to ensure that precision plays an important role. Less costly and more efficient studies should be used for improve suitability to the original on cadastral maps (NAP, 1980). Mainly terrestrial methods in cadastral mapping studies, photogrammetric and remote sensing methods are also used. The uses of these methods appear differences like necessary equipment, used techniques, accuracy requirements, staff and cost. Surveying of parcel boundaries and other details in cadastral works are performed using terrestrial measurement methods generally called as traditional method.

Traditional surveying concept has taken up into new shape from disciplines such as geodesy, surveying, photogrammetry and cartography (Zahir, 2012). Thanks to technological advances, more reliable, faster and less costly techniques emerged and other techniques were left useless (Silayo, 2005). Nowadays, within the scope multipurpose cadastre, geographical details (build, road, historical artifacts, art structures, water resources, energy resources etc.) which outside of parcel boundaries are also requirement. Due to the dynamics of this type of data is needed updated at specific time intervals. Making with terrestrial continuously measurement of these processes requires significant cost and labor. Therefore, availability of alternative measurement methods like photogrammetry and remote sensing in this kind studies should be explored (Silayo, 2005). Geographical data which generated with sub meter precision via photogrammetric and remote sensing methods will also help to gain time and speed in preparation of the cadastral maps. According to studies of Mutluoğlu and Ceylan (2005), have revealed that use of orthophoto is %75 less cost than directly terrestrial survey. Alkan and Solal (2010), in their study, emphasize the importance of determining real property by using photogrammetric methods considering cost, labor and time. In this study, comparisons made for obtaining, updating the present cadastral data and for better interpretation by using orthophoto data. Nowadays, using object and pixel based classifications which are commonly used in image processing methods, object extraction have made from orthophoto. Also, hand digitizing has been made from orthophoto. The obtained results were compared with the existing cadastral data and interpreted availability of needed geographical data for cadastral works on orthophoto. Yalman area in the district of Aksaray/Gülağaç was determined as a pilot application area for the study.

DATA COLLECTION TECHNIQUES USED IN EXISTING CADASTRE

Existing cadastral measurement techniques can be classified as direct and indirect. Direct techniques, is the process determining the points on land by measuring angles and distances with the help of classical measurement equipment. Coordinates and the area of each parcel in the field are calculated using mathematical methods. In indirect techniques, position information of the objects is obtained by using GPS, remote sensing and photogrammetry techniques. If we want to group the cadastral data collection techniques we can categorize as a simple; classical measurement techniques, GPS technique, photogrammetric techniques and remote sensing techniques. While terrestrial survey techniques identified directly, other operations can be described as indirect techniques (Zahir et al., 2012).
After 1950, in our country, aerial photogrammetry was emphasized and was applied as actively after 1955 in order to accelerate land cadastre works (Bıyık and Karataş, 2002). Nowadays, orthophotos that created by the elimination of geometric and projective errors is used to a significant extent in many disciplines. In many studies, orthophotos that presented in precisions of submeter can minimize the level of labor and cost. In order to display and observe the Earth, the images taken from satellites which sent to space were actively used in many areas (map, geology, forestry, agriculture etc.) due to improved technology. Nowadays, remote sensed data are used for many purposes. One of these applications is the use of very high resolution remotely sensed data in cadastre applications (Alkan and Marangoz, 2009). Especially, satellite images, due to spatial resolution down to 40 cm, plays an important role in for providing many spatial data (buildings, roads, historical, structures, water resources, energy resources, etc.) that required in cadastre work (Zahir et. al., 2012). Studies about the availability of remotely sensed data in the cadastral work has increased in recent years (Zahir et. al., 2012) (Zahir, 2012), (Mutluoğlu and Ceylan, 2005), (Yağcı and Erkek, 2012). In addition, feasibility of the cadastre work with unmanned aerial vehicles was examined by Rijsdijk and van Heinsberg, (2013).

PILOT STUDY AREA

Aksaray which is selected as the pilot area has flat land structure in the central Anatolia region of Turkey. Application put in process at Gulağaç/Yalman district of Aksaray.

Data Used in Application

In study, orthophotos of Aksaray was used as basic data which have 30 cm spatial resolution. Cadastral data of study area (parcel boundary, building, road, etc.) was used for the purpose of
comparison. In Application was benefited from; Erdas Imagine and e-Cognition Developer software for raster data, ArcGIS and NetCAD software for vector data.

Figure 5: Study Area

Obtain of Geographic Data Using Orthophoto

A lot of object extraction method was come into use with remote sensing thanks to developing and innovating technology. The most preferred object extraction method is object based image classification. It was compared with other classification methods and it has been seen that object based classification is give the best reason every time (Kalkan and Maktav, 2010), (Oruç et. al., 2007). Roads, buildings, rivers, farmlands details can be easily determined with object extraction from remotely sensed data. In addition to that, extraction and detection of unregistered buildings by using orthophotos is predicted. Three methods were used for the purpose of extracted geographical objects from the orthophoto, including object-based classification, pixel-based classification and manual digitizing. With these methods, classification of buildings and roads has been applied by using basic cadastral data. Classification results were directly compared with cadastral data and accuracy was investigated.

Object Based Classification

The extraction of the object is made out of orthophotos in the pilot process. Processing steps are as follows, respectively;

- **Segmentation Process;** Determination of the group of objects to be created for classification (*Figure 3,a*)
- **Determination Precision of Segmentation;** Generated segments are redefined according to the sensitivity of the object requested to be extract. (*Figure 3,b*)
- **Creating The Appropriate Function;** Generate function from the band values to distinguish details (*Figure 3,c*)
Proper method for classification process has been determined; function (rules) has been created and objects based classification process has been made. While making classification process, 2 main classes determined. These are respectively; roads and buildings. The result data obtained based from the specified classes, in order to be used in ArcGIS software is arranged in the vector data format. The resultant vector data is compared with the vector data obtained from the cadastral terrestrial survey.

**Pixel Based Classification**

Training data selected from object based classification was also used for pixel based classification. During application, classification process has been made with maximum likelihood algorithm which is commonly used. Land cover of classification process generated from 3 classes including build, roads and other. Pixel based classification process, because of perform on the spectral brightness of pixel values, not classified or misclassified pixel may occur. Raster data obtained from pixel based classification has been converted to vector data for use to comparison.

**Digitizing and Present Cadastral Data**

Orthophoto map digitized by hand for compare with cadastral data and the other obtained data. Manuel digitized map is shown in Figure 6. Present cadastral data belonging to Aksaray province used as main comparison material. In Figure 7, screenshot of the cadastral data is displayed. There are all objects that are subject to real property in the cadastral data.
Figure 8 : Pixel Based Classification and Raster-Vector Conversion

Figure 9 : Manual Digitizing

Figure 10 : Existing Cadastral Data
Comparison of Cadastre and Produced Data From Orthophoto

Some selected objects produced from orthophoto compared with present cadastral data. These are 5 buildings, 3 dirt roads and an asphalt road. Details and geometric comparisons of 5 different buildings produced with terrestrial data (a), manual digitizing (b), object based classification (c) and pixel based classification (d) is shown at figure 8. Samples of asphalt road and dirt roads and comparison results seen at Figure 9 and 10.

![Figure 8: Comparison of Building](image)

**Table 2: Comparison of Buildings Areas by using different methods**

<table>
<thead>
<tr>
<th>DETAIL</th>
<th>Cadastre(Reference)</th>
<th>Digitizing</th>
<th>Object-Based</th>
<th>Pixel-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m²</td>
<td>m²</td>
<td>%</td>
<td>m²</td>
</tr>
<tr>
<td>Build 1</td>
<td>157</td>
<td>146</td>
<td>92,99</td>
<td>142</td>
</tr>
<tr>
<td>Build 2</td>
<td>122</td>
<td>125</td>
<td>97,60</td>
<td>121</td>
</tr>
<tr>
<td>Build 3</td>
<td>156</td>
<td>163</td>
<td>95,70</td>
<td>167</td>
</tr>
<tr>
<td>Build 4</td>
<td>163</td>
<td>174</td>
<td>96,93</td>
<td>157</td>
</tr>
<tr>
<td>Build 5</td>
<td>234</td>
<td>226</td>
<td>96,58</td>
<td>221</td>
</tr>
</tbody>
</table>
Table 3: Comparison of Dirty Roads Areas by Using Different Methods

<table>
<thead>
<tr>
<th>DETAIL</th>
<th>Cadastre(Reference)</th>
<th>Digitizing</th>
<th>Object-Based</th>
<th>Pixel-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m²</td>
<td>m²</td>
<td>%</td>
<td>m²</td>
</tr>
<tr>
<td>Dirt Road 1</td>
<td>215</td>
<td>225</td>
<td>95,55</td>
<td>207</td>
</tr>
<tr>
<td>Dirt Road 2</td>
<td>736</td>
<td>713</td>
<td>96,87</td>
<td>721</td>
</tr>
<tr>
<td>Dirt Road 3</td>
<td>946</td>
<td>908</td>
<td>95,98</td>
<td>912</td>
</tr>
</tbody>
</table>

Figure 9: Comparison of Dirt Roads results, (a) Cadastral Data, (b) Manual Digitizing, (c) Object Based Classification, (d) Pixel Based Classification

Figure 10: Comparison of Asphalt Road, (a) Cadastral Data, (b) Manual Digitizing, (c) Object Based Classification, (d) Pixel Based Classification
Table 4 : Comparison of Asphalt Road Area by Using Different Methods

<table>
<thead>
<tr>
<th>DETAIL</th>
<th>Cadastre(Reference)</th>
<th>Digitizing</th>
<th>Object-Based</th>
<th>Pixel-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Road</td>
<td>3001</td>
<td>2918</td>
<td>2892</td>
<td>2656</td>
</tr>
<tr>
<td></td>
<td>% 97.23</td>
<td>% 96.36</td>
<td>% 88.50</td>
<td></td>
</tr>
</tbody>
</table>

Statistical Analysis for Results

The coordinate values of the each object (building and roads) are statistical analyzed by cadastral data as reference. Standard deviations eq. (2) obtained using divisions eq. (1) and means of the coordinate values. Shown in eq. (1) $\bar{x}$ is presented arithmetic means values of coordinates eq. (4), $N$ is number of point ($i=1,2,3,...,N$) and $x_i$ is coordinates of objects data. With presented $s$, standard deviation obtained with benefit from differences and mean of coordinate values.

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i = \frac{x_1 + x_2 \cdots + x_N}{N} \quad (1)$$

$$s = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \bar{x})^2} \quad (2)$$

$$s_{mean} = \frac{s}{\sqrt{N}} \quad (3)$$

According to the $t$-distribution table, surveyed coordinates (cadastre survey) with mean values obtained from methods (pixel based class., object based class. and digitizing) are expected to be equal. Therefore, foreseen that situation of between statistically expected difference values and calculated difference values equal to zero $H_0$: hypothesis. $H_0$ hypothesis is given eq.4. Also eq. 4 is shown means of cadastral coordinates ($x_{mean1}$) and coordinates calculated from other methods ($x_{mean2}$).

$$H_0: d=0 \quad (4)$$

$$d = x_{mean1} - x_{mean2}$$

Whether there is statistically significant difference values are determined through shown in eq. 5 $t$-distribution confidence limit of test value $t_{\alpha, 1-\alpha/2}$.

$$T_i = \frac{|d_i|}{s_{di}} \sim t(f) \quad (5)$$

Where $s_{di}$ is standard deviation of the difference $d_i$. In case of $T > t_{\alpha, 1-\alpha/2}$ coordinates calculated for each object from the mean values of each methods (object based class., pixel based class., manual digitizing), the deviation from the mean of the cadastral measurements are expressed as statistically significant. Otherwise ($T < t_{\alpha, 1-\alpha/2}$) changes is statistically insignificant.
In figure 11, accuracy of methods between each other were determined using mean standard deviation of buildings and roads coordinates. Cadastral surveying results which taken as a reference gave the best result with minimum standard deviation as expected. Then accuracies follow, respectively, digitizing, object-based and pixel-based methods. This results is similar to all buildings in the study field. This is an expected situation. There are some deviations originating from sensitivities of humans hand and eyes in manual digitizing process. Deviations in object-based classification process are related to deficiency of infrared-band and usage of band ratio. In pixel-based classification process the reason for the highest deviation ratio is algorithms which is used in classification process and the another reason for these deviations is the unclassified pixels while performing the pixel-based classification process.

Each method compared with cadastral data which accuracy is accepted as higher than others (Figure 12). Mean values of three methods are subtract to cadastral mean values for t-distribution confidence interval. This results shows that these are statistically insignificant according to t-distribution \( t_{\alpha/2} = 1.96 \) %95 confidence interval. Test values of dirt road results are statistically significant in pixel based classification method. For this reason, it can be said that there is unclassified pixels on some objects.
Pixel based classification distributed heterogeneous under the threshold. This shows that the coordinates have low accuracy their own. The reason for this, unlike object based classification, is each pixel evaluate individual in pixel based classification. Besides, because of digitizing was made by manual, encountered some errors in coordinates. These errors originated from digitizer eye error and shadows of builds. As a result of statistics it is seen that coordinates didn’t have homogenous distribution at manual digitizing technique. According to the results can be seen that the optimal distribution of standard deviation of coordinates in object-based classification technique. When methods compared statistically with each other shown that object based classification technique gave higher accuracy results than pixel based classification and manual digitizing. These results supporting by statistical analysis showed that object based classification method available on object extraction such as buildings and roads from orthophotos in cadastral works.

RESULTS AND SUGGESTIONS

This study focused on using orthophoto for extraction of subject of real property and investigated availability of orthophotos in cadastral works. Different types of data can be collected from using orthophoto images. In this study, buildings and roads were selected and made directly data extraction from the orthophotos. Objects such as buildings and roads can be extracted from orthophotos using image processing techniques. In this study, buildings and roads produced from orthophoto compared with cadastral surveyed data. The results show, firstly, that best accuracy result is getting from object based classification when methods coordinates compared with cadastral coordinates. Secondly, for the study shows, the digitizing method give the best results when compare of the methods their own. Besides, comparing area of objects (building and road) with area getting from cadastre, in this study reached more than %95 accuracy in digitizing and object based classification methods. Results have shown that producing data from orthophotos can be provide high accuracy results depending on resolution of aerial photos. According to results of accuracy in this study, it could be said that digitizing and object based classification methods be useful in studies which are needed precision similar with orthophoto resolution. For cadastral works, remote sensed data can be used to extract spatial data for second cadastre, cadastre renovation, cadastral update and multipurpose cadastre. In terms of labor, cost and accuracy, orthophotos can be used effectively in second cadastral works for countries needed high precision data such as Turkey. Besides, it can be said that unregistered or not yet registered structures/buildings which are keep rising day by day, easily detect on orthophotos. When spatial resolution of remote sensed data improves in the future, object extraction methods from orthophotos/satellite images can provide facilities for cadastral works.

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ÖZET


AZERBAIJAN REAL ESTATE REGISTRATION AND CADASTRE MANAGEMENT SYSTEM (RERCMS)

ABSTRACT

The Government of Azerbaijan, with the support of the World Bank, is implementing the "Real Estate Registration and Cadastre Management System " (RERCMS) project in Azerbaijan. The overall objective of the project carried out by Netcad Yazılım A.Ş. is to develop a reliable, transparent and efficient system of real estate registration system, supporting the real property markets and suitable systems for the State property management and utilization. It aims to carry out all activities through an IT system by transferring Real Estate Registration and Cadastre records throughout Azerbaijan to digital environment, thus ensuring effective monitoring and control of both private and public real estates. A public property management and administration system based on international standards will be established with the software to be developed under this project for the management of real estate registration and cadastre information. Thus, investments in this field will be encouraged, capacities of state agencies will be improved, data exchange between users will be possible when requested and soon conditions enabling data exchange for the entire country will be created.

Key words: Azerbaijan Real Estate Registration and Cadaster Management System, Cadaster Automation, RERCMS,
PROJE KAPSAMI

Dünya Bankası ile 14.03.2012 de imzalanan Proje kapsamında Azerbaycan ülkesindeki devlet ve özel tüm taşınmazların coğrafi ve sözel verilerin modern teknolojiler kullanılarak bir sistem üzerinde yönetildiği, diğer devlet kurumları ile entegrasyonun sağlanması amaçlanmaktadır.

Proje temelde dört ana bölümden oluşmaktadır.
- Bölüm A: Emlak Kaydı
- Bölüm B: Devlet Mülk Yönetimi ve Kayıt
- Bölüm C: Haritalama ve Arazi Kadastro
- Bölüm D: Eğitim, Politika Geliştirme ve Proje Yönetimi

Proje ile ulaşılmış hedeflenen hususlar aşağıda özetlenmiştir.
- Otomatik gayrimenkul kaydı, kadastro ve yönetim sisteminin geliştirilmesi
- İdari sistem ve servis sunumunun geliştirilmesi
- Kamuya ait mülklerin yönetimi ve özelleştirilmesi, iş süreçlerinin yeniden tasarlanması ve geliştirilmesi,
- Merkezi, bölgesel ve yerel ofisler için, uluslararası standartları temel alan ve bir entegre veri modeli kullanan, kayıt işlemlerini kapsayan, bir kamu mülkiyeti yönetim ve idare sisteminin kurulması
- Kurumsal paydaşların, Azerbaycan Cumhuriyeti merkezi bilgi veri tabanına Gayrimenkul Kaydı Kadastro ve Yönetim Sistemi (RERCMS) hizmetleri yoluyla Tek Noktadan erişimini sağlanması.
- Donanım, ağ, veri tabanı, veri ve yazılım uygulamaları açısından modern ve güvenli bir Veri Merkezi oluşturulması
- Kamu mülklerinin kaydı ve yönetim sistemi ve gayrimenkul kayıt ve kadastro sistemi ile çalışmak için, yardım masası, eğitim grubu, veri ve konu yönetim sistemlerini içeren, bir kullanıcı destek sistemi oluşturulması.

Şekil 1 de RERCMS’in e-devlet ile entegrasyonu kavramsal olarak sunulmuştur.

GERÇEKLEŞTİRİLEN ÇALIŞMALAR

Proje Yönetimi Dokümanları

- Project Plan
- Project Management Plan
- Risk Management Plan
- Risk Assessment Reports
- Configuration Management Plan
- Quality Management Plan
- Verification & Validation Plan
Şekil 1: e-Goverment and RERCMS Integration Scheme

Mevcut Durum Analizi ve Veri Düzenleme Çalışmaları

Proje başında yapılan analiz çalışmalarları ile mevcut durum incelenmiş ve aşağıda özetlenen durumlar tespit edilmiştir.

- Tapu ve kadastro işlerini yürüten Komite (SCPI) bünyesinde tapu verileri, dokuman arşiv verileri ve vektör veriler aşağıda sunulan birbirinden bağımsız farklı veri tabanlarında yönetilmektedir. (Şekil-2)
  - MQS database, Oracle’da
  - MAES database, SQL Server’da
  - İXMİM database, Access’de
  - Auction Center database; SQL Server’da
  - Scanned archive files of MQS; file base yapıda
  - DEKTIM database; Oracle SDE’de
  - Area Offices Data (PGDB); file base yapıda

- Coğrafi ve sözel verilerle ilgi olarak; veri tabanı ilişkilendirilmesinde bazı sorunlar olduğu, verilerde hem eksiklik hem de geometrik bazı sorunlar olduğu gözlemlemiştir.
- Proje sürecine paralel olarak sahadan kadastro verileri toplanmakta ve veriler sürekli güncellenmektedir.
Tespit edilen bu sorunların çözümü için aşağıdaki çalışmalar gerçekleştirilmiştir:

- Komite bünyesindeki tüm local ofislerin kendi bilgisayarlarda tuttukları düzensiz ve karışık yapıdaki coğrafı verileri, sözel veriler ile ilişkilerini sağlayan şekilde merkezi yapıda bir sistem hazırlanmıştır.
- Bu sisteme ülke çapındaki local ofislerin mevcut coğrafı verileri atılmış ve 18 adet ofisteki personele eğitimler verilmiştir. Veri güncelleme eğitimleri verilerek sistemin proje tamamlanmadan veri güncellenme altyapısı oluşturulmuştur.
- Kadastral verilerin migration işlemi ülke çapında tamamlanmıştır.
- Diğer mevcut merkezi uygulamalardaki sözel veriler için de, projeye ait kayıt desenine aktarımı sağlayan araçlar hazırlanmıştır. Veriler bu sistem üzerinde şekillendikçe veri ve ilişki sorunları daha net ortaya çıkmaya başlamış, alınan raporlar ile komite bilgilendirilmiş ve güncelleme çalışmaları ile Final migration sürecinde ortaya çıkacak problemler önceden çözülmeye başlanmıştır.

![Şekil 2: Mevcut Database ve Program Yapısı](image-url)
Data Migrationa konu olan veri kapsamı aşağıdaki sunulmuştur.

- Reform Maps: 2005 DWG files and 356 SHP files
- Topographic Maps: 3433 IMG file and file cartograms (Paftalar)
- Topographic Plans: 1797 IMG file and file cartograms
- Orthophotos: 1042 1/1000 Scale TIF file, 2150 1/5000 TIF file and cartograms
- Satellite Images: 439 TIF file and cartograms
- Devlet Mülkleri Yönetimi (Dektim): 22050 DWG files and ArcSDE geodatabase

1.1 Tasarım ve Yazılım Geliştirme Çalışmaları

Tasarım dokumanı; Gayrimenkul kaydı ve kamu mülkü yönetimi açısından mevcut iş süreçlerini biçimlendirecek, geliştirecek ve ilgili hakların kaydını sağlayacak, topluma sunulan hizmetleri iyileştirecek ve günümüz teknolojilerini dikkate alacak şekilde hazırlanmıştır. Tasarım aşamasında Interoperability, Security, Openness, Flexibility, Scalability IT mimari ilkeleri göz önünde bulundurulmuştur. Geliştirme çalışmalarını sırasında komite ve kalite kontrol firması ile birlikte çalışma platformu için JIRA, WIKI ve Google Drive uygulamaları kullanılmıştır. Tüm bu uygulamaların yetkileri komite ve kalite kontrol daki sorumlu kişilere verilmiştir, bu ortamlardan takibi yapılmıştır. Şekil-3 de hazırlanan uygulamalar ve ilişkileri görülebilir.

Tapu ve Kadastro süreçleri Cadastre ve Register olarak iki ayrı alt sistem olarak yürütülmektedir. Cadastre sistemini Türkiye yazılım firması Netcad, Register alt sistemini de Azerbaycan Yazılım firması Cybernet yürütülmektedir. Diyagramda görüldüğü gibi ayrı ayrı yürütülen bu alt sistemler servisler aracılığı ile konuştuklarını sağlar. Bu servislerin ne olduğu ve ne yaptığı aşağıdaki özetlenmiştir.

**Workflow Servis:** Cadastre ve Register sistemleri arasındaki iş akışı ve iletişimini sağlayan servistir.

**Security Servis:** Tek bir notadan sisteme giriş için iki firmanın kullandığı servislerdir.

**Document Management Servis:** Cadastre and Registration sistemlerinde oluşturulacak dokümanların arşivenmesi için kullanılabilecek servislerdir.

**Log Service:** Logların merkezi bir noktada depolanması için kullanılacak servisstir.

**Cadastral Service:** Cadastre sisteminin Registration sistemi ile entegrasyonunu sağlayan servislerdir. Registration tarafından Cadastre web base haritalarının kullanılması, Cadastre yazılımlarının tetiklenmesi ve bazı işlemlerin aynı session içinde yapılmasıdır.

**Registration Service:** Registration sistemminin Cadastre sistemi ile entegrasyonunu sağlayan servislerdir.

**Property Data Service:** Registration sistemdeki kayıtları arasında iletişimi sağlayan servisler.

Geliştirme çalışmalarını aşamasının takibi ve komite ile senkronizasyonu sağlayabilmek için iki ortam (Alfa,Beta) hazırlanmıştır. Alfa ortamında ilk testler yapılp, beta ortamında komite ile gerçek veriler üzerinden testler yapılarak uygulamaların istenen çözüme uygulunmuştur.
Şekil 3: RERCMS High Level Architecture

Kullanıcı Testi ve Pilot Uygulama

SONUÇ

Proje ile Azerbaycan ülkesindeki devlet ve özel tüm taşınmaz emlakçı ve özel verilerin modern teknolojiler kullanılan tek bir sistem üzerinde yönetilmesi, diğer devlet kurumları ile entegrasyonu sağlanmaktadır. Proje kapsamında;

- Otomatik gayrimenkul kaydı, kadastro ve yönetim sisteminin geliştirilmesi
- İdari sistem ve servis sunumunun geliştirilmesi
- Kamuya ait mülklerin yönetimi ve özelleştirilmesi, iş süreçlerinin yeniden tasarlanması ve geliştirilmesi, bunların Mülkiyet İşleri Devlet Komitesi (SCPI) tarafından kayıt ve yönetiminin entegrasyonu hızlandırılacak bir iş akışı şeması ile desteklenmesi.
- Merkez, bölgesel ve yerel ofisler için, uluslararası standartları temel alan ve bir entegre veri modeli kullanılan, kayıt işlemlerini kapsayan, bir kamu mülkiyeti yönetim ve idare sisteminin kurulması
- Kamuya ait mülklerin yönetimi ve özelleştirilmesi süreçlerinin yeniden tasarlanması ve geliştirilmesi, bunların özel, belediye ve kamuya ait mülkler için kayıt ve yönetiminin entegrasyonunun hızlandırılması
- Kurumsal paydaşların, Azerbaycan Cumhuriyeti merkezi bilgi veri tabanına Gayrimenkul Kaydı Kadastro ve Yönetim Sistemi (RERCMS) hizmetleri yoluya Tek Noktadan erişiminin sağlanması.
- Donanım, ağa, araçlar (ayrı bir ihale ile satın alınan), veri tabanı, veri ve yazılım uygulamaları açısından modern bir güvenlik organizasyonu (Veri Merkezi) oluşturulması
- Kamu mülklerinin kaydı ve yönetim sistemi ve gayrimenkul kayıt ve kadastro sistemi ile çalışmak için, yardım masası, eğitim grubu, veri ve konu yönetim sistemlerini içeren, bir kullanıcı destek sistemi oluşturulması

gerçekleştirilmekteidir.