Identification of Crop Areas Using SPOT – 5 Data

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Key words: remote sensing, SPOT 5, crop areas, agriculture

SUMMARY

In this research, application of remote sensing to agriculture especially for crop type determination was investigated using different classification methods. An agricultural field of SanliUrfa lying in the southeast of Turkey between 36^0 49'-37^0 00' north latitudes and 39^0 04'-39^0 13' East longitudes was selected as the pilot region since this city has the highest proportion of agricultural production of Turkey. As an example, 35% of cotton production, 8% of wheat production and 55% of the peanut production are fulfilled in SanliUrfa. Also, major agricultural fields of Turkey such as Ceylanpinar, Akcakale and Koruklu are located in SanliUrfa and these fields are under the control and management of the Ministry of Agriculture entities.

Multispectral images obtained from the SPOT 5 satellite acquired on 22-07-2009 and 24-09-2009 were used in this study. SPOT-5 has vegetation sensitive spectral bands and its 10 meter spatial resolution facilitates the detection of agricultural field boundaries. Different classification methods namely pixel-based and object-based were used in this study to identify the boundaries of agricultural fields, determine the areal distribution of the crops. Also, accuracy and efficiency of the pixel based and object based classification techniques were compared and discussed within different spectral and spatial aspects; using kappa statistics and confusion matrix.

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1. INTRODUCTION

Remote sensing systems with their synoptic viewing capability and variety of temporal and spatial resolution are important data source to derive agricultural information. Remote sensing methods are superior to conventional methods since fast and economic data acquisition and fast processing of data using computer based analyses are possible in remote sensing. Characteristics of agricultural field, difference of spectral reflectance of different crop types and differences in feature characteristics such as shape and texture are important parameters that should be considered while working agricultural areas with remote sensing. Remotely sensed data provide identifiable signatures for crop type, crop density, crop geometry etc. in order to perform agricultural survey and analysis.

With the development of remote sensing satellite systems, data derived from these systems has been started to be widely used to map crop areas in different temporal and spatial scales. It is possible to derive information about crop type, crop density and crop area with the availability of different satellite imagery and developments in image processing and interpretation systems (Turker et al., 2005).

Crop productivity information, which is a combination of two parameters namely the information about crop type and the information about spatial coverage of that crop, is very important for accurate crop yield estimation (Omkar et al, 2008). Crop productivity can be expressed in terms of vegetation health and biomass density that can be derived from spectral reflectance differences in different bands in satellite image. Spatial coverage of the crop area can be interpreted by aerial properties such as shape and specific texture which also can be derived from satellite imagery. Therefore, remotely sensed data can be used to produce these information via specific analyses and results of these analyses can be used to create crop maps.

Results of different studies that focused on crop area identification with remotely sensed data has pointed out that, determination of different crop types in their growing stages cannot be performed efficiently with single dated images. Within this context, classification of multitemporal images gives identifiable results with added phenologic information (Murthy et al, 2003).

Generally, classification and/or pattern recognition methods are used to identify and map crop areas from multitemporal satellite imagery. Several image classification techniques are available in the literature in which specific algorithms like Maximum Likelihood, Nearest neighbor and minimum distance are used to identify surface objects and produce thematic land cover maps (Harris, 2003).

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Several studies have been conducted to investigate the use of remotely sensed data in agricultural monitoring and researches. Harris (2003) used multitemporal Landsat images to determine agricultural change in selected two test areas located in Oman. He mainly focused on unsupervised and supervised classification methods. He utilized two ISODATA unsupervised classification with different number of clusters and a supervised maximum likelihood classification. The results of these classifications were compared and it was concluded that both ISODATA and Maximium likelihood methods could be able to define the spatial extent well.

In this study, pixel based and object based classification techniques were used to perform multitemporal crop area identification using two different dated SPOT 5 imageries. Dates were selected to represent the agricultural activity period for the selected study area. Pixel and object based classification results of these two images were compared and the best method in terms of accuracy and efficiency was proposed.

2. STUDY AREA

Sanliurfa is a city with population of approximately 465000. It lies on the south-eastern region of Turkey and is one of the important provinces within the Southeastern Anatolia Project (GAP) which is one of the most crucial projects of Turkish Government. One of the objectives of the GAP project is to improve productivity and diversify agricultural activities. SanliUrfa has the highest proportion of agricultural production of Turkey. As an example, 35% of cotton production, 8% of wheat production and 55% of the peanut production are fulfilled in SanliUrfa. Also, huge agricultural fields of Turkey such as Ceylanpinar, Akcakale and Koruklu are located in SanliUrfa and these fields are under the control and management of the Ministry of Agriculture entities.
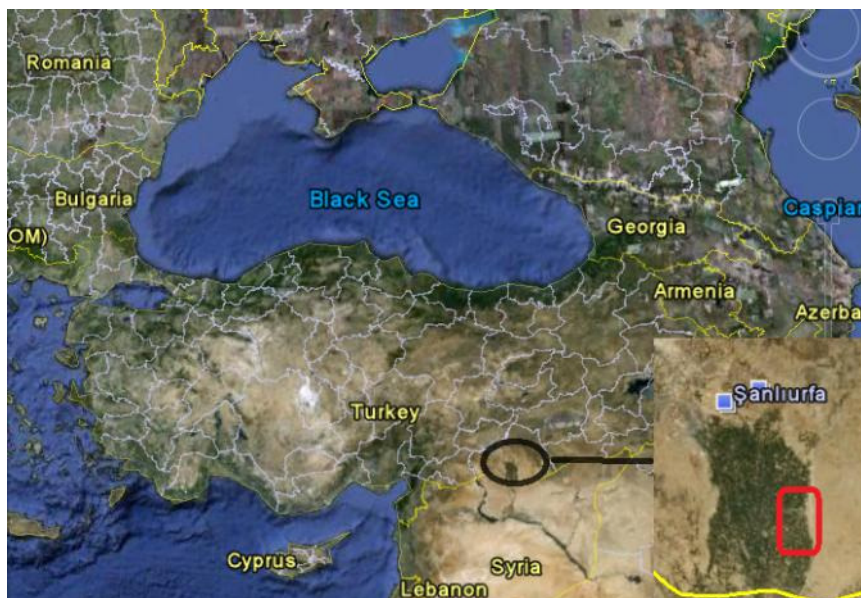

Figure 1. The location of Sanliurfa (black circle) and the study area (red box) – (Google Earth, 2010).

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The study area is called East Harran that is located in the east of Akcakale region, having large agriculture parcels and controlled agricultural activity (Figure 1). Between the seventh and ninth month of the year, only cotton and corn were farmed in this region. The planting and harvesting of the parcels are not stable, so different stages of farming can be seen on the satellite imagery.

3. METHODOLOGY

In this study, three different classification algorithms were performed for crop area identification and multitemporal change detection. The first two of them are ISODATA unsupervised classification and Maximum Likelihood supervised classification techniques which are two main pixel based classification algorithms and the last one is the object based classification algorithm.

3.1 Preprocessing

22-07-2009 and 24-09-2009 dated SPOT 5, multispectral images (four bands: B1: Green, B2: Red, B3: Near Infrared, B4: Middle Infrared) were used in this study. These images were obtained from High Resolution Geometric (HRG) sensors of the SPOT 5 satellite and have 10 meter spatial resolution.
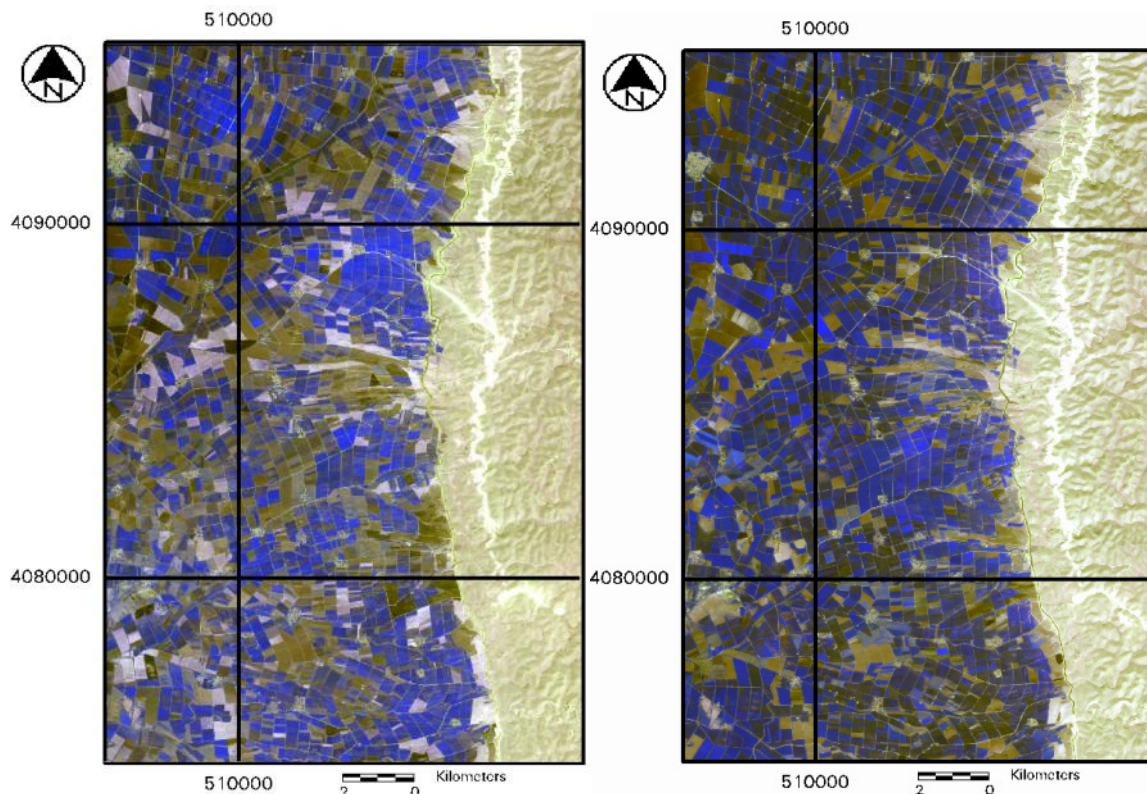

Figure 2. Orthorectified images of; a) 2009-07-22 dated and b) 2009-09-24 dated SPOT 5 satellite in 2/3/1 band combination

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Firstly, orthorectification procedure was utilized to these two images in order to correct geometric distortions. In this procedure 30 m ASTER Global Digital GDEM digital elevation model (DEM) and ground control points (GCP) collected from 1/25000 scaled maps were used. Orthorectification procedures were resulted with ± 0, 30 and 0, 42 pixel root mean square error (RMSE), respectively. Orthorectified images are shown in Figure 2.

3.2 Unsupervised Classification

This pixel–based classification technique classifies the pixels and forms clusters or classes according to the n dimensional spectral space whose dimensions are specified by the number of bands in satellite imagery. Results of this technique are spectral clusters automatically identified by computer algorithm (Foody, 2002; Alparslan et al., 2009).
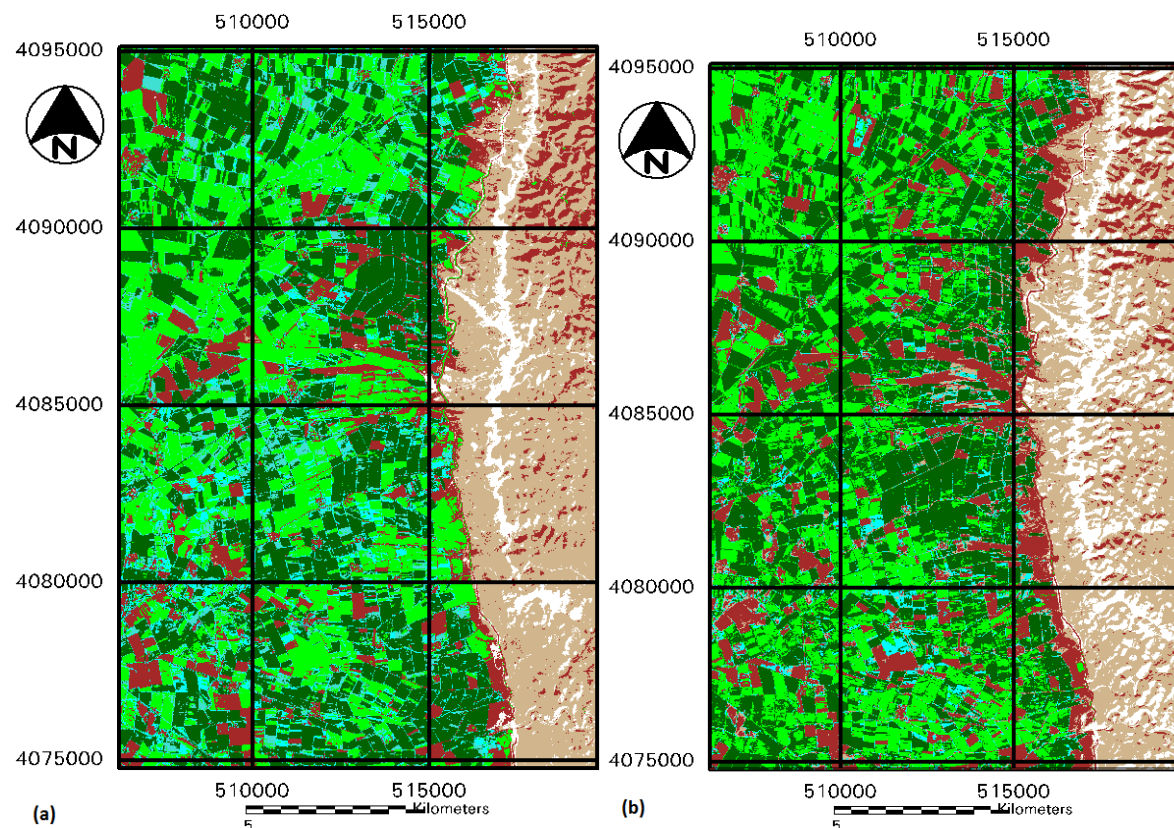

Figure 3. Unsupervised ISODATA classification results of; a) 22-07-2009 dated and b) 24-09-2009 dated SPOT 5 satellite images (Dark Green: Cotton; Green: Corn; Magenta: straw; Brown: empty parcels, tan: Bare soil, white: dry river channels).

In this study, Iterative Self-Organizing Data Analysis Technique (ISODATA) was used for unsupervised classification process. 1st, 2nd and 3th bands of SPOT 5 images corresponding to near infrared, red and green wavelength portions were used for this classification. 20 spectral classes were created with 0, 99 convergence threshold. The results were interpreted visually and combined into 9 final classes with recode operation for crop area identification

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using ground truth information obtained from SanliUrfa Agricultural Research Institute (Figure 3).

3.4. Supervised Classification

Supervised Classification is a technique which requires the *a priori* knowledge of the concerned region and this can be fulfilled by the selection of training areas defined by the analyst having the knowledge about land cover and spectral characteristics of the region. These training sites are the representatives of land cover categories on the image and used to train the classification algorithm. Classification procedure runs with use of homogenously distributed signatures that are associated with training sites and the result is the determination of information classes (Kucukmehmetoglu et al., 2008).

In this study, Maximum Likelihood classification method was used for supervised classification. 40 training sites with known ground truth were used as signatures. The classification results are evaluated with visual interpretation and these 40 information classes were reduced to final 6 thematic classes as in the previous method.
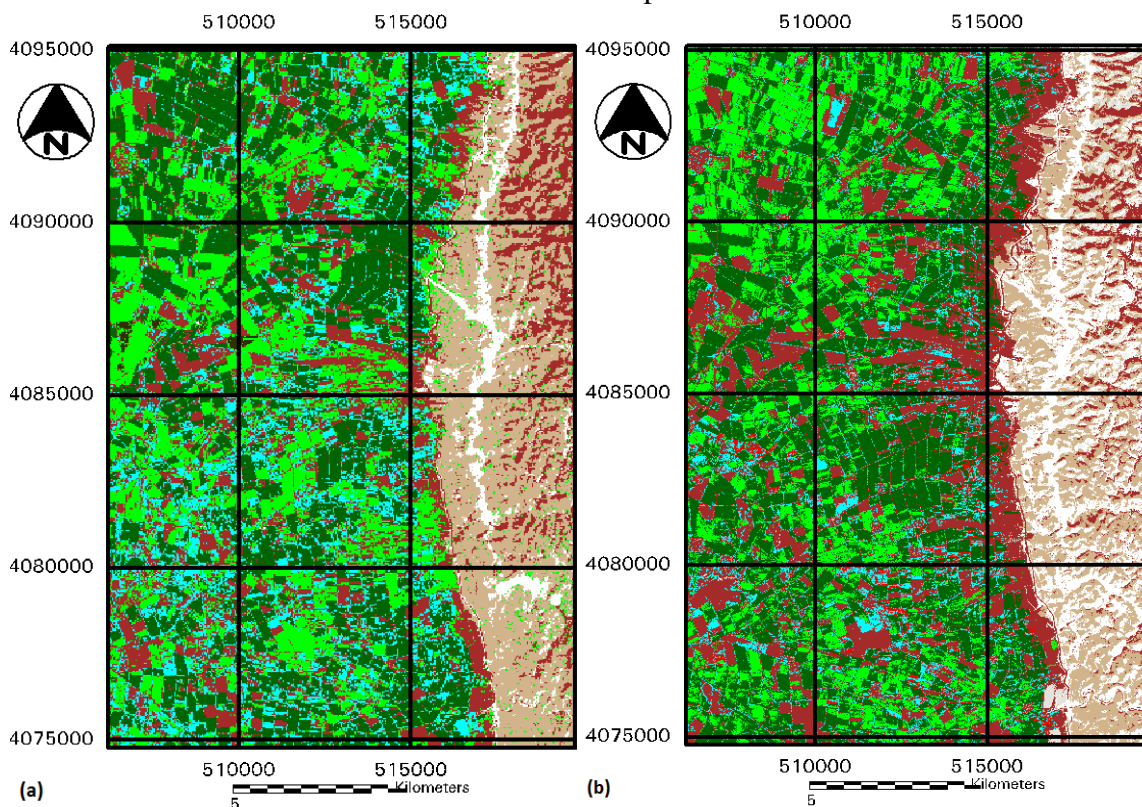

Figure 5. Maximum Likelihood supervised classification results of; a) 22-07-2009 dated and b) 24-09-2009 dated SPOT 5 satellite images (Dark Green: Cotton; Green: Corn; Magenta: straw; Brown: empty parcels, tan: Bare soil, white: dry river channels).

3.4. Object – Based Classification

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The basic processing units of object-oriented image analysis are segments (also called image objects) but not pixels like in pixel-based methods (Benz et al 2004). During the segmentation process, image is subdivided into segments and then these objects are classified.

The scale and heterogeneity criteria control the outcome of the segmentation algorithm. The scale parameter defines the size of the image object therefore different scale values are used for different data sets and different objects. There is a relationship between scale and image spatial resolution and scale and size of the objects. On the other hand, heterogeneity criterion is computed using spectral or non-spectral layers and this criterion controls the merging decision (Mattheu et al., 2005).

Different segmentation parameters were tested and their results were examined visually to find out the best parameter settings for this research. Multi resolution image segmentation with the scale parameter 50 was found appropriate to identify the agriculture parcels (Figure 5) whereas the color criterion was assigned as 0.7 and shape was assigned as 0.3. Compactness and smoothness parameters that defines heterogeneity criterion were assigned to 0.5.

Image objects were extracted as the result of this segmentation process. The defined image objects were compared with ground truth and the verified objects were used as classification samples in the nearest neighbor classification step. Classification samples of a class were selected considering the homogenous distribution of samples in the study area and probability histogram of the class which is generated automatically by adding samples. In the next step, classification process was performed using collected sampling objects (Figure 6).
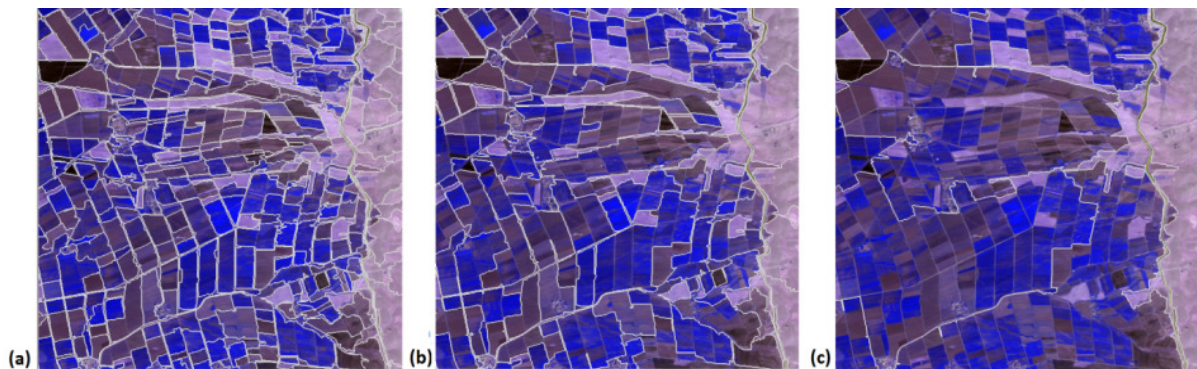

Figure 5. Multiresolution image segmentation at different scales; a) 50, b) 100 and c) 500

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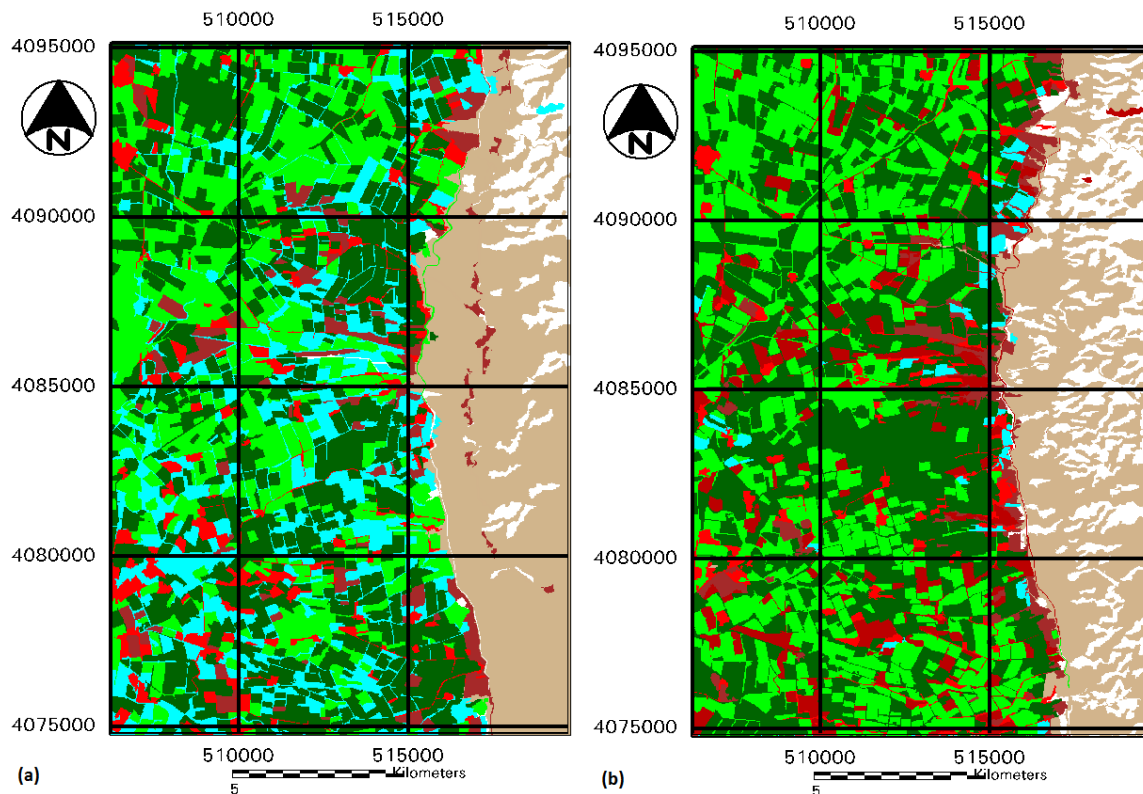Sydney, Australia, 11-16 April 2010

Figure 6. Nearest neighbor object based classification results of; a) 22-07-2009 dated and b) 24-09-2009 dated SPOT 5 satellite images (Dark Green: Cotton; Green: Corn; Magenta: straw; Brown: empty parcels, tan: Bare soil, white: dry river channels).

3.5. Accuracy Assessment

Several researchers had discussed different methods to analyze the accuracy of remotely sensed data (Congalton and Green, 1999; Koukoulas and Blackburn, 2001). However, the most widely used accuracy measures are derived from a confusion or error matrix (Foody, 2002). In this research, to assess the accuracy of classifications, the confusion matrix and some common measures derived from this matrix namely, overall accuracy, user's accuracy, producer's accuracy and kappa coefficient were used. An error matrix is a simple cross-tabulation of the mapped class label against that observed in the ground or reference data for a sample of cases at specified locations (Campbell, 1996; Foody, 2002).

100 random points were selected to generate accuracy assessment report of each classification. These points were representative of each different class and the number of points was selected considering the size of the study area and available ground truth data.

4. RESULTS

The results of this study show that, classification of remotely sensed data gives valuable information in agricultural activities in terms of crop type identification and crop area identification.

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The two basic classification approaches were evaluated with accuracy assessment procedure and visual interpretation of the result images based on ground truth information.

According to accuracy assessment results, for the unsupervised classified image of 22-07-2009 dated image; overall classification accuracy was 84.33%, kappa value was 0.7875. For the unsupervised classification of 24-09-2009 dated image overall classification accuracy was 83.45% and kappa value was 0.8100. For the supervised classification of 22-07-2009 dated image; overall classification accuracy was 80.00%, kappa value was 0.7595. For the supervised classification of 24-09-2009 dated image overall classification accuracy was 82.22%, kappa value was 0.8036. For the 22-07-2009 dated object based classified image; overall classification accuracy was 88.60%, kappa value was 0.8385. For the 24-09-2009 dated object based classified image; overall classification accuracy was 87.50%, kappa value was 0.8430.

Evaluation results with visual interpretation illustrated that all classification techniques reached a reasonable accuracy in crop type determination and spatial locations of the crop types were mostly determined. At this point, object based classification technique results gave more accurate information in determining the agricultural parcels in terms of homogeneity and shape as a result of generating image objects with image segmentation. Pixel based classification techniques failed to determine the borders of agriculture parcels especially in which the parcel held different surface cover having heterogeneous reflectance. On the other hand, each segment created in object based classification has a unique value, so differences of surface patterns inside the segment cannot be designated.

In conclusion, this study searched the efficiency of satellite images in crop type and area determination. The results indicated that, acceptable identification performance of crop areas can be obtained by using both pixel based and object based classification techniques. Object based classification results gave superior results compared to pixel based classification techniques.

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REFERENCES

Alparslan, E., Coskun, H.G., Alganci, U., 2009. Water Quality Determination of Küçükçekmece Lake, Turkey by Using Multispectral Satellite Data, The Scientific World JOURNAL, 9, pp. 1215–1229.

Benz, U.C., Hofmann, P., Willhauck, G., Lingenfelder, I., Heynen, M., 2004. Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS - ready information. ISPRS Journal of Photogrammetry and Remote Sensing 58, pp. 239-258.

Campbell, J. B., 1996. Introduction to Remote Sensing (2nd ed.). Taylor and Francis. London.

Congalton, R. G., and Green, K., 1999. Assessing the accuracy of remotely sensed data: principles and practices. Boca Raton: Lewis Publishers.

Foody, G.M., 2002. Status of land cover classification accuracy assessment. Remote Sensing of Environment, 80, pp.185–201.

Harris, R., 2003. Remote sensing of agriculture change in Oman International Journal of Remote Sensing, 24 (23), pp.4835–4852.

Koukoulas, S., and Blackburn, G. A., 2001. Introducing new indices for accuracy evaluation of classified images representing semi-natural woodland environments. Photogrammetric Engineering and Remote Sensing, 67, pp.499– 510.

Kucukmehmetoglu, M. and Geymen, A. (2008) Measuring the spatial impacts of urbanization on the surface water resource basins in Istanbul via remote sensing. Environmental Monitoring and Assessment, 142, pp.153–169.

Mathieu, R., Aryal, J. 2005. Object-oriented classification and Ikonos multispectral imagery for mapping vegetation communities in urban areas. *SIRC 2005 – The 17th Annual Colloquium of the Spatial Information Research Centre University of Otago, Dunedin, New ZealandNovember 24th-25th 2005*

Murty, C.S., Raju, P.V. and Badrinath, K.V.S. 2003. Classification of wheat crop with multi-temporal images: performanceof maximum likelihood and artificial neural networks. International Journal of Remote Sensing, 24(23), 4871 – 4890.

Omkar, S.N., Senthilnath, J., Mudigere, D. and Kumar M.M., 2008. Crop Classification using Biologically-inspired Techniques with High Resolution Satellite Image. Journal of Indian Society of Remote Sensing, 36, 175-182.

BIOGRAPHICAL NOTES

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Cankut Ormeci received his BSc and MSc in Civil Engineering and PhD in Geodesy and Photogrammetry Engineering at Istanbul Technical University (ITU). He was a Research fellow of Alexander von Humboldt Foundation in the Institute of Photogrammetry and Topography of Karlsruhe University (Germany) between 1981 and1983. He is a Professor at Geomatic Engineering Department of ITU and the Director of Center for Satellite Communications and Remote Sensing (ITU-CSCRS). He has been the principal investigator of many national projects and participated to international projects. He has published 6 SCI articles, 70 papers and 4 books.

Ugur Alganci

He has graduated from Istanbul Technical University, Geodesy and Photogrammetry Engineering Division in 2006. He completed Masters of Science education in Geomatics Engineering at the same University in 2008. He has been a PhD Student in Geomatics Engineering since 2008 and working as a Research Assistant in the Center for Satellite Communications and Remote Sensing since May 2009. He has worked as a Researcher in TUBITAK projects as remote sensing expert. He has research articles and conference papers mostly focused on water quality analysis and land use analysis for environmental monitoring of watersheds. He is a member of Turkish Chamber of Surveying Engineers.

Elif Sertel

Elif Sertel received her BSc in Geodesy and Photogrammetry Engineering and MSc and PhD in Geomatic Engineering at ITU. She was a Fulbright Scholar at Rutgers University, USA between August 2006 and January 2008 and she was a Post-Doctoral Researcher between January 2008 and September 2008 at Rutgers University supported by a NSF project. Elif Sertel is an Assistant Professor at Geomatic Engineering Department of ITU and she is the Vice-Director of ITU- CSCRS. She has been involved several national and international research projects and published 11 SCI articles and 25 papers. She is a member of Union of Chambers of Turkish Engineers and Architects, Chamber of Surveying Engineers (HKMO), American Geophysical Union, American Meteorological Society, Fulbright Association and the Association of American Geographers.

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