EVALUATION OF CLASSIFICATION METHODS FOR DETECTION OF GREENHOUSES FROM SPOT 5 SATELLITE IMAGERY

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Abstract
Monitoring and mapping greenhouse areas accurately using remotely sensed data is very important for urban and rural planning, agricultural yield estimation, monitoring and planning crop proportion, natural resource management, and sustainable development. The conventional techniques for greenhouse mapping are time consuming, and expensive. Remote sensing technologies are very important to extract accurate and reliable greenhouse information. The main objectives of this research are (1) to compare the performance of the supervised classification techniques including maximum likelihood (ML), and support vector machines (SVM) for land cover classification with emphasis on greenhouse detection and (2) to find out the ability of SPOT 5 satellite imagery for detecting greenhouses in selected study area Anamur district of Mersin, Turkey. The performance of classification methods, was compared by using error matrix. Overall accuracy and Kappa statistics were computed. Based on the results, SVM and MLC performances were similiar for the selected study area and SPOT 5 MS data.

Keywords*: Greenhouses, Classification, Support Vector Machines, SPOT 5*

INTRODUCTION

Greenhouse growing is important for food safety, besides its contribution to the economy and employment. The worldwide application of this kind of growing is 15% glass greenhouses and 85% plastic greenhouses (Sonmez and Sarı, 2006). Because of its superior ecological properties, Turkey has global importance in terms of vegetable and fruit production, and 87% of Turkey's greenhouse agriculture (37,703 ha) is in the Mediterranean region. Protected cultivation wich is providing evaluation for especially small businesses by obtaining high efficeny from per unit area has significant place in agricutural activities in Turkey. Protected Cultivation Agriculture includes greenhouses and under low plastic tunnels manufacturing. % 80 of greenhouses and also %95 of low plastic tunnela in our countery are located in Mediterranean Region (Tüzel and Eltez 2007). Because of the climate is Mediterranean Climate and it is milder than the other regions protected cultivation can be done more economical when compared to the other regions. In scale of Turkey, Mersin provinces protected cultivation area size ranks second place. Between the years 2004-2013, Mersin provinces have increased its share protected cultivation production area and manufacturing in Turkey. In Turkey general it has increased from %18 to %21,8, on the amount of production it has increased from %16,3 to %16,5 (Promer Planning, 2016).

Monitoring and mapping greenhouse areas accurately using remotely sensed data is very important for greenhouse registration, urban and rural planning, agricultural yield estimation, monitoring and planning crop proportion, natural resource management, public health and sustainable development. Remote sensing technologies are very effective tool to extract accurate and reliable greenhouse information. Greenhouse detection and mapping by using remotely sensed data is a complex task. There are a limited number of studies in the literature about greenhouse detection or delineation from high-resolution satellite images with different classification methods (Aguera et al., 2006; Carjaval et al., 2010; Koç-San, 2013; Tasdemir and Koç-San., 2014). High-resolution satellite images can be used efficiently for detecting existing greenhouses and monitoring greenhouse expansion.

The main aim of this study is to determine greenhouses in Anamur district of Mersin, in the digital environment by using high resolution SPOT 5 MS satellite data. Two different classification methods which are Maximum Likelihood (ML) and Support Vector Machine (SVM) classification were conducted and their performances were compared using error matrix. Post classification change detection was applied to determine the expansion of greenhouses in Anamur, Mersin.

STUDY AREA AND DATA

The selected study area is Anamur district of Mersin and it is located in the Mediterranen region of Turkey (Figure 1). The climate is Mediterranean with mild and rainy winters and hot and humid summers. The population of the distric is 63.983 according to 2014 Turkish Statistical Institute. The population growth rate is %3,97. When considering plan mosaic with the incrased density residential areas reached up to 453 ha's. Average population density is 385 ki/ha in these areas. Anamur District where placed on western border of Mersin Province is composed by %59 forest , %22 field, %11 cultivated area and %1 other. Coastal areas and coastal plains are the areas that where all economic, social activities, urban functional areas, transportation facilities and the population density placed in (Promer Planning, 2016). The Anamur distric is one of the most important area for greenhouses in Turkey.

SPOT 5, multispectral images (four bands: B1: Green, B2: Red, B3: Near Infrared) were used in the study acquired in the year of 2006 and 2014 to examine the mapping and expansion monitoring potential of two supervised classification method in Anamur. These images were obtained from High Resolution Geometric (HRG) sensors of the SPOT 5 satellite and have 5 meter spatial resolution. SPOT 5 MS sensor acquires data in 3 spectral bands that cover a wavelength range from 500 nm– 890 nm with a spatial resolution of 5 m. In addition, topographic maps at the scale of 1: 25 000 and field collected hand hold GPS data, Aster images were used for pre-processing and accuracy assessment of the derived thematic information.

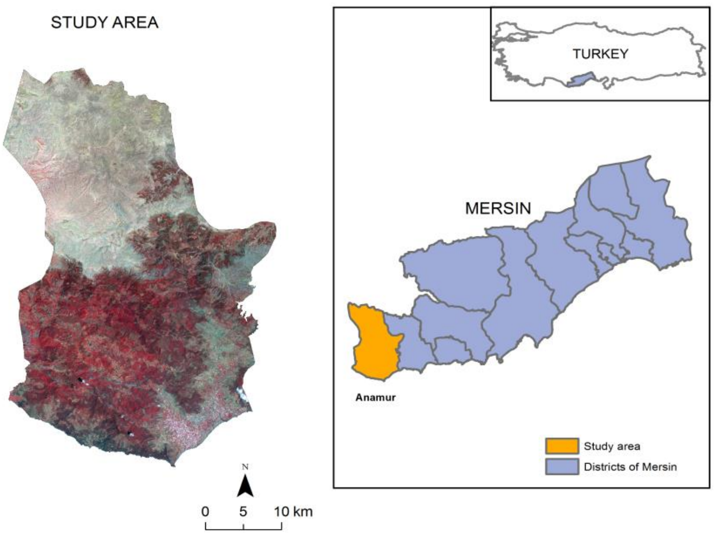

Figure 1. Study area

METHODOLOGY

Pre-processing

Image pre-processing steps were conducted to eliminate sensor problems and geometric distortions. Multi-temporal SPOT 5 images were geometrically registered to the Universal Transverse Mercator (UTM) projection system (ellipsoid WGS 84, and datum WGS 84) by using ground control points, primarily highway intersections, evenly distributed across the image. In the orthorectification 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 less than 0.5 pixel (2.5m) root mean square error (RMSE), for each of the two images. Figure 2 shows the flowchart of the study to derive greenhouse category of 2 different years.

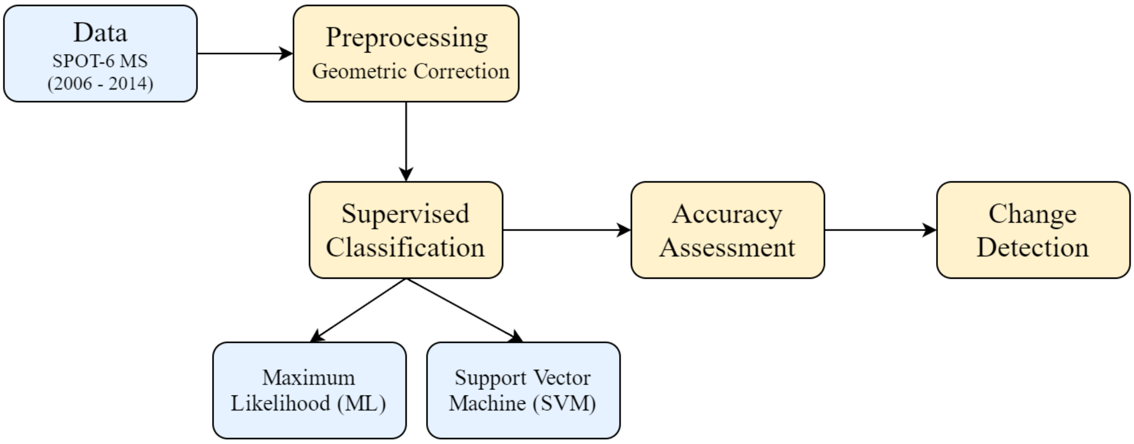

Figure 2. Flowchart of the study

Classification

Classification is a process of grouping pixels that have similar spectral values to transfer data into information for determining earth resources (Bozkaya et al., 2015, Balik Sanli et al. 2008, Bektas and Goksel, 2005). In this study, pixel-based Maximum Likelihood and Support Vector Machine supervised classification method were used to analyze the high-resolution, multi-spectral SPOT 5 imagery to extract information about greenhouses in the selected region. 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).

Supervised classification is a technique that is based on the statistics of training areas representing different ground objects selected subjectively by users on the basis of their own knowledge or experience (Liu and Mason 2009). These training sites are the representatives of land cover classes on the image and used to train the classification algorithm. Classification conducts with use of homogenously distributed signatures that are associated with training sites and the result is the determination of information classes.

Maximum Likeliood Classification

In this study, ML classification method was used as supervised classification. In the classification stage, for the 2006 and 2014 dated images, 2500 and 6000 training areas were determined respectively. The two spectrally separable, land cover classes identified by Maximum Likelihood were: i) greenhouse, ii) others that includes green areas and forest, agriculture / bare ground / grassland, artificial surfaces, and cloud (Fig. 3a). The classification results are evaluated with visual interpretation and these 40 information classes were reduced to final 2 thematic classes as greenhouses and other.

Support Vector Machine Classification

The SVM method, which was originated in the late 1970s by Vapnik, is one of the machine-learning algorithms. It is based on statistical learning theory and has recently been extensively used in remote sensing for pattern recognition and classification. Only a brief review and basic information are provided here, but readers can find further details in Vapnik (1995). It was originally designed for binary classification, and it allows the use of optimal algorithms to locate the best boundaries separating the binary classes in the feature's space. Here, the boundary is called the optimum separating hyperplane, which is aimed at maximizing the margin width.

The SVM classification method was implemented by using the Radial Basis Function (RBF) kernel. The most challenging and important factor for the SVM classifications was suitable choice of the kernel types and the optimum parameters (Bektas Balcik et al., 2012). The parameters for the RBF kernel were set to 0,33 and 100 for γ (gamma= 1/number of the band) and C (error penalty), respectively, for the SVM classification. The pyramid parameter was set to a value of 0 to process the satellite data at full resolution (5 m) (Figure 3b).

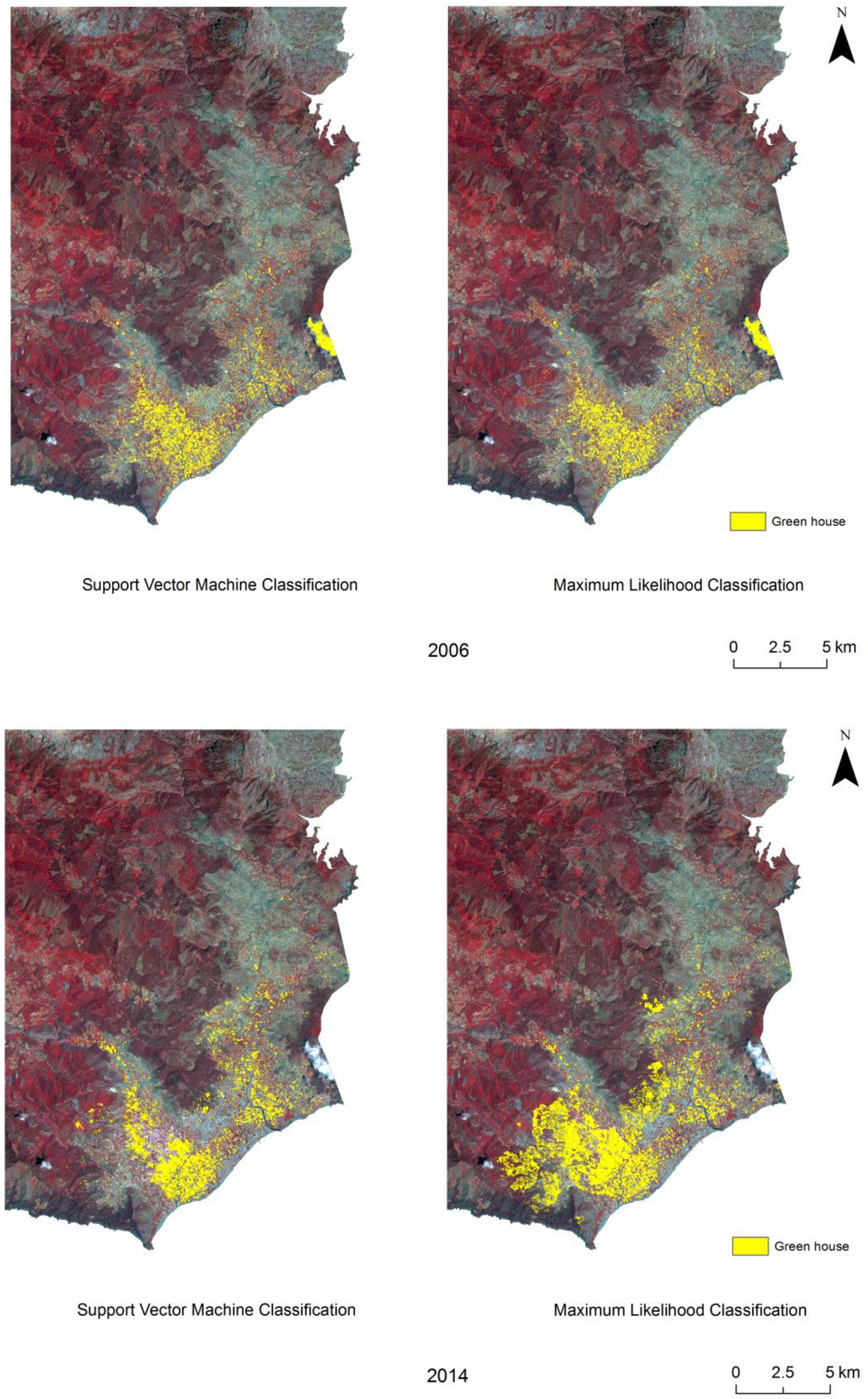

Figure 3. Results of Support Vector Machine and Supervised Classification methods a) 2006 b)2014

Many methods for assessing the accuracy of classification have been assessment discussed and used in remote sensing (Foody 2002). Detailed field study were conducted for classification and accuracy assessment purposes. Confusion or error matrix is the most widely mentioned and conducted method for accuracy assessment by using reference data, such as aerial photographs and field collected data. Different measures can be calculated from confusion matrix to examine classification accuracy, including errors of omission and commission, producer's and user's accuracies and the KAPPA coefficient (Foody 2002). Totally 1283 and 1230 random points, for the 2006 and 2014 dated images, were selected for two classes to assess the accuracy of the four classified images. The overall accuracy and a KAPPA analysis were used to perform classification accuracy based on error matrix (Table 1). The results show that there is a mixed pixel problem between land cover categories such as greenhouse –artificial surfaces and clouds in the study area. The reason for the mixed classes can be the pansharpened processing steps that has the ability to change the brightness value of the data.

Table 1. Accuracy assessment results

Year	**2006**	**2014**
Overall Accuracy (MLC)	95,98	96,14
Kappa Statistics (MLC)	0,68	0,71
Overall Accuracy (SVM)	96,34	95,85
Kappa Statistics (SVM)	0.70	0.72

RESULTS

The results showed that Spot 5 MS images could be used to produce greenhouse maps and statistics. General pattern and trajectories of greenhouses in the Anamur district were evaluated through the years 2006 and 2014. Based on accuracy assessment results greenhouse maps were produced with similar overall accuracy and Kappa statistic values of over 95.00 % and over 0,65, respectively by using Support Vector Machine and Maximum Likelihood supervised classification methods. The magnitude of change was calculated and change information derived from SVM classified images. The results showed that the increase of greenhouse area is determined 200,685 hectar between the year of 2006 and 2014.

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REFERENCES

Aguera, F., Aguilar, M. A., and Aguilar, F. J., 2006. Detecting greenhouse changes from quickbird imagery on the mediterranean coast. International Journal of Remote Sensing, vol. 27, no. 21, pp. 4751–4767.

Balik Sanli, F., Bektaş Balcik, F., Goksel, C., 2008. Defining temporal spatial patterns of mega city Istanbul to see the impacts of increasing population. Environmental Monitoring and Assessment, Vol. 146, No.1-3, pp: 267-275.

Bektas Balçık, F., Goksel, C., 2005. Remote Sensing And GIS Integration For Land Cover Analysis, A Case Study: Bozcaada Island. Water Science and Technology, Vol:51, No:11, pp: 239-244.

Bektaş Balçık F., Balık Şanlı F., Abdikan, S., Esetlili, T., Göksel, C., Kurucu, Y.: Mapping Crop Types Using Support Vector Machine Classifiers from RapidEye data in Menemen Plain, İzmir. International Soil Congress on Land Degradation and Challenges in Sustainable Soil Management, İzmir, Extended Abstract.

Bozkaya, A. G., Bektas Balcik, F., Goksel, C., Esbah, H.: Forecasting land-cover growth using remotely sensed data: a case study of the Igneada protection area in Turkey. Environmental Monitoring and Assessment, Vol. 187, No: 59, 2015, DOI 10.1007/s10661-015-4322-z.

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

Koc-San., D., 2013. Evaluation of different classification techniques for the detection of glass and plastic greenhouses from worldview-2 satel- lite imagery. J. Appl. Remote Sens., vol. 7, no. 1, pp. 1913–1928.

Liu, J G., Mason, P J., 2009. Essential Image Processing and GIS for Remote Sensing, New York: Wiley-Blackwell.

Sonmez, N.K., Sari M**.,** 2006. Use of remote sensing and geographic information system technologies for the developing greenhouse databases. Turkish Journal of Agriculture and Forestry, 30(6), 413-420.

Tasdemir K., and Koc-San, D., 2014. Unsupervised extraction of green- houses using worldview-2 images," in Geoscience and Remote Sens- ing Symposium (IGARSS), 2014 IEEE International, pp. 4914–4917.

Tüzel Y., Eltez RZ., 1997. Protected cultivation in Turkey, a contribution towards a data base for cultivation in the Mediterranean Region. In: Abbou-Hadid AF ed. Regional Working Group Greenhouse Crop Production in the Mediterranean Region, FAO.

Promer Planning, 2016. Mersin İl Çevre Düzeni Planı Ve Kent Bütünü Araştırma-Analitik Etüt Çalışmaları. Project Raporu, Mersin Büyük Şehir Belediyesi.

Vapnik V. N., 1995. The Nature of Statistical Learning Theory. , Springer-Verlag , New York.

BIOGRAPHY

Dr. Cigdem GOKSEL is currently working as an Assoc. Prof. at the Istanbul Technical University (ITU), Faculty of Civil Engineering Department of Geomatic Engineering. She received her B.Sc.in 1984, M.Sc. in 1989 and Ph.D. degree in 1996 from ITU. She was visiting scholar at Murray State University's Mid-America Remote Sensing Center (Geosciences) KY–USA in 1999. Her main research areas are monitoring landuse landcover change and remote sensing and GIS integration for the environmental studies. She has more than 90 scientific publications related with different remote sensing applications. She has involved and supervised several national and international research and projects in the field of remote sensing and integrated technologies.

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