Turkish Journal of Engineering

Turkish Journal of Engineering (TUJE)
Vol. 3, Issue 1, pp. 32-38, January 2019
ISSN 2587-1366, Turkey
DOI: 10.31127/tuje.444685
Research Article

LAND USE AND LAND COVER CHANGES USING SPOT 5 PANSHARPEN IMAGES; A CASE STUDY IN AKDENIZ DISTRICT, MERSIN-TURKEY

Çiğdem Göksel *[1] and Filiz Bektaş Balçık [2]

[1] Istanbul Technical University, Geomatics Engineering Department, Istanbul, Turkey
ORCID ID 0000-0001-8480-1435
goksel@itu.edu.tr

[2] Istanbul Technical University, Geomatics Engineering Department, Istanbul, Turkey
ORCID ID 0000-0003-3039-6846
bektasfi@itu.edu.tr

* Corresponding Author
Received: 17/07/2018 Accepted: 06/08/2018

ABSTRACT
The main objective of the study is to quantify main changes in urban area of Akdeniz district of Mersin province using Pan sharpen SPOT 5 MS (with 3 bands) satellite images. In this study, land cover and land use maps of 2006 and, 2014 are produced using Maximum Likelihood supervised classification technique to detect the growth of urban area in the selected area. Preprocessing methods, including geometric and radiometric correction were performed. From to changes method was applied to determine the land cover/land use transformation in the region. An accuracy assessment was conducted using overall accuracy and Kappa statistics. Results show that maps obtained from images for 2006, and 2014 had an overall accuracy of 82.96%, and 84.00%, and a Kappa coefficient of 0.80, and 0.82, respectively. The results showed that between the selected years the district faced a huge transformation from agricultural fields and bare lands to artificial surfaces. Change detection between 2006 and 2014 shows that most of the agricultural fields (6295,1 ha) have been increased; moreover, artificial surfaces and green houses have also increased. The largest decrease has occurred for bare lands area of which approximately 3942,5 ha. According to the results, artificial surfaces was increased by 189 ha from 2006 to 2014 in Akdeniz District of Mersin.

Keywords: *Land Use, Land Cover, Change Detection, SPOT, Remote Sensing*

1. INTRODUCTION AND AIM OF THE STUDY

Acquired Earth Observation data (EO) by remote sensing satellites has greatly provided a temporal broad view of earth surface and remote sensing has improved an important tool to monitor and manage land surfaces. Compared to field-based studies, remote-sensing technology has many advantages for quantitatively measuring and forecasting land-cover changes due to practical data acquisition, effective cost, and application of spatiotemporal data. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Coppin *et al*., 2004). Accurate and reliable change detection of land-use/land-cover (LULC) has an important role in order to determine and control local, regional, and global urban sprawl and development around city (Lu *et al*., 2004, Bektas and Goksel, 2005; Bozkaya *et al*., 2014; Bozkaya *et al*., 2015). Management and monitoring of land use features within a time plan is significant for local and regional authorities. Besides, it is highly essential for maintaining life quality of both urban and rural environment and their habitants, and utilizing the existing sources effectively.

Remote sensing allows for determination of land use/land cover statistically and visually based on time and location in a fast and economical way (Banister *et al*., 1997; Goksel, 2016; Hellawell, 1991; Jat *et al*., 2008). A commonly used approach for image analysis is digital image classification. The purpose of image classification is to label the pixels in the image with meaningful information from the real world to produce thematic maps. Subsequently, these thematic maps used to apply change detection. Several studies have stated the crucial necessity to obtain consistent, accurate, and up-to-date spatial information on land cover and the scale of its change for the Earth's resources (Weng, 2002; Dogru *et al*., 2006; Serra *et al*., 2008; Yagoub and Bizreh, 2014)

Traditionally, various pixel-based techniques usually were used to create LULC classifications (Bozkaya *et al.*, 2015, Bektas Balcik & Karakacan Kuzucu, 2016). The pixel-based techniques include either a supervised or unsupervised classification or a combination of these (Bektaş Balçık, 2010). In this study, conventional Maximum likelihood supervised classification method conducted to determine main LULC categories in selected district using 3 bands of SPOT 5 MS data.

There are two fundamental methods for temporal change detection established on remotely sensed data; pre-classification and post classification techniques. Though numerous algorithms of pre-classification techniques for instance image rationing, principle components analysis or vegetation indices are applied to define the change or no change maps, post classification techniques compare the classification results of different dated satellite data to produce "from–to" map to map change information (Fung and Siu, 2000; Jensen, 2004).

In this study, change detection of land cover and land use classes were investigated and evaluated for Akdeniz District of Mersin province, Turkey. Selected region has developed rapidly over the last three decades due to emerging industries, urbanization, and tourism. Maximum likelihood of supervised classification was used to extract land use/cover information from the remotely sensed data. The main objectives of this research were: (1) to derive land cover and land use categories of Akdeniz district of Mersin for the years of 2006 and 2014. (2) to apply post processing *from-to* change detection method to explore the LULC transformations and the impacts on surrounded environment in the selected districts that produce; (3) to experience and discuss the potential of 3 bands pan-sharpened SPOT 5 MS data in a heterogeneous study area using conventional supervised classification method and error matrix. The research outcomes showed the transformations and changes in LULC categories of the selected region that has a huge economical and strategic importance in Mediterranean region of Turkey.

2. STUDY AREA AND DATA

Based on the National Strategies on Regional Growth, Mersin is defined as a potential metropolitan city which can be alternative for Istanbul, Ankara and Izmir in Turkey. Based on EU's regional growth systematics NUTS (The Nomenclature of territorial units for statistics), Turkey is divided into three levels, twelve regions, twenty-six sub-regions and eighty-one cities. Mersin is classified as TR62 (Mediterranean region/Adana-Mersin sub-region). Mersin, region, sub-region and country location and administrative structure within the transportation network was evaluated in terms of Turkey's is one of the important city.

Mersin province lies between 36-37° northern latitudes and 33-35° east longitudes. This plain city is located in the mid-south region of Anatolian Peninsula and has a coastal line in Mediterranean Sea and surrounded with Toros mountains. Together with its 13 counties and 304 districts, Mersin is the second biggest city in Cukurova region with a surface area of 16.245 km². The city of Mersin, which is one of the populated urban centers located in the eastern Mediterranean region of Turkey (Alphan and Celik, 2016). This region has developed rapidly over the last three decades due to industries, urbanization, and tourism. Mersin International Port, which is one of the largest ports of Turkey, lies to the east of the city. Geographic locations of the port and the industries have led the city of Mersin to grow on the west coast since the early 1980s.

The selected region, Akdeniz district, has a significant role in Mersin in terms of economic and cultural aspects, with its 1.783 km² surface area, and total population of 276000. Akdeniz District is located in the eastern part of Mersin, Turkey (Fig. 1). The region has Mersin International Port, which is one of the largest ports of Turkey. Subsequently, this part of the city is mostly occupied by industrial and/or commercial units that are associated with the port. The district is an area that experienced a fast increase of urban population in the recent decades in Mersin (Report, 2016). Rapid urbanization and industrialization have important effect on natural resources, agricultural fields and urban environment (Alphan, 2013; Alphan and Sonmez, 2015; Burak *et al*., 2004). The remote sensing technique using satellite imagery has been recognized as an effective and powerful tool in monitoring and detecting land use and land cover changes.

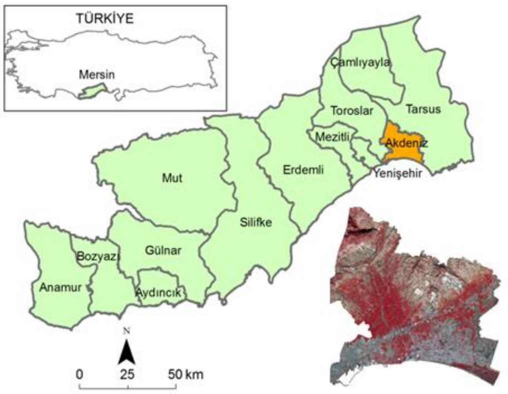

Fig. 1. Study Area

For change detection of land use/land cover, two pan-sharpened SPOT5-MS images, dated 2006 and 2014, were used. The SPOT5-MS images included 3 bands and the spatial resolution of the images was 5m. In addition, 1/25000 scaled standard topographic maps and 1/5000 scaled digital orthophotos were used with these satellite images for rectification and ground truth.

3. METHODOLOGY

In this study, SPOT 5 multispectral data processed using conventional methods and supervised classification. Figure 2 shows the flowchart of the detailed application steps of the study used to derive *from to* changes in Akdeniz district, of Mersin Province.

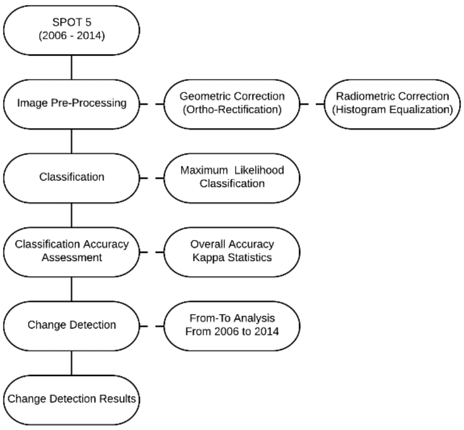

Fig. 2. Flowchart of the study

3.1. Image Preprocessing

In change detection studies, it is inevitable for obtaining accurate results that satellite images should have the same coordinate and projection system (Richards and Jia, 2006). First, geometric correction was applied to eliminate systematic and nonsystematic errors for the dataset consists of more than one frame having different acquisition dates. The SPOT5 images with 5m spatial resolution were processed as ortho (Level 3A) level. The images that are processed in this level are produced by using The Shuttle Radar Topography Mission Digital Terrain Elevation Data 1 (SRTM-DTED1) and satellite orbit parameters and have ±30 m positional accuracy. Then, topographic normalization process was carried out. In ortho-imagery production stage, the ortho-photos belonging to the study area were utilized by means of "map to image" method. 2D geometric correction with 1st degree polynomial transformation was applied in order to increase the positional accuracy of images for accurate change detection analysis. On one hand, geometric correction for 2014 dated SPOT5 MS image was executed with 148 homogenously distributed ground control points. On the other hand, 120 ground control points were used for the geometric correction for 2006 dated SPOT5 MS image. In this context, nearest neighborhood method was chosen for resampling due to its ease of computation and capability of avoiding data loss. Root means square errors (RMSE) were calculated as 7.72 m and 4.98 m for 2006 and 2014 dated images, respectively. The rectification process applied for whole Mersin area and the RMSE values were calculated at acceptable accuracy to produce 1/50 000 scaled Environmental Master Plan of Mersin.

In the second stage, histogram equalization as a radiometric correction technique was applied. As a third step, mosaicking was executed, and then the images that will be classified were prepared based on corresponding province and county borders. As a last step, Maximum Likelihood supervised classification algorithm was applied to determine land cover and land use changes of the Akdeniz region in Mersin.

3.2. Classification of Satellite Images

Classification of a remotely sensed imagery is a process of transforming digital data obtained by satellite images having different spectral resolution to images illustrating land use/land cover. The main goal of classification is to cluster pixels having similar reflectance and assign them to corresponding attribute class in real world (Elachi and van Zyl 2006).

In this study, Maximum Likelihood which is one of the pixel-based supervised classification techniques was applied. In this method, training sites are identified by the analyst (Liu and Mason 2009; Mather 2004). An extensive field survey within the study was conducted for determination of ground truth. Photos of study area were taken at 60 seconds period, with a high resolution camera mounted with 120° on the front window of the survey vehicle. In addition to photographs, GPS coordinates of ground control points were recorded simultaneously. By this way, location information was acquired related to land use/land cover features that lacks of information. Therefore, 1/5000 scaled ortho-photos were used for ground truth. For classification process, 200 training sites were identified. The land use/land cover classes are defined based on Corine Level 1. Figure 3 illustrates the classification results for 2006 and 2014, respectively and Table 1 shows the area of each LULC categories for 2006 and 2014.

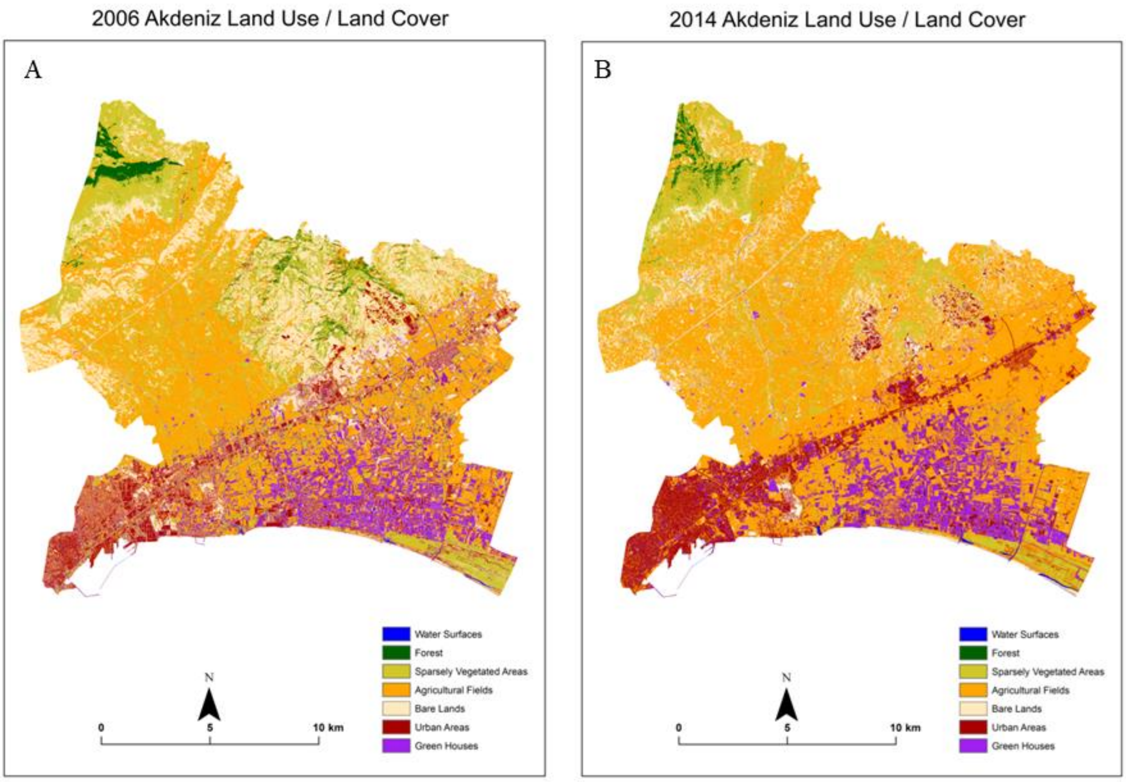

Fig. 3. Akdeniz district LU/LC classification results A) 2006, B) 2014

Table 1. Area of land cover types for 2006 and 2014

Classes	Area (ha) (2006)	Area (ha) (2014)
Water surfaces	66.17	126.38
Forest	573.55	243.53
Sparsely vegetated area	6710.13	4206.95
Agricultural fields	10472.10	16767.20
Bare lands	7296.07	3353.54
Artificial surfaces	2954.72	3144.03
Green houses	2376.27	2607.42

The significant limitations of the classification can be listed as contrasting differences caused by seasonal changes and cloud coverages in the images, mixing greenhouses and bright surfaces (such as quarry and industrial regions, or the type of soil and rock), mixing water features and forests due to SPOT5 imagery consisting of 3 bands. Pixel based traditional supervised classification algorithms are based on spectral information of each pixel of an image and don't take into account the problem of mixed pixels. If a pixel of remote sensing images contains several land cover types, such pixels are known as mixed-pixels (Zhu, 1995). Heterogeneous landscapes of Akdeniz district and selected classification algorithm are the main reasons for mixed pixel problem and the average accuracy assessment results.

3.3. Accuracy Assessment

Accuracy assessment of classification is essential to assure the quality of thematic maps produced using remote sensing data. Additionally, accuracy assessment is very important for understanding the detected change results and employing these results for land management, urban land planning and decision making (Foody, 2002). To evaluate the error ratio in the classified image data, in other words, to determine the consistency of the classified image and the ground truth, accuracy is assessed by comparing the training sites selected in the classified image with the ground truth (Congalton, 1991; Sertel and Akay, 2015). Aerial photos, maps, plans, GPS data and the photos acquired during field survey are used as a reference (ground truth). For assessing accuracy, creating error matrix and computing kappa coefficient (κ) regarding to this matrix is the most widely used method. Kappa statistic (κ) values are between 0 and 1 and 0.8-1 interval indicates the ideal classification results (Cohen, 1960).

Within the study, the accuracy of the classification results was assessed by comparing classified images with the GPS data, the photos acquired during field survey and higher resolution satellite images. In this context, 270 points were selected as field collected training sites. Table 2 shows the accuracy assessment results for 2006 and 2014 dated classified images.

Table 2. Accuracy assessment results

SPOT 5 MS image	Number of control points	Overall Accuracy	Kappa Statistics (κ)
2006	270	% 82.96	0.80
2014	270	% 84.00	0.82

3.4. Change Analysis

The changes in land use/land cover are regarded as driving forces of transformation and modification of earth surface (Turner, 1990). These changes are performed by the decisions of authorities within the social, economic, cultural, political, environmental and ecological procedures (Aspinall and Hill, 2008). To determine the changes accurately, firstly; geometric, atmospheric, and radiometric correction should be carried out and secondly; the images should be classified with high classification accuracy.

For this study, "from-to" analysis for two classified images (2006 and 2014 dated) was employed and the analysis results indicating the differences between two images were presented in detail in Table 3. The change statistics below gives an explanation on the question of where land use/land cover changes are occurring (Table 3). The results include sparsely vegetated areas, agricultural fields, bare lands and greenhouses.

Table 3. From-To change detection results

Classes (ha) 2006 From	Artificial Surfaces Area (ha) 2014 To	Bare Lands Area (ha) (2014) To
Sparsely vegetated area	321.40	640.98
Agricultural fields	593.16	947.207
Bare lands	730.99	-
Green houses	481.723	67.06
Total unchanged area	12541.77	

4. RESULTS

This study has explored the potential of pan-sharpened satellite-remote sensing and geospatial technologies in producing land use/land cover maps and statistical analysis of the selected study area. This research, with the aim to determine the urban development and its effects on Akdeniz district of Mersin province, shows changing land use/land cover dynamics in an objective way by utilizing different dated two SPOT5 MS images with a series of processing procedures and field surveys. Although SPOT 5 pan-sharpened images have high spatial resolution, 3 bands have disadvantages to produce land use/cover maps and statistics because of mixed pixels and similar spectral characteristics of targets in heterogeneous Mediterranean landscape.

General pattern and trajectories of land use and land cover in the Akdeniz district were evaluated through the years, 2006 and 2014. Land use/land cover maps were produced with an overall accuracy of over 82.00% by using Maximum Likelihood supervised classification method. The magnitude of change was calculated and "from–to" change information derived from classified images. The results of change trends in classification showed that the dominancy of artificial surfaces tends to increase at the coastal part of the district in a short period of time (i.e., from 2006 to 2014).

Especially, in the inland areas that includes sparsely vegetated areas and forest a huge transformation were occurred from sparsely vegetated areas to artificial surfaces and bare lands. Therefore, from-to changes results indicated that total unchanged area is 12541.7 ha in the study area. The highest transformation was seen from bare lands to artificial surfaces in the region. Therefore, the agricultural fields were changed to artificial surfaces and bare lands.

Regarding to the temporal change detection results for Akdeniz district which has geographic and strategic importance, following remarks can be expressed:

- Built-up areas were increased, especially in the coastal line (residential tourism areas)
- Rich agricultural areas were transformed into bare land or residential areas.
- In bare lands around Mersin International Port, the built-up areas belonging to logistics industry were increased.
- Based on the general change detection results, green houses were increased in the district.

Akdeniz is crucial not only for industry or service sector, but also for agriculture and undercover greenhouse activities. Agriculture, industry and service sector are actually the fundamental components of sustainable development for both Akdeniz district and whole Mersin.

These results and analyses can be used as a base study for sustainable environmental management of heterogonous Mediterranean region of Turkey. In this context, monitoring using remote sensing technology has a huge importance to keep sustainable management under control.

ACKNOWLEDGEMENTS

This paper was carried out within the scope of "Project of the Province Wide Research and Analytical Works for the Environmental Master Plan of Mersin". We are thankful to Mersin Metropolitan Municipality as the client and contractor PROMER Planning Eng. Inc. of this project. We have to express our appreciation to the project team for sharing their experience and collaboration.

REFERENCES

Alphan, H. (2013). Bi-temporal analysis of landscape changes in the easternmost Mediterranean deltas using binary and clas- sified change information. *Environmental Management*, 51, 541–554.

Alphan, H., & Celik, N. (2016). Monitoring changes in landscape pattern. Use of Ikonos and Quickbird images. *Environmental Monitoring and Assessment*, 188(81).

Alphan, H. and Sonmez, F. (2015). Mapping availability of sea view for potential building development areas. *Environmental Monitoring and Assessment*, 187(7).

Aspinall, R. J., & Hill, M. J. (2008). Land use change: science, policy, and management: CRC Press.

Banister, D., Watson, S., & Wood, C. (1997). Sustainable Cities: Transport, Energy, and Urban Form. *Environment and Planning B: Planning and Design, 24*(1), 125-143, doi:10.1068/b240125.

Bektas, F., & Goksel, C. (2005). Remote sensing and GIS integration for land-cover analysis: a case study:Bozcaada Island.*Water Science and Technology*, 51(11), 239–244.

Bektaş Balçık, F (2010). Mapping And Monitoring Wetland Environment By Analysis of Different Satellite İmages And Field Spectroscopy', PhD Thesis, Istanbul Technical University

Bektas Balcik F., Karakacan Kuzucu A. (2016) "Determination of Land Cover/Land Use Using SPOT 7 Data With Supervised Classification Methods". *GeoAdvances Workshop*, 2016. Istanbul.

Bozkaya, A. G., Bektas Balcik, F., Goksel, C., Dogru, A. O.,Ulugtekin, N. N., & Sozen, S. (2014). Satellite-based multitemporal change detection in Igneada flooded forests. *Romanian Journal of Geography*, 58(2), 161–168.

Bozkaya, A. G., Bektas Balcik, F., Goksel, C., Esbah, H. (2015) Forecasting land-cover growth using remotely sensed data: a case study of the Igneada protection area in Turkey. *Environmental Monitoring Assess*, 187: 59

Burak, S., Doğan, E. and Gazioğlu, C. (2004). Impact of urbanization and tourism on coastal environment. *Ocean and Coastal Management*, 47(9–10): 515–527.

Cohen, J. (1960). A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement, 20*(1), 37-46.

Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment, 37*(1), 35-46.

Sertel, E., Akay, S.S. (2015). High resolution mapping of urban areas using SPOT-5 images and ancillary data" International Journal of Environment and Geoinformatics (IJEGEO)., 2 (2), 63-76

Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B., Lambin, E. (2004) Digital change detection methods in ecosystem monitoring: A review *International Journal of Remote Sensing*, 25 (9), pp. 1565-1596.

Dogru, A. O., Bektas Balcik, F., Goksel, C., & Ulugtekin, N. N. (2006). Monitoring Coastal Dunes By Using Remote Sensing And GIS Integration In North West Part Of Turkey: A Case Study Of Kilyos Dunes. *Fresenius Environmental Bulletin*, 9b, 15

Elachi, C., & van Zyl, J. J. (2006). *Introduction To The Physics and Techniques of Remote Sensing*: Wiley.

Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote Sensing of Environment, 80*(1), 185-201

Fung, T., & Siu, W. (2000). Environmental quality and its changes, an analysis using NDVI. *International Journal of Remote Sensing*, 21(5), 1011–1024.

Goksel, C., Balcik, F. B., Keskin, M., Celik, B., Cihan, C., Yagmur, N. (2016). Evaluation of Classification Methods for Detection of Greenhouses from Spot 5 Satellite Imagery. *6th International Conference on Cartography and GIS*, Albena, Bulgaria, 13-17 June

Hellawell, J. M. (1991). Development of a rationale for monitoring. In B. Goldsmith (Ed.), *Monitoring for Conservation and Ecology* (pp. 1-14). Dordrecht: Springer Netherlands.

Jat, M. K., Garg, P. K., & Khare, D. (2008). Monitoring and modelling of urban sprawl using remote sensing and GIS techniques. *International Journal of Applied Earth Observation and Geoinformation*, 10(1), 26-43.

Jensen, J. R. (2004). *Digital change detection. Introductory digital image processing: A remote sensing perspective* (pp. 467–494). New Jersey: Prentice-Hall

Liu, J. G., & Mason, P. (2009). Essential Image Processing and GIS for Remote Sensing: Wiley.

Lu, D., Mausel, P., Brondízio, E., Moran, E. (2004) Change detection techniques. *International Journal of Remote Sensing*, 25 (12), pp. 2365-2407.

Mather, P. M. (2004). *Computer Processing of Remotely-Sensed Images: An Introduction*: Wiley.

Report, (2016). *Project of the Province Wide Research and Analytical Works for the Environmental Master Plan of Mersin*. Mersin Municipality (Ed.). In Turkish.

Richards, J. A., & Jia, X. (2006). *Remote Sensing Digital Image Analysis: An Introduction*: Springer Berlin Heidelberg.

Sanlı F., Bektaş, F., & Göksel, C. (2008). Defining temporal spatial patterns of mega city Istanbul to see the impacts of increasing population. *Environmental. Monitoring Assess*. 146:267–275

Serra, P., Ponsa, X., & Sauri, D. (2008). Land-cover and land-use change in a Mediterranean landscape: a spatial analysis of driving forces integrating biophysical and human factors. *Applied Geography*, 28, 189–209

Turner, B. L. (1990). *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere Over the Past 300 Years*: Cambridge University Press.

Weng, Q. (2002). Land-use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic modelling. *Journal of Environmental Management*, 64, 273–284.

Yagoub, M. M., Bizreh A. Al. (2014) Prediction of Land Cover Change Using Markov and Cellular Automata Models: Case of Al-Ain, UAE, 1992-2030. *Journal of the Indian Society of Remote Sensing*, Volume 42, Issue 3, pp 665–671

Zhu, S. (1995). Based on the mixed-pixel image classification of remote sensing technology. *Journal of the People's Liberation Army Institute of Surveying and Mapping*, 12(4). pp.276-278.