Research Article
Eur J Forest Eng 2018, 4(2): 50-55

Spatiotemporal Change Detection of the Linden Forests in Bursa, Turkey*

Burhan Gencal, İnanç Taş, Abdullah E. Akay**
Bursa Technical University, Faculty of Forestry, 16310 Bursa, TURKEY.

Abstract

Nonwood forest products potentially provide many economic, social and environmental benefits in Turkey. Increasing public demand for nonwood forest products has led to the development of spatial planning and updating of existing plans. In order to ensure the sustainable management of nonwood forest products, their trends and spatial distributions by time can be estimated by using land use/land cover change detection approach. The Linden is one of the most important nonwood forest products in Turkey and the most widespread distribution of linden is located in the province of Bursa. In this study, it was aimed to determine the spatiotemporal changes of one of the world's largest linden forests in Yeniköy Forestry Enterprise Chief within the border of Bursa Forestry Regional Directorate. Change detection analysis was applied to Landsat 5 TM image and Landsat 8 OLI/TIRS image captured in August 2008 and in July 2017, respectively. The spatiotemporal change detection was implemented on these two images by using various digital image processing techniques (pre-processing, classification, post-processing, and change detection) through ERDAS Imagine 2015, ArcGIS 10.5, and ENVI 5.3 program. The supervised classification, applied on both images using ERDAS Imagine 2015 program, revealed that there were six significant land use/land cover types in the study area; linden, other deciduous trees, wetlands, swamp, sand, and other lands (settlements, agriculture, open areas). The results indicated that there was increase in the areas of wetlands, sand, and other lands, while the area of linden forest, other deciduous trees, and swamp decreased from 2008 to 2017. According to the accuracy assessment results, the classification processes applied on 2008 and 2017 images provided overall accuracy of 84.38% and 82.81%, respectively. It is determined that some of the linden forests have been converted into residential areas and farmlands to grow crops.

Keywords: Spatiotemporal change detection, land use/land cover change, linden, classification

1. Introduction

The term non-wood forest product is often used for “goods of biological origin other than wood derived from forests, other wooded land and trees outside forests” (Dembner and Perlis, 1999). Non-wood forest products in general are essential for the daily life of millions world-wide and they are main source of income especially for rural people in many parts of the world (Chupezi et al., 2009). In addition, these plants are also consumed by people for healthcare, nutritional and many other needs. Thus, spatial planning of non-wood plants is very important in terms of production planning and updating of existing plans.

In order to ensure benefits of non-wood forest products, it is important to locate nonwood plants and determine their population distribution. The trends and spatial distributions of these plants by time can be estimated by using spatiotemporal change detection approach. Advanced features of Geographical Information System (GIS) and Remote Sensing (RS) technologies h as been effectively used to assess and monitor land use/land cover changes at low cost and in short time (Desai et al., 2009; Akay et al., 2014).

GIS is an information system that performs the processes of collecting, storing, processing, and transferring the graphical and non-graphical data obtained by spatial observations (Yomralıoğlu, 2005). This information system is based on geographic locations and the linking of all kinds of data to these locations. RS refers to the acquisition of information about the object or the earth using electromagnetic radiation (light) without direct contact with the object or the earth (Jong et al., 2004). Due to the fact that GIS and RS technologies can work together, quick and accurate solutions can be produced in spatiotemporal change detection analysis in the field of forestry (Çakır et al., 2008; Dewan and Yamaguchi, 2009; Sivrikaya et al., 2009; Ruelland et al 2010).

The Linden is one of the most important nonwood forest plants in Turkey. Linden flowers, which are economically very valuable nonwood product, are

* This work has been partially presented in 4th NWFP Symposium
**Corresponding author: Tel: +90-224-3003426 E-mail: abdullah.akay@btu.edu.tr
Received 11 Dec 2018; Accepted 19 Dec 2018

mainly used in medical and cosmetic industries due to the active substances such as tannins, mucilage, sugar, oils, gum. Besides, boiled Linden flowers are commonly consumed as herbal tea in Turkey to prevent flu and cold, relief chest and bronchi, and relax nervous system (Tuttu et al., 2017). The most widespread distribution of linden is located in the province of Bursa, covering approximately 7000 ha of the Caucasian linden (*Tilia rubra*) and 400 ha of the Silver linden (*Tilia tomentosa*) forest. In this study, spatiotemporal change detection of one of the world's largest linden forests in Yeniköy Forestry Enterprise Chief was conducted based on series of Landsat images.

2. Material and Methods

2.1. Study Area

The spatiotemporal change detection study was performed for a linden forest located in Yeniköy Forestry Enterprise Chief (FEC) of Bursa Forest Regional Directorate (Figure 1). The geographic location of the study area is 40° 23' 49" N - 40° 18' 04" N latitudes and 28° 06' 50" E - 28°28' 47" E longitudes. Yeniköy FEC has a total land of 11153 ha with 7922 ha of high forest, 1093 ha of degraded forest, and 2138 ha of deforested areas. The main land use types in the region are forest, flooded forest, swamp, water bodies, agriculture, sand, roads, and open areas. The dominant trees in the region besides linden are alder, oak, ashen, poplar, stone pine, and black pine.

2.2. Digital Image Process

In order to perform image processing techniques, a digital database has been generated for the study. The database included forest management maps (1/25000), Landsat 5 TM (Thematic Mapper) image and Landsat 8 OLI/TIRS (Thermal Infrared Sensors) image with 30 m spatial resolution acquired in the year of 2008 (August) and 2017 (July), respectively.

Figure 1. Study Area

The digital image processing included four main stages: 1) pre-processing, 2) classification, 3) post-processing, and 4) change detection. The image processing applications were performed on the satellite images via ERDAS Imagine 15, ArcGIS 10.5, and ENVI 5.3 programs.

2.2.1. Pre-processing

To generate color infrared (CIR) images, firstly the appropriate band combinations were implemented on Landsat images. Bands 4, 3, and 2 of Landsat images were combined by using "Layer Stack" function under "Utilities" tool menu of ERDAS Imagine 15. Then, geometric correction of satellite images were performed by using forest management maps and ground control points as the references. In order to eliminate systematic errors and to improve the quality of remote sensed data, radiometric correction was implemented using "Radiometric Calibration" tool under ENVI program. After radiometric correction, atmospheric correction was used to remove the scattering and absorption effects of the atmosphere. The true surface reflectance was estimated by using "FLAASH Atmospheric Correction" tool working in ENVI. In the final stage of pre-processing, the border of the study area obtained from forest management map was used to subset linden forest area from Landsat images (Figure 2).

2.2.2. Image Classification

To generate land use/land cover maps for both satellite images, Supervised Classification method in ERDAS 15 was used based on a set of user-defined classes, by using the appropriate spectral signatures. In classification process, "User-Defined Polygon" function with a high degree of user control was used to reduce the chance of underestimating class variance (Moller-Jensen, 1997). The spectral signatures were collected from the satellite images by drawing a polygon around training sites based on general knowledge obtained from topographic maps and forest management maps. Then, the parallelepiped non-parametric rule provided by ERDAS 15 was used to run supervised classification. After the classification process, "Recode" function was applied to combine the classes into six main classes including linden, other deciduous trees, wetlands, swamp, sand, and other lands (settlements, agriculture, open areas) (Table 1).

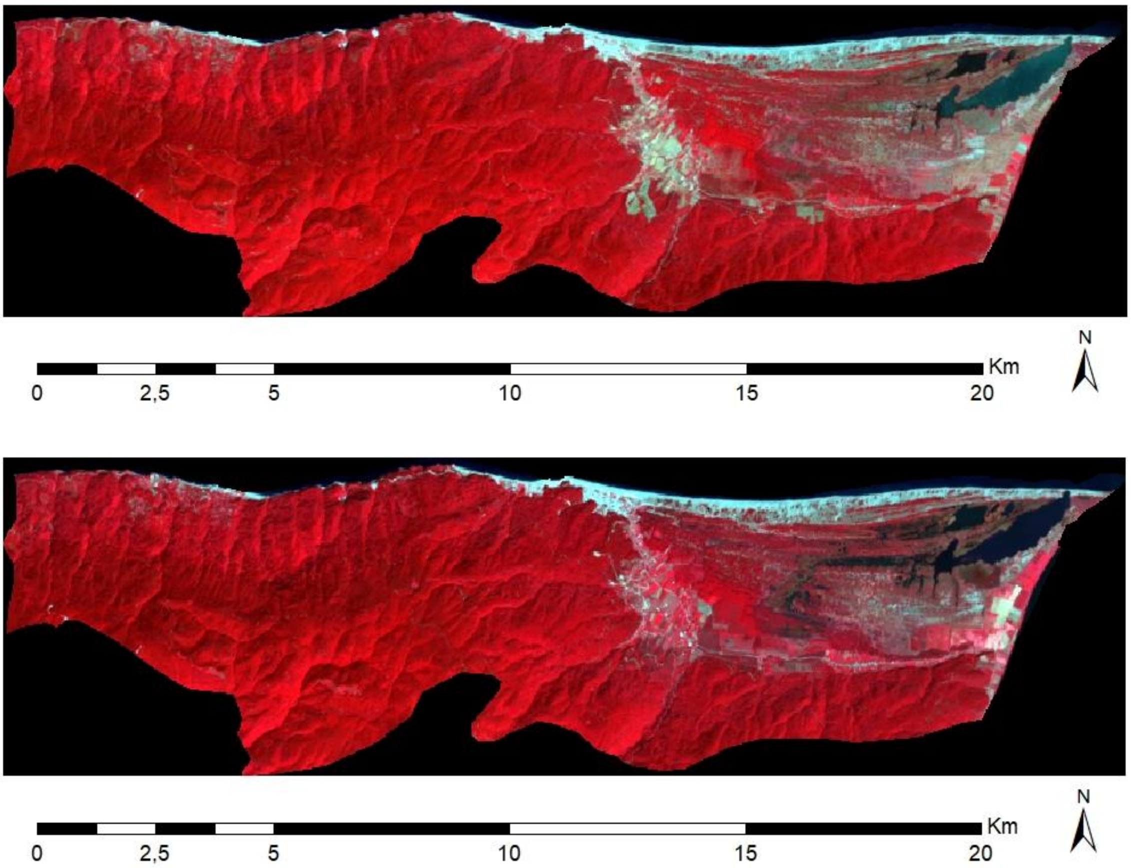

Figure 2. Landsat 5 TM image from 2008 (above) and Landsat 8 OLI/TIRS image from 2017 (below)

Table 1. The classes used in classification process

Class name	Class description
Linden	Linden forest
Other deciduous trees	Other trees such as alder, oak, ashen, poplar
Wetlands	Wetlands and water bodies
Swamp	Swamps in the flooded forest area
Sand	Areas covered with sands
Other lands	Settlements, agriculture, open areas

2.2.3. Post-processing

To evaluate the success of the classification process, accuracy assessment analysis was performed by using “Accuracy Assessment” tool in ERDAS Imagine 15 (ERDAS Field Guide, 1999). In accuracy assessment, a total of 512 control points was automatically selected. A random sampling approach was preferred to assess the accuracy of spatiotemporal change analysis. The referenced values were recorded on the “Accuracy Assessment Table” based on forest management maps and field observations. The overall accuracy was computed by using user’s accuracy (a measure of commission error) and producer’s accuracy (a measure of omission error) for land use classes.

2.2.4. Change Detection

Spatiotemporal change detection analysis was used to detect land use/land cover changes of linden forest in the Yeniköy Forest Enterprise Chief based on the series of Landsat images. Change detection analysis is widely preferred method for identifying and quantifying differences between images at different times (Lillesand and Kiefer, 2000). After accuracy assessment analysis, change detection method was implemented by comparing the classified images of the study area.

3. Results and Discussion

Classified images of the study area were used to evaluate temporal changes of land use for nine years period. Supervised Classification method was implemented to classify land use classes based on series of Landsat images. The images produced as a result of classification are shown in Figure 3. The overall accuracy of the classification was evaluated by considering the user’s accuracy and the producer’s accuracy for the land use classes. The reference values based on management maps and field observations were compared in the accuracy analysis with random sampling approach.

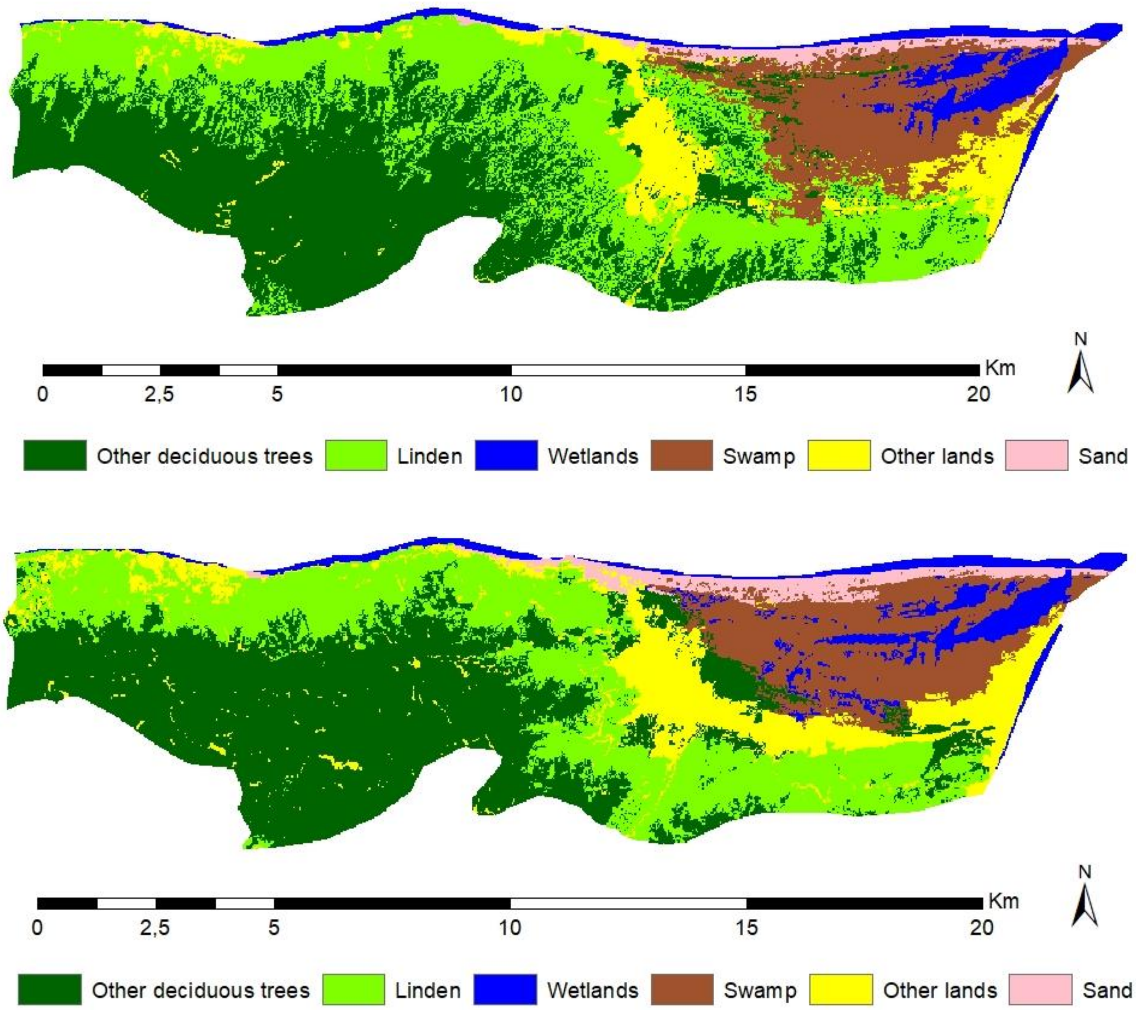

Figure 3. Classification results of 2008 (above) and 2017 (below) Landsat images

The results of classification procedures implemented on Landsat images indicated that the most common land use class within the study area was other deciduous trees followed by linden forests (Table 2). Classified images were used to evaluate spatiotemporal changes of land use in the study area. It was found that the areal distribution of wetlands, sand, and other lands (settlements, agriculture, open areas) increased, while the area of linden forest, other deciduous trees, and swamp decreased between the year of 2008 and 2017. The results showed that linden forest and stands with other deciduous trees were altered with the favor of settlements, agriculture, and open areas. Previous studies also reported that forest covers potentially decreased due to human activities (Akay et al., 2014; Akay et al., 2017). It is anticipated that the areas covered with swamp were converted to wetlands and sands.

The accuracy of the classified image was assessed by using randomly selected 512 points based on referenced forest management maps. The results indicated that classification process applied on 2008 and 2017 images provided overall accuracy of 84.38% and 82.81%. respectively. The overall Kappa Statistics were 0.77 and 0.78 for image classifications, respectively.

Table 2. The areal summary of the land use/land cover change

Class name	Area (%)		Areal Change
	2008	2017	(%)
Linden	32.75	26.60	-6.15
Other deciduous trees	38.75	38.69	-0.06
Wetlands	5.31	5.97	0.67
Swamp	12.58	12.38	-0.20
Sand	2.07	3.34	1.26
Other lands	8.55	13.02	4.48

Classification of 2008 image provided satisfactory results in terms of distinguishing sand, wetlands, and swamp; however, accuracy of linden forest and other lands (settlement, agriculture and open areas) were relatively low. The highest producer's and user's accuracy was reached in classification of wetlands and sand, respectively. On the other hand, the lowest producer's and user's accuracy was encountered in classification of other deciduous trees and linden forests, respectively (Table 3). The relatively low user's accuracy (72.99%) of linden indicated that there was misclassification between linden forest and other deciduous trees.

Classification of 2017 image provided satisfactory results in terms of distinguishing wetlands and swamp; however, accuracy of linden forest and other lands were relatively low. The highest producer's and user's accuracy was reached in classification of wetlands and other lands, respectively. The lowest producer's and user's accuracy was encountered in classification of linden forest and other deciduous trees, respectively (Table 4)

.

Table 3. The results of accuracy assessment based on classification of 2008

Class name	Reference Totals	Producers Accuracy	Users Accuracy
Linden	145	87.59%	72.99%
Other deciduous trees	215	76.74%	89.67%
Wetlands	21	100.00%	95.45%
Swamp	76	93.42%	91.03%
Sand	13	76.92%	100.00%
Other lands	42	90.48%	86.36%

Table 4. The results of accuracy assessment based on classification of 2017

Class name	Reference Totals	Producers Accuracy	Users Accuracy
Linden	147	77.55%	82.61%
Other deciduous trees	190	88.42%	80.00%
Wetlands	24	91.67%	91.67%
Swamp	63	82.54%	91.23%
Sand	22	81.82%	90.00%
Other lands	66	63.00%	100.00%

4. Conclusions

Nonwood forest products in general are essential for the daily life of both rural and urban populations. In order to ensure the sustainable management of nonwood forest products, their trends and spatial distributions by time should be estimated by using land use/land cover change detection approach. Linden are the most important nonwood forest products in Turkey, and especially in Bursa. The most widespread distribution of linden is located in Yeniköy Forestry Enterprise Chief within the border of Bursa Forestry Regional Directorate. In this study, spatiotemporal changes of land use/land cover in the linden forest located in Yeniköy Forest Enterprise Chief in the city of Bursa were detected based on series of Landsat images. The results indicated that the area of the linden forest decreased about 6% for about 10 years periods. In order to protect and restore linden forests, the border of these forests should be carefully delineated. Besides, special strategies should be developed for linden forests and properly integrated into the forest management plans. Furthermore, more advanced models can be developed in the future by using the stand parameters in different ecological conditions. On the other hand, mechanization level for forestry operations, suitable logging techniques and harvesting methods deal with the related stand structures should be determined according to decrease top soil loss amounts in stands.

References

Akay. A.E.. Erdas. O.. Reis. M.. Yuksel. A., 2008. Estimating sediment yield from a forest road network by using a sediment prediction model and GIS techniques. *Building and Environment*. 43(5):687-695.

Akay. A.E.. Sivrikaya. F.. Gulci. S., 2014. Analyzing riparian forest cover changes along the Firniz River in the Mediterranean City of Kahramanmaras in Turkey. *Environmental Monitoring and Assessment*. 186(5):2741-2747.

Akay, A.E., Gencal, B., Taş, İ., 2017. Spatiotemporal change detection using Landsat imagery: the case study of Karacabey flooded forest, Bursa, Turkey. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume IV-4/W4, 2017 4th International GeoAdvances Workshop, 14–15 October, Safranbolu, Karabuk, Turkey.

Chupezi. T.J.. Ndoye. O.. Tchatat. M.. Chikamai. B.. 2009. Processing and marketing of non-wood forest products: potential impacts and challenges in Africa. *Discov. Innov.*. 21(1):60-65.

Çakır. G.. Sivrikaya. F.. Terzioğlu. S.. Keleş. S.. Başkent. E.Z.. 2007. Monitoring 30-year Changes in Secondary Forest Succession with Land Cover in Artvin Forest Planning Unit of Northeastern Turkey. *Scottish Geographical Journal*. 123(3): 209 – 226.

Dembner. S.A.. Perlis. A., 1999. Non-wood Forest Products and Income Generation. *Unasylva*. 50(198).

Desai. C.G.. Patil. M.B.. Mahale. V.D.. Umrikar. B.. 2009. Application of remote sensing and geographic information system to study land use/land cover changes: a case study of Pune Metropolis. *Advances in Computational Research*. 1(2):10-13.

Dewan. A.M.. Yamaguchi. Y.. 2009. Land use and land cover change in Greater Dhaka. Bangladesh: Using remote sensing to promote sustainable urbanization. *Applied Geography*. 29: 390-401.

ERDAS Field Guide, 1999. Fifth Edition, Revised and Expanded. Atlanta, Georgia. 698 p. http://web.pdx.edu/~emch/ip1/FieldGuide.pdf

Jong. S.M... Meer. F.D... Clevers. J.G., 2004. Basics of Remote Sensing. In: Jong S.M.D.. Meer F.D.V. (eds) Remote Sensing Image Analysis: Including the Spatial Domain. Remote Sensing and Digital Image Processing. vol 5. Springer. Dordrecht.

Lillesand. T.M.. Kiefer. R.W.. 2000. Remote Sensing and Image Interpretation. 4th ed. New York: Wiley.

Moller-Jensen. L.. 1997. Classification of Urban land cover based on expert systems. object models and texture. Computers. *Environment and Urban Systems*. 21(3/4):291-302.

Ruelland. D.. Levavasseur. F.. Tribotte. A.. 2010. Patterns and dynamics of land-cover changes since the 1960s over three experimental areas in Mali. International *Journal of Applied Earth Observation and Geoinformation*. 12(1):11–17.

Sivrikaya. F.. Çakır. G.. Keleş. S.. Başkent. E.Z.. 2009. Spatiotemporal Dynamics of Land Use/Land Cover and Timber Carbon Storage: A Case Study from Bulanikdere.Turkey Chapter. Pages:215-247. Geoinformatics for Natural Resource Management. Editors: Joshi. P.K.. Pani. P.. Mohapartra. S.N.. Singh. T.P.. Nova Science Publishers. 634 pp. ISBN: 978-160692-211-8.

Tuttu. G.. Ursavaş. S.. Söyler. R.. 2017. Harvest amounts and ethnobotanical uses of the linden flowers in turkey. *Anatolian Journal of Forest Research*. 3(1): 60-66.

Yomralıoğlu. T., 2005. Geographical Information System Basic Terms and Applications. Akademi Publishing. 480 p. ISBN: 975973690x.