Planning and Controlling of Hazelnut Production Areas with the Remote Sensing Techniques

Mehmet SENER[1], Birsen ALTINTAS[2], Huseyin Comert KURC[1]
[1]NKU, Faculty of Agriculture, Department of Biosystem Engineering, Tekirdag, Turkey.
[2] Ministry of Food Agriculture and Livestock**,** Sakarya Provincial Directorate, Sakarya, Turkey.

Received (Geliş Tarihi)**: 22.03.2012** **Accepted** (Kabul Tarihi)**: 25.03.2013**

Abstract: Sakarya, along the Black Sea, spreads on 483.500 ha area and it has significant resources, not only in agricultural areas (especially hazelnuts production) but also in forest resources. Changes in life styles, study area have been enforced major changes, particularly in Hazelnut production areas. In order to compensate the suffering of producer due to irregular supply and demand and reduce the load on government due to over purchasing, production should be kept under control by monitoring land use/cover. Uses of traditional methods to investigate land use/cover characteristics are highly time consuming and expensive, which are not in fact necessary. For this reason, as in many areas, using satellite images in the investigation of the land characteristics is preferable. In this study, land use/land cover of Sakarya province was detected using Landsat image. Supervised classification was performed with using maximum likelihood algorithm. In the end of the study, six classes, 87.374 ha for hazelnut production, 168.801 ha for agriculture, 179.627 ha for forest 1, 22.226 ha for forest 2, 1.497 ha for special products and 18.312 ha for water site, were detected respectively. The overall accuracy and kappa coefficient were calculated as 86% and 0.81 % respectively. The results showed that 47.263 ha area was suitable and allowable for hazelnut production according to Hazelnut Law and Regulations whereas presently hazelnut grown area is about 87.374 ha, which means that in 40.111 ha unsuitable area hazelnut is produced illegally.
Key words: Sakarya, Landsat, Hazelnut production, Land use, Land cover

Uzaktan Algılama Tekniği ile Fındık Üretim Alanlarının Planlanması ve Kontrolü

Özet: Sakarya, Karadeniz kıyısında, 483.500 hektar alana yayılmış, başta fındık üretimi alanları olmak üzere tarım ve orman alanları bakımından önemli bir ilimizdir. Sakarya ilinde özellikle fındık üretim alanlarında zaman içerisinde büyük değişiklikler yaşanmıştır. Devlet üzerindeki aşırı alımdan dolayı meydana gelen ekstra yük ile çiftçiler üzerindeki arz-talep ilişkilerindeki düzensizlik nedeniyle oluşan sıkıntıları ortadan kaldırmak için arazi kullanım ve örtüsü izlenerek üretimin kontrol altında tutulması gerekmektedir. Geleneksel yöntemlerle arazi kullanım ve örtüsünün belirlenmesi çok zaman alması yanında aşırı pahalıdır. Bu nedenle, birçok alanda olduğu gibi, arazi kullanım ve örtüsünün araştırılmasında uydu görüntülerinin kullanımı tercih edilmektedir. Bu çalışmada, Sakarya ilinin arazi kullanım ve örtüsünün saptanmasında Landsat uydu görüntüsü kullanılmıştır. Arazi kullanım ve örtüsünün belirlenmesi, maksimum benzerlik algoritması kullanılarak kontrollü sınıflandırma metoduyla gerçekleştirilmiştir. Çalışma sonucunda, fındık ekili alan 87.374 ha, tarım alanı 168.801 ha, orman 1 alanı 179.627 ha, orman 2 alanı 1, 22.226 ha, özel ürün ekili alan 1.497 ha ve su yüzeyi 18.312 ha olarak saptanmıştır. Ortalama sınıflama doğruluğu ve kappa katsayısı sırasıyla % 86 ve 0.811 olarak hesaplanmıştır. Sonuçta, fındık kanunu ve yönetmeliğine göre fındık üretimi için uygun alan 47, 263 ha olmasına rağmen, şu anda 87.374 ha alanda üretimin yapıldığını saptanmıştır. Bu durum, çalışma alanında fındık üretimi için uygun olmayan 40.111 hektarlık alanda yasa dışı üretimin gerçekleştirildiğini göstermektedir.
Anahtar kelimeler: Sakarya, Landsat, Fındık üretimi, Arazi kullanımı, Arazi örtüsü

INTRODUCTION

Turkey has approximately 84% of the hazelnut area of the world with about 70% of global supply. According to the data in 2009, 332.000 producers make production in 642.000 ha in Turkey. Sakarya is the second province after Ordu province in terms of hazelnut production area (69.276 ha) whereas it is in the first place in terms of produced amount (88613 ton) and yield from a unit area (1280 kg/ha) (TUIK, 2009).

Within the framework of Common Agricultural Policy (CAP), Turkey has made the Law on the Detection of Plantation Areas and Planning of Hazelnut Production, issued 2844. With this law, the following areas have been determined as suitable for hazelnut production: areas within the height of 750 m, 3rd class areas which have more than 6% slope and areas which have 4 and 4 up land use ability classes (GTHB, 2011). In accordance of the Law of Hazelnut, 47.263 ha area and 24,518 producers are allowed for hazelnut production in Sakarya (GTHB, 2007). However, according to GTHB 2006, registered hazelnut production is made in 68.660 ha, apart from this, unregistered production takes place in approximately 20.000 ha (GTHB, 2006). It is obligatory that adaptation to societal standards for all generation, from amount of agricultural products to the stage of

Corresponding Author: Sener, M., msener04@hotmail.com

productivity and quality during the integration period to European Society (Reis and Yomralioglu, 2002). Within the aim of protecting market price, arranging the supply, obtaining the production standards and limiting the unregistered production, land use/cover information should be determined up-to-date.

Determining land use/cover using traditional methods are time consuming and expensive and generally the available data is not generally updated or reliable sufficiently (Estes and Mooneyhan, 1994; Jones and Vaughan, 2010). By means of developed satellite and computer technologies, compared with traditional methods, it is possible to produce more economic, fast and reliable data (Bennett et al., 2000; Booth et al., 2005). Multi spectral satellite systems are used as common tools for vegetative changes and land cover can be determined. Up to present, benefits of this kind of data with the aim of monitoring and detection of the vegetation cover are accepted commonly (Binh et.al. 2005; Esetlili and Kurucu, 2003; Price et al., 1992). Landsat image used for creating land use/ cover is one of the most wide-spread satellite images since it has suitable band width (Woodcock and Macomber, 2001).

The key data processing steps includes data acquisition, image preprocessing, image enhancement, classification and accuracy assessment. Supervised classification was used in determination of LU/LC map with using Maximum Likelihood Algorithm.

The objective of this study carried out was to determine the land use/land cover of Sakarya province, propound the distribution and size of the hazelnut production areas by using Landsat image. Results of this study were compared with the assessment reports data of the Ministry of Food, Agriculture and Livestock Provincial Directorate (GTHB) dated 2007.

MATERIAL and METHODS

Study Area

Research area is located between 29^o 57'- 30^o 53' east longitude and 40^o 17'- 41^o 13' North latitude (Figure 1). Sakarya, located in Marmara Region, is surrounded with Bolu from east, Kocaeli and Bursa from west, Bilecik from south and the Black Sea from north. The characteristic features of Marmara and West Black Sea climatic region dominate the study area. It is hot and rainy in summers and warm and rainy in winters. Average annual rainfall is 840.5 mm. Average relative humidity is %72. Average temperature is 14.4 ^{o}C. Research area is covered with forest, Hazelnut, special product, water areas and agricultural areas. Its elevation from sea level is 30-43 m. (Isik, 2007).

An image processing techniques was applied for determination of land use/cover map of Sakarya. The key processing steps are as follow:

- Data acquisition and truthing,
- Image preprocessing and Enhancement,
- Supervised classification, and
- Accuracy assessment.

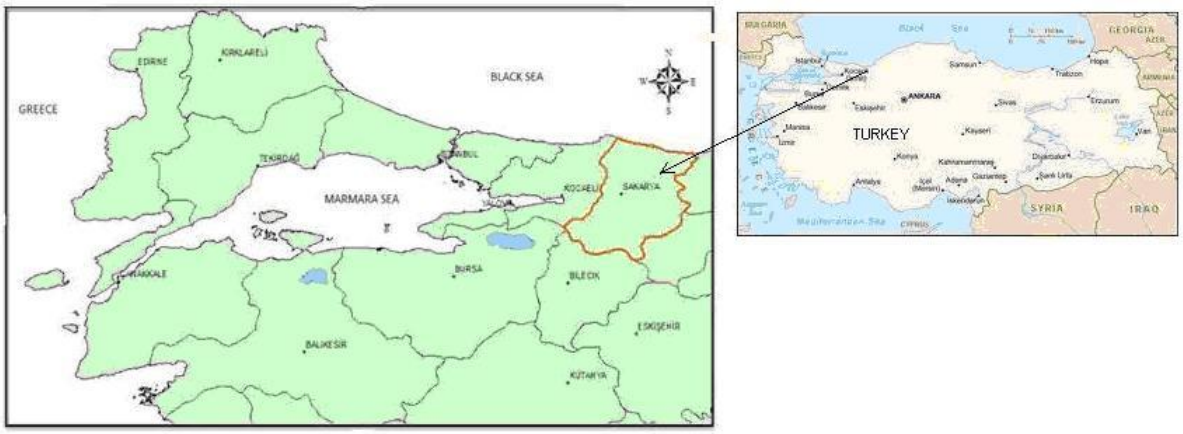

Figure 1. Study area

Data acquisition and truthing

Within the scope of research, LANDSAT TM satellite image dated 13 March 2007 was used to determine the land use/land cover. LANDSAT satellite image has 30 m resolution for six bands allowing for discrimination of land use and cover. The ancillary data used included Ikonos high resolution image, topographic maps (1: 25000 scale) and field works as instructed by Brooks et al. (2006). Ikonos high resolution satellite image taken on the date of 2006 June was used in order to assist the visual support for classification. Field data collected through informal interviews by the regional researcher and farmers were employed to identify training areas used for supervised classification and afterwards to evaluate the classification results. Ground truthing data which belong to these classes were obtained by using Global Positioning System (GPS).

Image preprocessing and enhancement

Erdas imagine 9.1 was used in preprocessing and classifying the acquired images. Geo-referencing of images was executed on the basis of ground control points, derived from 1: 25000 scale topographical maps. LANDSAT TM image dated 2007 was coordinated with geographical correction as UTM 35 North and WGS84 datum. Error made in the course of geometrically correction is calculated under 0.5 pixels allowed for error value. Study area is detected and subset on LANDSAT satellite image (Figure 2). Settlements and coastal are removed from the image in order not to cause spectral confusion on determination of Sakarya province map and that image was prepared for the process of classification.

In order to increase the interpretation of the image, image enhancement was made. With this aim, false color images were created. In this study, 3rd, 4th and 5th bands were selected for classification according to the multivariate image statistics (Genc et.al 2005). Furthermore, it was benefited from vegetation indexes as auxiliary data in this classification. In this study, it was benefited from Normalized Difference Vegetation Index (NDVI) in the process of supervised classification. The Normalized Difference Vegetation Index (NDVI) is an index of vegetation 'greenness' that takes advantage of the contrast between visible and near-infrared reflectance of vegetated surfaces (Hatfield et.al., 1984; Tucker and Sellers, 1986 Goward and Dye, 1987; Ozyavuz 2010). NDVI was used as an additional band in supervised classification to make a contribution to image interpret (Figure 3).

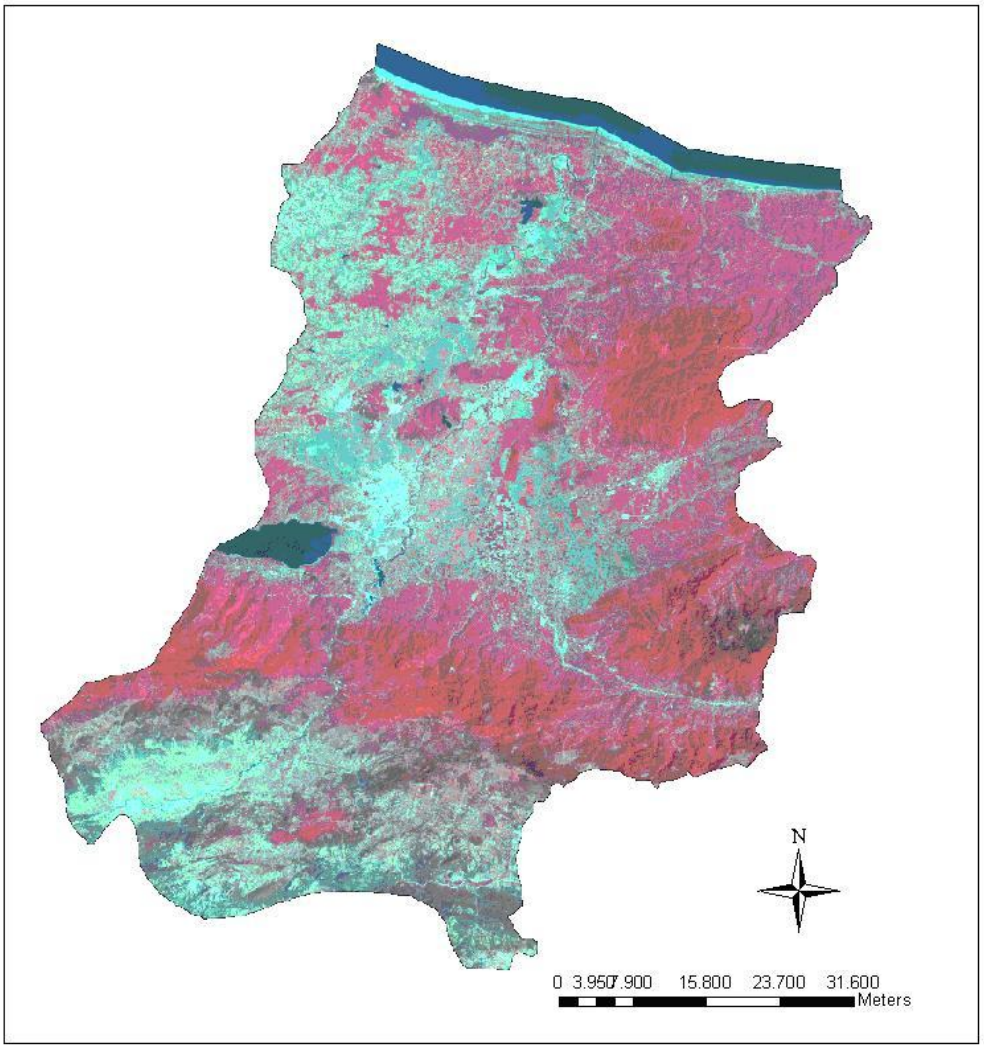

Figure 2. Landsat TM Satellite Image for 2007

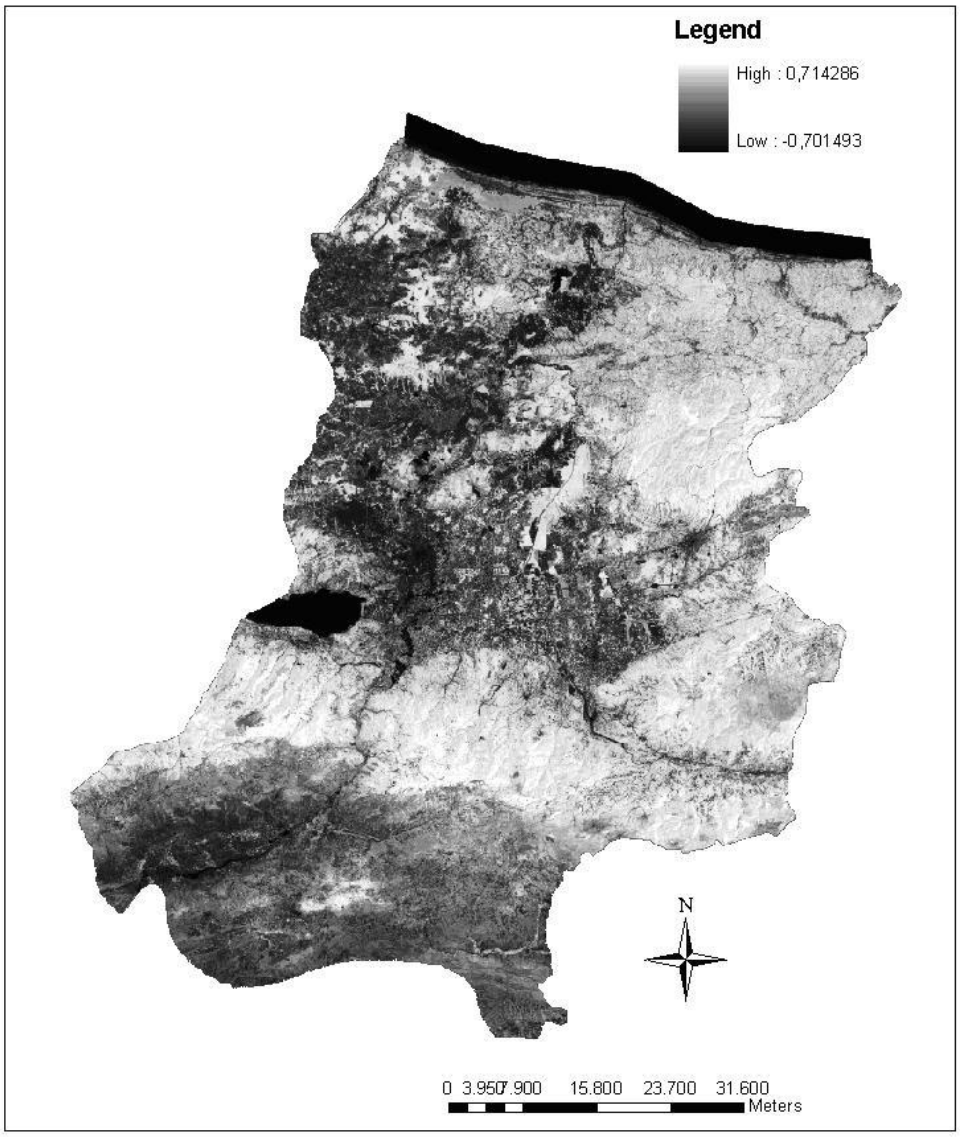

Figure 3. NDVI Map of Sakarya Province

Classification

Supervised classification is the most commonly used method in classification with remote sensing data (Baker et.al. 1991; Kershaw and Fuller, 1992; Brodley and Friedl, 1999) Steps for supervised classification in general: a) detection of training areas b) classification c) accuracy analysis. To perform a highly accurate classification in supervised classification; training areas that uncover spectral characteristics of each class efficiently must be determined within the images (Foody, 1990; Chuvieco and Congalton, 1998; Barandela and Juarez, 2002). Training sets were created with the help of field trips, Ikonos high resolution image and image interpretation of colour composites from satellite imagery (Genc et.al. 2005) In the process of classification, maximum likelihood classifier is used. The Maximum Likelihood Classifier (MLC) is based on the information that each pixel belongs to a certain class with a high degree of probability (Ince, 1986; Kershaw and Fuller, 1992).

The actual land use /cover classification of the area was divided into 6 classes which were identified during the field studies:

Forest 1: there are pieces from conifers, fir, black pine, yellow pine, Turkish pine, stone pine, juniper, redwood, broad-leaved fagus, oak, chestnut, lime, plane tree, cedar, Acer, ash tree.

Forest 2: there are especially ash tree, juniper, box tree and fagus and trees in the form of brush.

Agriculture & pasture: This class includes agricultural land and pastures

Water: lakes and Sakarya River is classified as water areas and

Special product: there are special onion is grown in wetland.

Selected 256 control points to carry out accuracy were controlled with the field studies and Ikonos

images. Accuracy assessment was calculated by comparing reference data and classified image. User accuracy, producer accuracy and kappa statistic were generated for accuracy assessment (Janssen and Van Der Wel, 1994; Congalton and Green, 1998).

RESULTS and DISCUSSION

According to the supervised classification, LU/LC map produced and presented in Figure 4. LULC classes for Landsat 2007 summarized in Table 1.

Results of this study were compared with the assessment reports data of the Ministry of Food Agriculture and Livestock, Provincial Directorate (GTHB) dated 2007. As a result of the comparison, It was found that "special product" and non-agricultural area (water and Settlement) showed a strong agreement in terms of percentage of LULC found in both of classified image and GTHB' report. Special product was found to be 0.31% both, in classified image and GTHB's report. Non-agricultural area was found 4.96% of the by classified image and reported as 4.50% in GTHB's report.

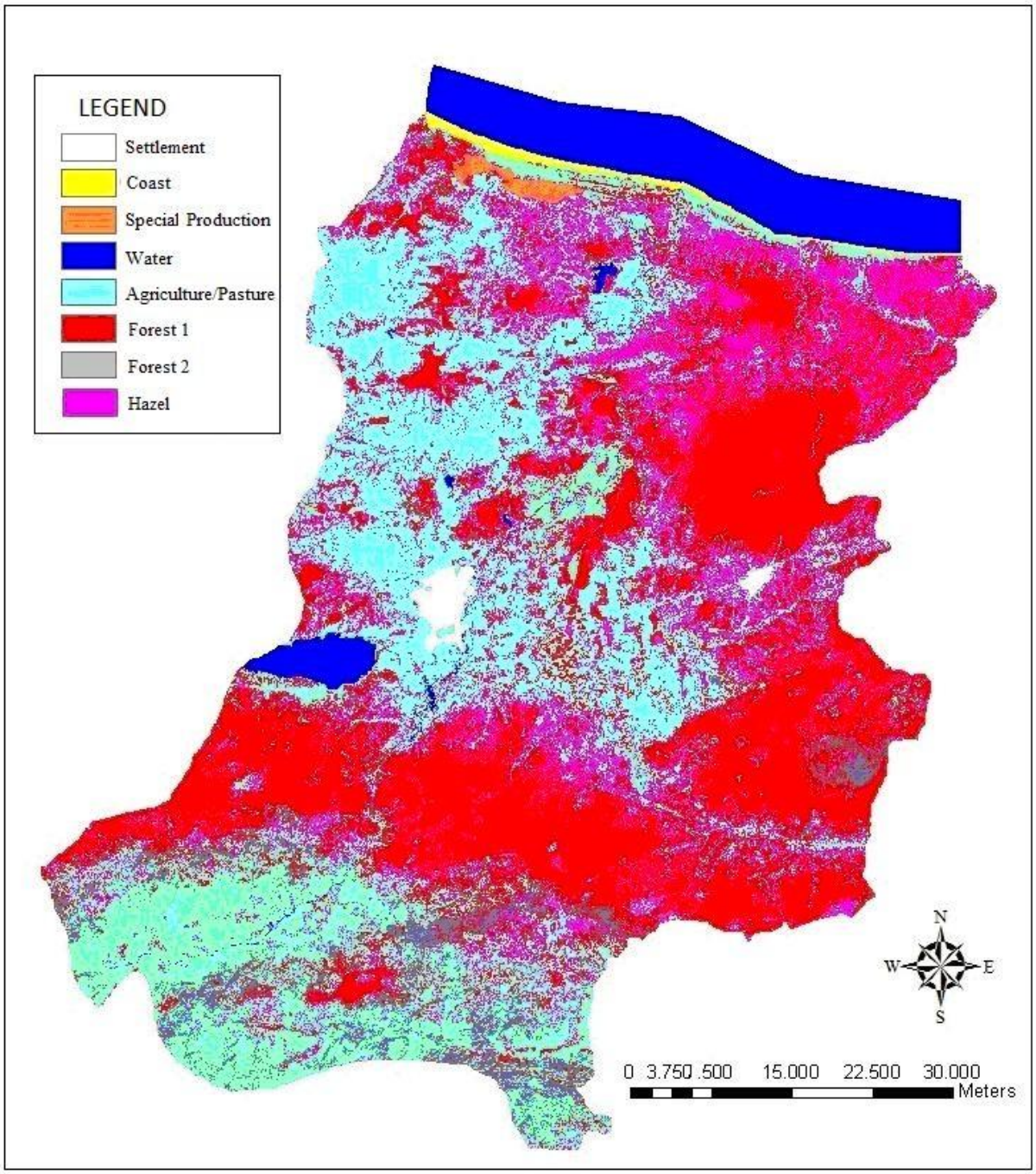

Figure 4. Land Use/Land Cover Map for 2007

On the other hand, Agriculture & Pasture", "total forest" (Forest 1 and Forest 2) and Hazelnut categories displayed differences within the classified image and GTHB's report.

Agriculture & Pasture was 34.91% and 38% in classified image and GTHB's report, respectively. Total forest area covered 41.75% in the classified image whereas it was 43% in GTHB's report. Hazelnut was 18.07% in the classified image against 14.10% in GTHB's report. There was 18.811 ha difference between the hazelnut area given in GTHB (2007) report and determined by supervised classification. However, in hazelnut report by GTHB (2006), the registered hazelnut area was 68.660 ha. It was indicated that there was also 20.000 ha unregistered hazelnut areas apart from the present registered hazelnut areas. The results of GTHB (2006) and this study seem to be overlapped. The reason of increasing hazelnut area has been thought to be, the areas changed into hazelnut, which have lost their forest features and the other agricultural areas.

As it was stated in GTHB (2007), though Sakarya had 47.263 ha suitable areas for hazelnut production, in this study it was determined that there were 40.111 ha unsuitable registered and unregistered areas. Moreover, production in the unsuitable areas has been affecting the balance of market price. During the redundant production, not only the producers can't sell the product for its real price but also the government buys products unnecessarily

Table 1. Land Classes and Occupied Area

Class	Area (ha)	Percentage (%)
Hazelnut	87.374	18.07
Agriculture & pasture	168.801	34.91
Forest 1	179.627	37.15
Forest 2	22.226	4.60
Special product	1.497	0.31
Water	18.312	3.79
Settlement	5.663	1.17

Turkey has to obey the rules of EU to join the Union. When the quota is exceeded considering the production amount of member countries, related countries have to pay money for European Agricultural Guarantee Fond as a fine. So as to apply the production quotas as required all the production facilities should be kept under register. For this reason, preventing unregistered production is the most important subject in the adjustment studies with European Union.

In order to examine the validity of the results provided from this study, accuracy analysis was carried out. In the accuracy analysis of the established classification, accuracy rating between the real category of pixel and the category of assigned each pixel was detected. Overall accuracy was 86.33% and Overall Kappa Statistics was 0.811. While the producers' accuracy and user accuracy was found 81.32% and 80.85% respectively (Table 2). During analyze of overall accuracy, USGS standard (85 %) has been based on. In this study, USGS standard was ensured with 86.63% overall accuracy. Overall Kappa values for classified image has a strong agreement for the (>80%) classification accuracy. Producer's accuracy calculates the percentage of pixels classified as a particular land cover that actually are that land cover. User's accuracy calculates the percentage of reference pixels for a given land cover that are correctly classified (Congalton and Green, 1998). It was seen that, spectral confusion between the two forest areas and Hazelnut areas caused some errors but those were within the limits. Results of overall accuracy test showed that the reliability of the obtained land use/land cover characteristics using the Landsat image was very acceptable. This has proven that Landsat image is a useful tool to investigate LULC.

Table 2. Accuracy Assessment of Land Use and Land Cover Classification

Class	W	F1	F2	Hz	Ag	S.P.	Total column	Total correct	Producers accuracy %	Users accuracy %
W	13						13	13	100.00	100.00
F1		74		4	5		83	74	81.32	89.16
F2		2	10				12	10	90.91	83.33
Hz		1	5	38	3		47	38	82.61	80.85
AP			9	4	79	1	93	79	90.80	84.95
S.P.			1			7	8	7	87.50	87.50
Total Line	13	77	25	46	87	8	256			

W: Water, F1: Forest 1, F2: Forest 2, AP: Agriculture & pasture, Hz: Hazelnut, S.P.: Special Product

CONCLUSION

In this study carried out in Sakarya, land use/cover maps were determined and differences were put forward by comparing them with available data. In the summary, the following conclusion can be drawn from the above analysis:

- In this study, supervised classification was tested in determination of LU/LC in Sakarya by using Landsat image. In fact it was identified that adequate accuracy was ensured according to the accuracy assessment, on the other hand using satellite images which have multi-temporal and higher spectral

resolution could increase the accuracy in complex forest nuts area.

- At the end of the study, it was determined that hazelnut production was being carried out on 87.734 ha area. However, within the conditions determined by hazelnut law, the suitable land area for hazelnut production in Sakarya is 47.263 ha. As it can be understood from the numbers, hazelnut production is made in 40.111 ha unsuitable area. The situation causes over production in this region. The exceeding hazelnut production in mainly unregistered area and registered unsuitable area prevents the market price to be identified steadily. Shifting the purchasing of agricultural products to private sector will help the market conditions to be more secure. Thus, if there is an exceeding production quota next season, they will try to avoid making unnecessary production in unsuitable areas, because of a potential fall in the prices which will not let them sell the products so this will result in pecuniary loss. This situation will also reduce the pressure for the government who is supposed to buy these products in order to eliminate the over production. Besides, producing the hazelnut in unsuitable areas may prevent the producing of suitable plant which is supposed to be in the same area.
- Precautions should be taken in order not to let the production take place in unsuitable areas which is stated in the related law of Hazelnut and current promotion for alternative products should be increased. For promotions to be effective agricultural policies should be realistic and the farmers should be given guarantee that there will be no fluctuations in the market conditions.

REFERENCES

Anonymous, 2010. Effects of European Union are in 100 issues on everyday life. Republic of Turkey, General Secretariat of European Union, Presidency of Civil Society, Communication and Culture, Ankara,72p.

Baker, J., Briggs, S., Gordon, V., Jones, A., Settle, J., Townsend, J., Wyatt, B. 1991. Advances in Classification for Land Cover Mapping Using SPOT HRV Imagery. International Journal of Remote Sensing, 12: 1071–1085.

Barandela, R., Juarez, M. 2002. Supervised Classification of Remotely Sensed Data with Ongoing Learning Capability. International Journal of Remote Sensing, 23 (22): 4965–4970.

Bennett, L.T., Judd, T.S., Adams, M.A. 2000. Close-range Vertical Photography for Measuring Cover Changes in Perennial Grasslands. Journal of Range Management. 53(6): 634-641.

Binh, T.N.K.D., Vromant, N., Hung, N.T., Hens, L., Boon, E.K. 2005. Land Cover Changes Between 1968 and 2003 in Cai Nuoc, Ca Mau Peninsula, Vietnam. Environment, Development and Sustainability, 7: 519-536.

Booth, D.T., Cox, S.E., Fifield, C., Phillips, M., Williamson, N. 2005. Image Analysis Compared with Other Methods for Measuring Ground Cover. Arid Land Research and Management, 19: 91-100.

Brodley, C., Friedl, M. 1999. Identifying Mislabeled Training Data. Journal of Artificial Intelligence Research, 11: 131–167.

Brooks, C.N., Nevada, R., Powell, R.B., French, N.H.F., Shuchman, R.A. 2006. Multi-Temporal And multi-platform Agricultural Land Cover Classification in Southeastern Michigan. ASPRS 2006 Annual Conference Reno, May 1-5, Nevada.

Chuvieco, E., Congalton, R.G. 1998. Using Cluster Analysis to Improve the Selection of Training Statistics in Classifying Remotely Sensed Data. Photogrammetric Engineering and Remote Sensing, 54: 1275–1281.

Congalton, R.G., Green, K. 1998. Assessing the Accuracy of Remotely Sensed Data: Principles and Practices, New York: Lewis Publishers.

Esetlili, M.T., Kurucu, Y. 2003. Research on Supervised Classification Methods to Determine Cotton Planted Areas by Remote Sensing Technique. Ege University, Journal of Agricultural Faculty, 40(2): 105-112.

Estes, J.E., Mooneyhan, D.W. 1994. Of Maps And Myths. Photogrammetric Engineering and Remote Sensing, 60: 517–524.

Foody, G.M. 1990. Direct Ground Survey for Improved Maximum Likelihood Classification of Remotely Sensed Data. International Journal of Remote Sensing, 11: 1935–1940.

Genc, L., Smith, S., Charles, S., McCorry, F. 2005. A Comparison of Landsat Thematic Mapper and Indian Remote Sensing Data for Land Use and Land Cover Change Assessment. Trakya University Journal of Science. 6(2): 17-28.

Goward, S.N., Dye, D.G. 1987. Evaluating North American Net Primary Productivity with Satellite Observations. Advances in Space Research, 7: 165-174.

GTHB, 2006. Hazelnut Report. Ministry of Food Agriculture and Livestock, Sakarya Provincial Directorate, 5 p.

GTHB, 2007. Project and Statistics Branch 2007 Annual Activity Summary. Sakarya, Turkey: Ministry of Food Agriculture and Livestock, Sakarya Provincial Directorate, 39 p.

GTHB, 2011. The Regulation of Procedures And Principles on Planning Hazelnut Production and Determining the Planting Areas with Supporting the Producers Who Prefer Planting Alternative Products Instead of Hazelnut and Supplying Technical Help for These Producers. Ministry of Food Agriculture and Livestock Sakarya Provincial Directorate.12p. www.tarim.gov.tr/files/ Mevzuat/yonetmelik_son/ findik~1.pdf

Hatfield, J.L., Asrar, G., Kanemasu, E.T. 1984. Intercepted Photosynthetically Active Radiation Estimated by Spectral Reflectance. Remote Sensing of Environment, 14: 65-75.

Ince, F. 1986. Maximum Likelihood Classification, Optimal or Problematic? A Comparison with the KNN Classification Izmit, Turkey: TUBITAK, Marmara Scientific and Industrial Research Institute, Electronic Research Unit, Technical Report No. TR-86/09.

Isik, S. 2007. Sakarya's Agriculture Geography. Sakarya, Turkey: Sakarya University, Institute of Social Sciences, MSc thesis, 123 p. Sakarya, Turkey.

Janssen, L., Van Der Wel, F. 1994. Accuracy Assessment of Satellite Derived Land Cover Data: a review. Photogrammetric Engineering and Remote Sensing, 60: 419-426.

Jones, G.J., Vaughan, R.A. 2010. Remote Sensing of Vegetation. New York: Oxford University Press, 400p.

Kershaw, C.D., Fuller, R.M. 1992. Statistical Problems in the Discrimination of Land Cover from Satellite Images: A Case Study in Lowland Britain. International Journal of Remote Sensing, 13: 3085–3104.

Ozyavuz, M. 2010. Analysis of Changes in Vegetation Using Multi Temporal Satellite Imagery, the Case of Tekirdag Coastal Town. Journal of Coastal Research, 26 (6): 1038-1046.

Price K. P, Pike D. A, Mendes L. 1992. Shrub Dieback in a Semiarid Ecosystem the Integration of Remote Sensing and Geographic Information Systems for Detecting Vegetation Change. Photogrammetric Engineering and Remote Sensing, 58(4): 455-463.

Reis, S., Yomralioglu, T. 2002. Using Landsat ETM to Obtain Land Use Map of the Province of Trabzon, 7th ESRI and ERDAS Users Meeting, Ankara, Turkey.

Tucker, C.J., Sellers, P. 1986. Satellite Remote Sensing of Primary Production. International Journal of Remote Sensing, 7: 1395-1416.

TUIK. 2009. Turkish Statistical Institute. http://www.tuik.gov.tr/bitkiselapp/bitkisel.zul accessed on 16 December, 2009.

Woodcock C. E., Macomber S. A. 2001. Monitoring Large Areas for Forest Change Using Landsat: Generalization across Space, Time and Landsat Sensors. Remote Sensing of Environment, 78 (1): 194-203.