African Journal of Biotechnology Vol. 9(35), pp. 5676-5685, 30 August, 2010
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.900
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

Spatial and temporal analysis of forest cover changes in the Bartin region of northwestern Turkey

Ayhan Atesoglu* and Metin Tunay

Bartin University, Faculty of Forestry Forest Engineering Department 74100-Bartin-Turkey.

Accepted 22 July, 2010

This study analyzed the changes in the forest areas in Bartin province of Turkey and the surrounding areas using remote sensing data and GIS techniques. Three Landsat Thematic Mapper (TM) images of the study region, recorded in 1987, 1992, and 2000, were utilized. The main land-use characteristics were derived using a maximum-likelihood classification technique. The remotely sensed data allows monitoring of current land use/land cover and detection of temporal changes. Furthermore, a temporal and spatial comparison of the classified image can be performed using Geographical Information System (GIS) to show land-use changes. GIS analysis of the classification results based on reference datasets revealed that the area covered by forests decreased significantly and that the amount of the reduction corresponded mainly to increased agricultural land use. The reasons for this negative impact on forested areas were growth in the region's population, and expansion of agricultural areas and settlements. The classification results also showed that past, afforestation work had been successful.

Key words: Land use/land cover, remote sensing, GIS, deforestation, Bartin province, Turkey.

INTRODUCTION

Most of the world's vegetation is in a constant state of flux at a variety of spatial and temporal scales. These changes are driven by seasonal and interannual climate variations, long-term climatic shifts, vegetation succession, and human or natural disturbances (Lambin, 1996). Deforestation and forest degradation are often monitored in national programs because information on changes in forest resources is needed to support political decisions and the planning of forest management regimes for rehabilitation purposes (Apan, 1997; Tokala et al., 1999). Multi-temporal satellite images have often been used to detect changes in land use/ or cover types (Singh, 1986; Coppin and Bauer, 1996; Varjo, 1996; Lambin and Ehrlich, 1997). Spatial patterns in the landscape may influence a variety of ecological phenomena (Meentemeyer, 1989; Turner, 1989), such as the distribution and persistence of populations (Fahig and Paloheimo, 1988), the horizontal flow of materials such as sediments and the nutrients they contain, and the spread of disturbance, as well as other important processes such as net primary production (Turner, 1990). The spatial setting of landscape elements is conditioned by the combination of both biophysical and human forces (Fernandez et al., 1992; Zonneveld, 1995; Mendoza and Etter, 2002). At temporal scales of decades, human land-use activities are basic factors in shaping changes in land use, sometimes due to specific management practices and other times due to the social, political, and economic forces that control land uses. These human-induced temporal changes in the landscape affect both biotic and abiotic processes (Green et al., 1994; Vasconcelos et al., 2002).

In a world with an increasing population and consequently increasing pressure on natural resources, there is a greater demand for current, accurate spatial information. This issue of reliable information has taken on global dimensions, as the world community has recognized the need to assess problems and tasks such as environmental studies, economic planning, and resource management in many diverse geographical regions. Without this information, scientists cannot complete valid studies and decision-makers will often fail to make the correct choices

*Corresponding author. E-mail: aatesoglu@yahoo.com. Tel: +90 378 2235166. Fax: +90 378 2235065.

Abbreviations: GIS, Geographical information system; **TM,** thematic mapper; **GCPs,** geometrically corrected using 21 uniformly distributed ground control points; **UTM,** universal transverse Mercator; **RMS,** root-mean-square.

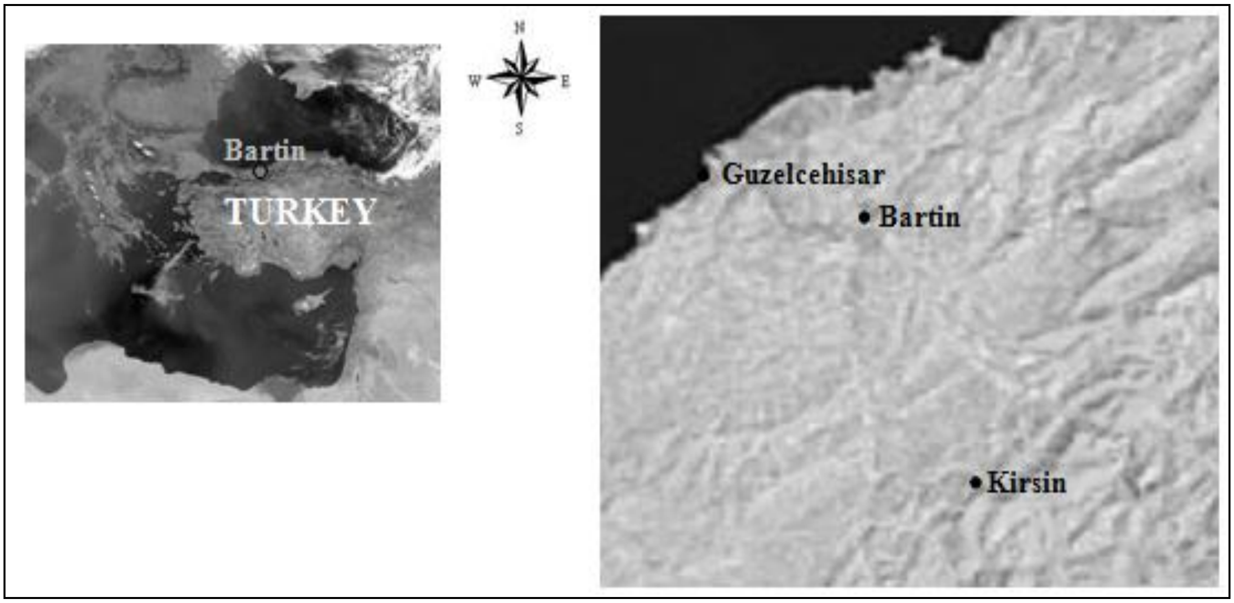

Figure 1. The location of the study area (Bartin province and its surroundings in a Landsat TM image)

(Haack and English, 1996; Locklin and Haack, 2003). Remote sensing techniques provide reliable information with good coverage and in repetitive way.

The forest areas of Bartin province and surrounding areas in northwestern Turkey cover a total area of 175 553 ha and contain an estimated tree volume of 13 578 867 /m^3. Therefore, it is one of the main country's forest. Because the forests are "natural", with high-quality trees and extensive species variation, this region is become an important global resource. Oaks (*Quercus* spp.), European hornbeam (*Carpinus betulus*), chestnut (*Castanea sativa*), beech (*Fagus orientalis*), Scots pine (*Pinus sylvestris*), Crimean pine (*Pinus nigra*), Turkish fir (*Abies bornmülleriana*), juniper (*Juniperus* spp.), and English yew (*Taxus baccata*) are the main species in this region. These mixed forests provide diverse biological conditions that support a rich variety of wildlife (TMMOB 1999). In last 3 years, a total of 16589 m^3 of kiln-dried beech timber has been exported from the Bartin forests, with harvest volumes increasing steadily (Ascıoglu, 2001). This above mentioned quantity of timber shows the great economic contribution of this region's forest resources to the sustainable development of Turkey.

The Bartin forests are always affected by people of local and towns or cities located in close proximity to the forests. Villagers mostly depend on agriculture and animal husbandry, however, region's fields and pastures are insufficient to meet their requirements. Therefore, it is common for farmers and herders to transform forest land into agricultural fields, pastures, nut groves, settlements, and other human uses (Tunay and Atesoglu, 2002). Moreover, construction of buildings in response to growth in population and the increased extent of settlements have also put pressure on the forest resource. On the other hand, the efforts of local forest directorates have created limited areas of new forest in the region. As a result of this mixture of activities, serious problems have arisen in relation to land use in the region (Hızal et al., 1996).

The purpose of the present study was to detect the changes in forest cover and land use in the study area. The information provided by this study will aid in understanding, influencing, and monitoring settlement in the area as more people arrive and as the agricultural frontier is extended.

MATERIALS AND METHODS

Deforestation, afforestation, and land-use changes were studied at three locations in or near the Bartin region. The area extends approximately from latitude 41° 23' to 41° 46' and longitude 32° 08' to 32° 28' (Figure 1). The study area is covered by forests, agricultural lands, meadows or pastures, and settlements. The total population lives in cities and villages. Intensive tourism in the Guzelcehisar-Inkum region, which lies within the borders of Bartin province, has increased the value of the land. For that reason, the current patterns of land use in this region may lead to serious trouble as a result of development of land to support tourism. Forests close to settlements are at risk of destruction. In contrast, forested areas around the Kozcagiz-Kirsin settlements have increased in size as a result of local inhabitants' tendency to grow hazelnuts to increase their income.

Three Landsat (TM) scenes aguired on 25.07.1987, 19.05.1992, and 12.07.2000 were used. Landsat TM uses a seven-band multispectral system with a 28.5 m spatial resolution and a single-frame area that covers 185 x 185 km. The datasets were geometrically corrected using 21 uniformly distributed ground control points (GCPs) digitized from the 1:25 000 scale topographic maps of the study area then it was rectified to the Universal Transverse Mercator (UTM) coordinate system using a nearest-neighbor resampling procedure (Jensen, 1986) with an average Root-Mean-Square

Table 1. Coefficients used in the Tasseled Cap Transformation of the Landsat TM images (Coefficients were provided by Tung Fung and Lyn Hanna-Folkes of the University of Waterloo, Ontario).

Parameter	TM1	TM2	TM3	TM4	TM5	TM7
Brightness	0.3037	0.2793	0.4743	0.5585	0.5082	0.1863
Greenness	- 0.2848	- 0.2435	- 0.5436	0.7243	0.0840	- 0.1800
Wetness	0.1509	0.1973	0.3279	0.3406	- 0.7112	- 0.4572

(RMS) error of less than 1 pixel. False color composite of bands 1, 4, and 7 were used. The datasets were spectrally enhanced to increase the interpretability of the image by increasing contrast (Schowengerdt, 1997). Because these images captured 95% or more of the total data changes using less than half of the original number of TM bands, the size of the data set was also reduced. The transformation coefficients used for each band are given in Table 1. Ancillary data that are used during classification of the Landsat TM images included management plans**,** stand and age-class maps, topographic maps, aerial photographs, and personal knowledge of the study area. Classification was performed using a module of the PCI Geomatica V9.1 remote sensing software.

Post-classification approach was applied to detect LULC changes. In this approach, images obtained on two dates are independently classified and registered. An algorithm can then be employed to determine which pixels have changed in classification between dates. In addition, statistics and change maps can be compiled to express the specific nature of the changes between the two dates. Obviously, the accuracy of such procedures depends upon the accuracy of both independent. Errors that are present in either of the initial classifications are compounded during the change detection procedures (Lillesand and Kiefer, 1994).

TM image of 1992 and 2000 TM images were classified separately using maximum-likelihood classification procedure. In this phase, we assigned the main training sites as forest, sea, agricultural area, settlement, sandy-stony-rocky area, and “cloud cover”, which was available in one image as an additional class.

Tasseled Cap Transformation (Christ and Kauth, 1986) to the 1987 and 2000 TM images was applied to assess the afforestration effort (Table 1). GIS was used to analyze forest cover changes by comparing the most current classified image (from 2000) with land use/land cover maps provided by the General Directorate of Rural Services. Agricultural and idle lands were vectorized from classified image using the PCI Geomatica software. Then the vector data was transferred to the Arcview version 8.1 GIS software to overlay it with land use maps produced in 1984.

The current status of the lands that underwent a change in land use or cover type between images was determined by ground-truthing (that is visiting these lands). Land use/land cover changes and their causes were determined through discussions with the organizations and persons who were involved in these changes.

RESULTS AND DISCUSSION

The statistical analysis result showed that the Kappa coefficients for each year were 98 and 99%, overall accuracies for each year were 80.5 and 88% in 1992 and 2000, respectively. However, in terms of the primary purpose of the classification (to map the locations of the “forest” category), the producer’s accuracies were less good but still acceptable: 83 and 80% in 1992 and 2000, respectively. The corresponding user’s accuracies were 71 and 97%, respectively. The forest class was one of the most reliable categories associated with this classification work from both the producer’s and the user’s perspective.

Land-use/land cover changes

The Land-use/land cover maps for 1992 and 2000 are presented in Figure 2. The change in the forested areas between the years was negative (-5.6%), indicating a decrease. However, the change was 6.3% (an increase) for agricultural areas. This result indicated that the changes in Bartin province and its surrounding areas appeared to represent a transformation of the land from forest into agricultural and settlement use. Furthermore, the increase in settlements (0.3%) resulted from construction activities in recent years. The change in the amount of sandy-stony-rocky areas (-0.5%) resulted from dense industrialization and construction activities in these areas.

The change in the forested area within the study area was compared (Food and Agriculture Organization report, FAO 2001). The results are shown in Tables 2 and 3 for Turkey and the study area.

In two-thirds of the countries in which agricultural land continued to expand, forest areas decreased in size; in the remaining one-third, forest areas expanded (IIASA/FAO, 2002). This indicated that most of the new agricultural land has been created by clearing forests, and that this situation will continue in the future. Increasing populations and consumption per person will increase the pressure on natural resources and will lead to serious problems endanger sustainable management of forests. It has been calculated that the population of the world will have reached 9 billion by 2050 (IIASA/FAO 2002). Most of the new agricultural land required to feed these people will result from agricultural expansion into forests (FAO, 2001). The change in forest area in the study area was negative (-0.44%) in contrast to the annual change in the forested area for Turkey as a whole (Table 4). FAO’s population data for Turkey and Turkish population data for the study area are given in Tables 4 and 5. By comparing these tables, it is clear that the annual population change and the change in the rural population in the study area were much larger than those for Turkey as a whole.

In the study area, most people live in rural areas, where the population increase has been twice the average increase for Turkey as a whole. This demonstrates that the pressure on the forested areas in the region will

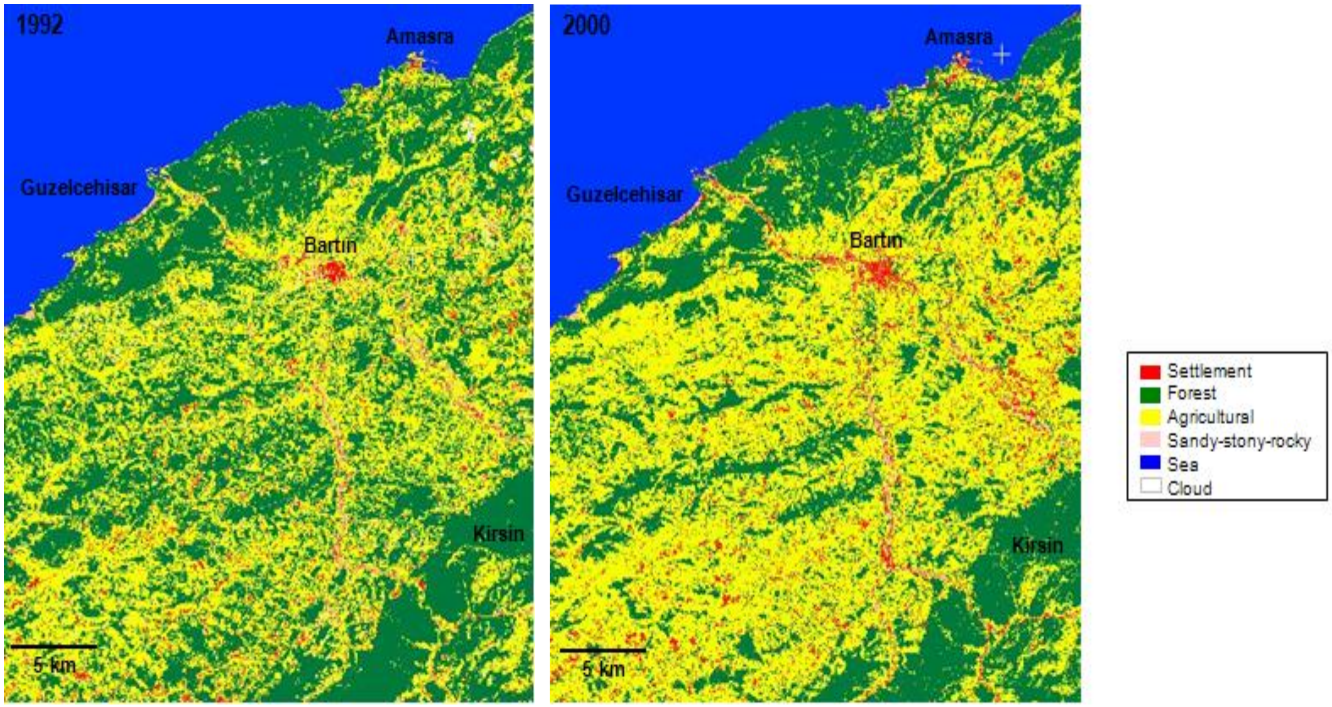

Figure 2. Land use/land cover types in the study area in 1992 and 2000.

Table 2. Forest resources and management in Turkey (FAO 2001).

	Forested area in 2000				Change in forested Area 1990 – 2000	
Turkey ($x10^3$ ha)	**Total forested area ($x10^3$ ha)**	**% of Turkey's land area**	**Per-capita area (ha)**	**Afforestation ($x10^3$ ha)**	**(ha/year)**	**(%)**
76 963	10 225	13.3	0.2	1 854	22 000	0.2

Table 3. Forest resources and management in Bartin province (data from classified images for 1992 and 2000).

	Forested area in 2000				Change in forested area 1992–2000	
Bartin ($x10^3$ ha)	**Total forested area ($x10^3$ ha)**	**% of Bartin's land area**	**Per-capita area (ha)**	**Afforestation ($x10^3$ ha)**	**(ha/year)**	**(%)**
214.3	175.6	82	0.95	5.5	-775.65	-0.44

continue to increase. In the following sections, we have presented data for specific regions within the study area that are representative of the main trends in Bartin province.

Deforestation in Guzelcehisar

Changes in LULC were captured in the area along the Bartin river and in the district of Guzelcehisar. The increase in the area of agricultural land in the classified images of 1992 and 2000 can be detected (Figure 2). The area covered by forests has decreased. This means that some forests have been converted into agricultural land. The reasons of deforestation in this area can be probably resulted from its proximity to large settlements, such as Bartin, and from the fact that the value of the land for tourism activities is very high. It is worth to mention that cadastral surveys of the forested areas in these districts have not yet been completed, so occupation of forested areas is common and local people have gradually converted some forests into agricultural lands

Table 4. Basic population data for Turkey (FAO 2001).

Turkey ($x10^3$ ha)	Total in 1999* $x10^3$	Density in 1999* (Persons/km^2)	Annual change* 1995 – 2000 (%)	Rural in 1999** (%)
76 963	65 546	85.2	1.7	25.9

*Census statistics provided by the United Nations (UN 1999).

Table 5 Population data for the study area (DIE 2004).

Bartin ($x10^3$ ha)	Total in 2000 $x10^3$	Density in 2000 (Persons/km^2)	Annual change 1997 – 2000 (%)	Rural in 2000 (%)
214.3	206	96.1	3.3	74

(Figure 3). GIS analysis indicated that 373.99 ha of forested area were transformed into other uses such as (settlements, agricultural areas, etc.) by the year 2000 (Table 6). In addition, direct field observations of the study area revealed that much of the forested area had been occupied and destroyed.

From 1984 to 2000, the deforestation rate was 23 ha/year. This was resulted from inadequate inspection of forested areas and intensive tourism, which increased the value of non-forestry use of the land. Deforestation has been caused by increased numbers of new settlements and agricultural activities. These factors represent the current and future impact of anthropogenic on the area.

Land use change in Kozcagiz–Kirsin

Kirsin is an inner-forest village in the district of Kozcagiz. The people living in the region are the poorest in the whole study area. Therefore, they have been forced to convert forests into agricultural land in order to earn an income. When the people realized in the early 1990s that growing hazelnuts had a relatively high potential for earning income, they decided to grow hazelnuts instead of performing other agricultural activities. Hazelnuts are now produced in an area of nearly 700 ha in the region. It can be clearly seen in the 1992 TM image that open areas had expanded compared with those in the 1987 TM image (Figure 4), and these open areas are largely used to grow hazelnuts. As the hazelnut growing activities increased, hazelnut fields rapidly replaced other agricultural land, and these fields were covered with hazelnut trees in the 2000 TM image. To produce this change, many fields were cleared to permit planting of hazelnut trees (Figure 5).

Since other wooded areas outside forests constitute a buffer between alternative land uses, it is important to observe changes in such areas. To make broader and more meaningful political interventions among forestry, agricultural, and environmental uses of land, trees growing outside forests should also be integrated into evaluation and monitoring studies (IIASA/FAO 2002). It seems inevitable that agricultural areas will expand at the expense of forests (FAO 2001). In this case, the most important question in terms of sustainable future economic activities, food safety, and sustainable forest management is to what extent these wooded buffer zones can absorb the rise in the demand for agricultural land. In other words, how and to what extent can these wooded areas be used for agricultural production?

Anthropogenic changes in the study area

The forested areas within the study area are divided by Turkish foresters into three management classes: high forest, unproductive high forest, and coppice. As a result of the destruction of forested areas, many high forests have been changed into unproductive high forests or coppices. Forests that have been thinned to levels below a certain critical density can no longer fulfill their hydrological and soil-preservation functions. It is important that these areas be converted into dense vegetation-covered lands to ensure their sustainability without ruining their natural structure.

A study of 891 case files (the number of files discussed between 1986 and 2003) in the archives of the Bartin Forest Directorate reveals crime statistics about destruction of forests for the study region. The area affected by the crimes totaled 1079 ha in total forested area of 175,600 ha (Table 7). As Table 7 shows, the number of crimes is higher in areas under coppice management than in other management classes. The area managed as high forest (60,206 ha) was 3.2 times the area of unproductive high forest management (18,850 ha), therefore areas managed as high forest are affected more in size compared to the areas in unproductive high forest management class.

The destruction of forest areas managed as coppices has been quite devastating, and as a result, afforestation studies in these areas are very important. In a total area of 623.11 ha in the district of Guzelcehisar, which has experienced extensive destruction of forests, afforestation

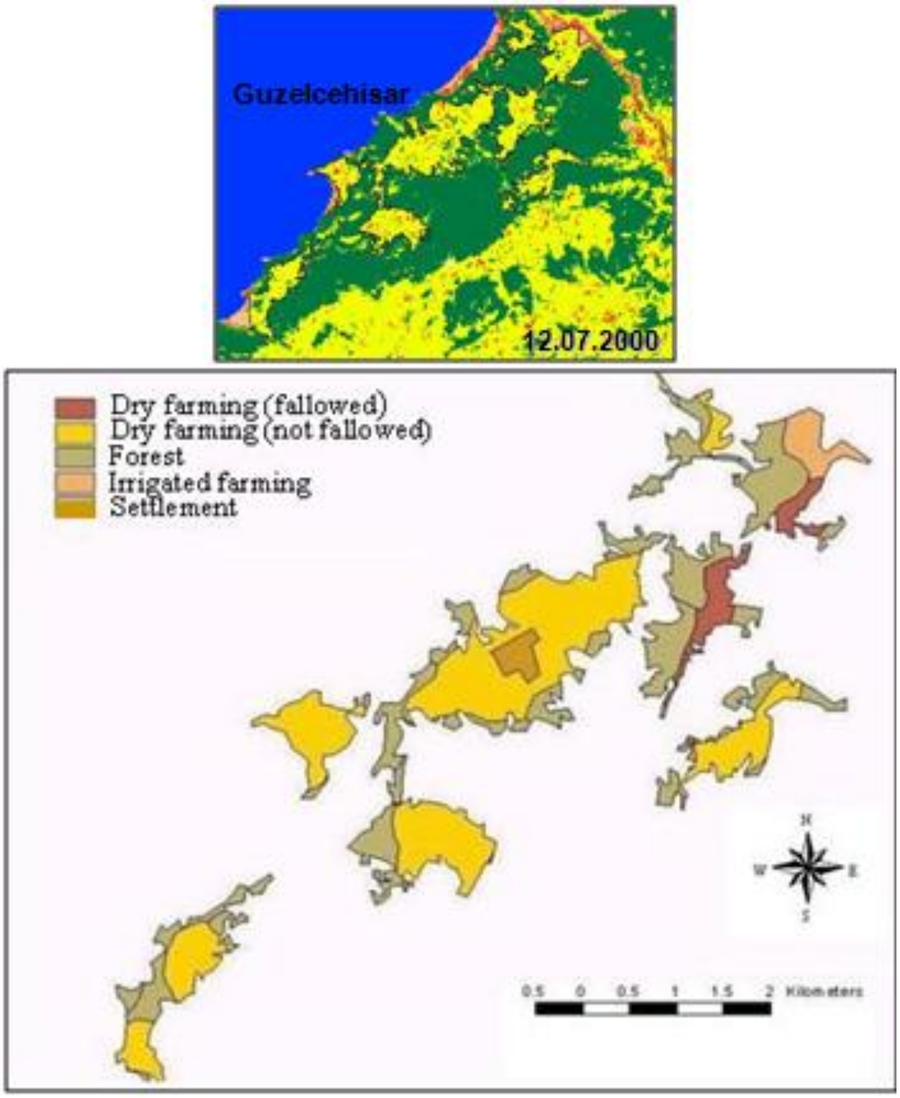

Figure 3. The vectorized classification of changes in land use in the district of Guzelcehisar since 1984.

Table 6 Statistics obtained from comparison of the vectorized 2000 classification image with the land-use maps prepared by the General Directorate of Rural Services in 1984 (Areas represent the change in area of a specific land use since 1984).

Land use statistics	Size (ha)	Change since 1984 (%)
Dry farming (fallowed)	61.06	6.39
Dry farming (not fallowed)	458.09	47.92
Forest	373.99	39.12
Irrigated farming	6.92	0.72
Settlement	55.88	5.85
Total	955.94	100

during the past 12 years has been very successful (Figure 6A). The success in converting such coppice fields into high forests is important because it allows the fields to fulfill their hydrological and soil-protection functions.

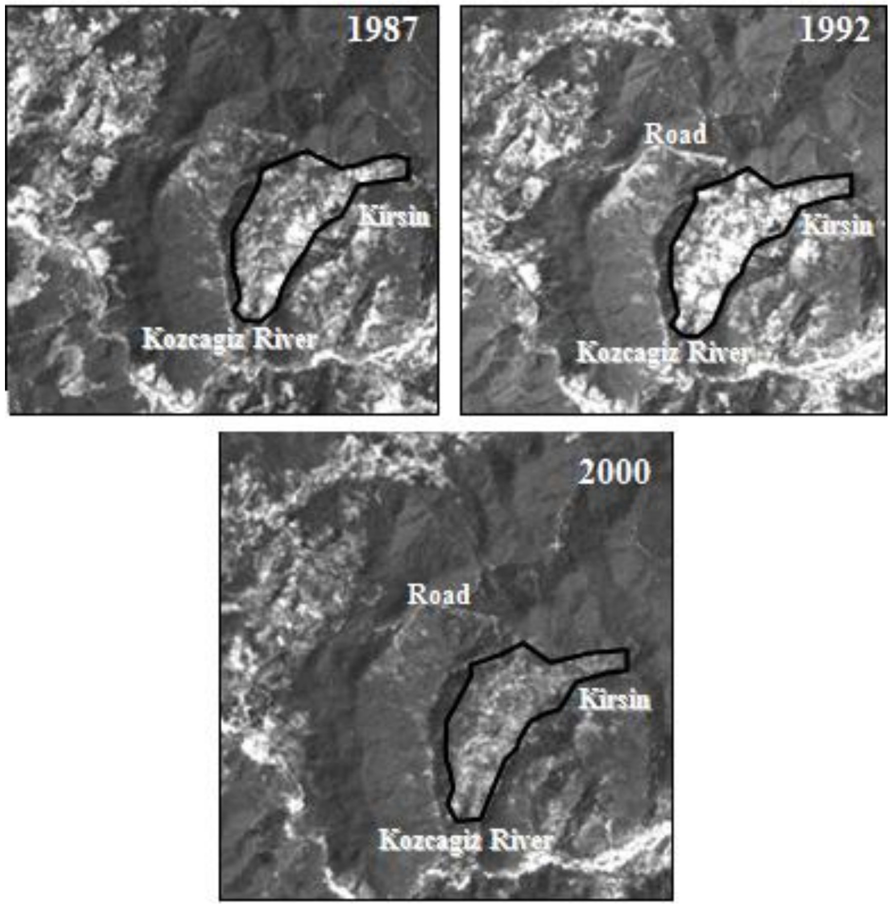

Figure 4. Landsat TM images fro Kirsin village.

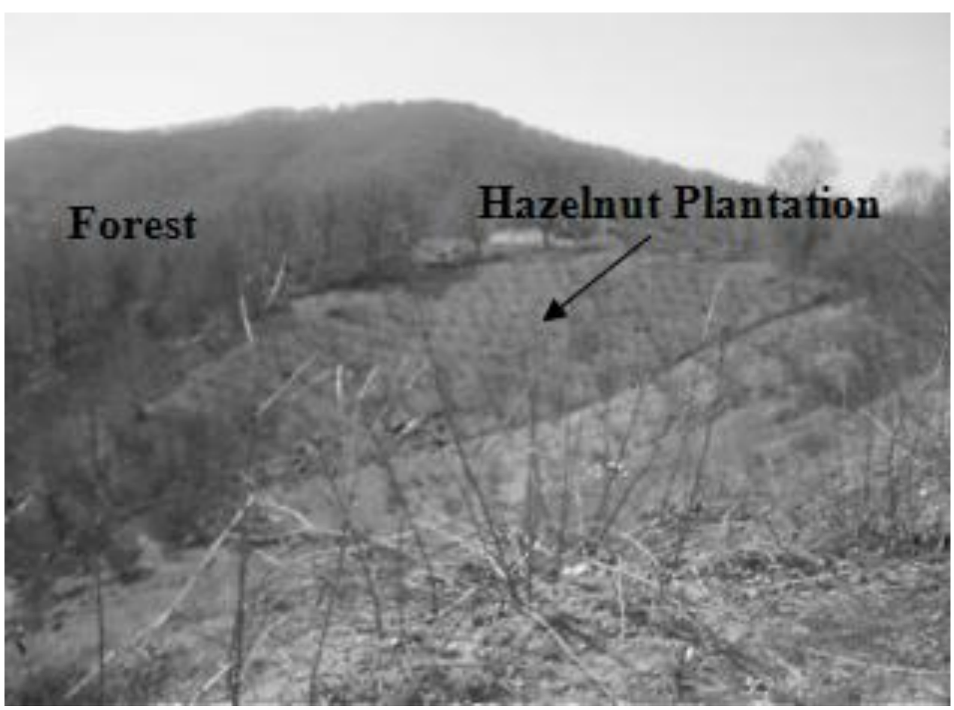

Figure 5. A view of a hazelnut plantation created by deforestation.

Table 7. The distribution of the crimes committed in forested areas between 1986 and 2003 according to the type of forest management.

Type of forest management	Total area (ha)	Area affected by the crimes (ha)	Number of crimes	% of total area
High forest	60 206	225	173	0.4
Unproductive high forest	18 850	170	197	0.9
Coppice	96 544	684	521	0.7

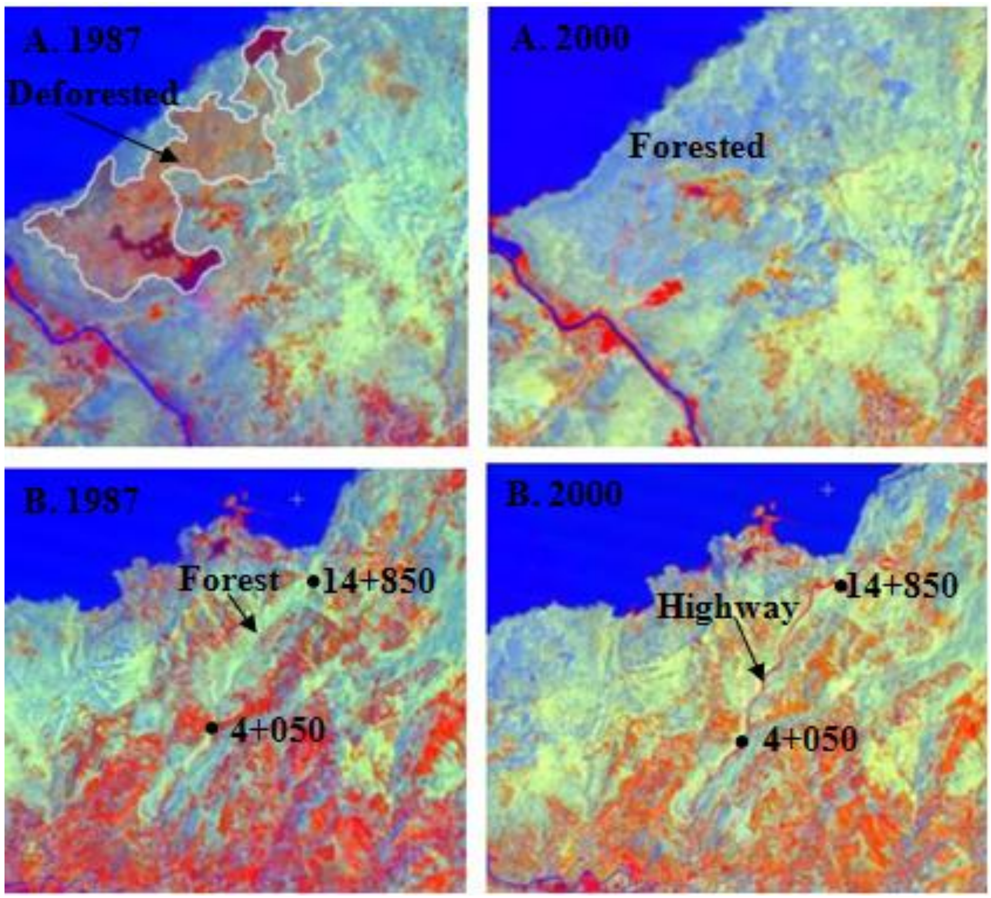

Figure 6. (A) TCA image of the area showing the successful afforestation. (B) TCA image showing the destruction caused by the Bartin–Amasra highway.

In contrast with the afforestation studies, highway construction between Bartin and Amasra caused considerable damage to a very large area of forest (Figure 6B). Forest destruction between positions 4 + 050 km and 14 + 850 km on the highway totaled 32.7 ha, and forest loss due to mass wasting on steep slopes that destroyed areas of forest totaled 3.1 ha. As a result, a total of 35.8 ha of forest were destroyed.

Conclusions and recommendation

The present study revealed serious land use/land cover changes in the study area. In this region, a "traditional" land-use system exists, in which the land use is not decided on the basis of land capability classifications. In the study area, the forests have been decreased by conversion into agricultural land, hazelnut fields, settlements, and other non-forest uses. According to satellite images, the deforestation rate in the area between 1992 and 2000 averaged 775.65 ha per year. Agricultural activities that failed to include soil protection measures led to recession of forested areas close to settlements and thus damaged the natural ecosystem functions (example, soil protection, hydrological protection). Forested areas have been intensively deforested for agricultural and residential purposes. This process has also diminished the species composition of the forests and decreased their density. Forests with reduced densities can no longer fulfill their hydrological and soil-protection functions. Thus, coppice areas and unproductive high forests should be transformed into dense productive wooded areas and protected against damage to their natural structure for the benefit of future generations.

The study results demonstrate that remote sensing is useful to support fieldwork and document the locations and extents of environmental changes. Remotely sensed images offer a strong ability to permit monitoring of temporal changes, such as those that are occurring in the forested areas in Bartin province. More importantly, the dimensions and positions of these changes can be determined with enough accuracy to support informed management decisions.

It is more important to prevent impacts than to reduce them. Some recommendations that would help to achieve this goal for the study area are:

1. In order to prevent further destruction of the forests, legal measures should be strictly applied. In addition, legal sanctions should be increased and strict inspection mechanisms to detect and prevent deforestation should be employed. It is known that deforestation and occupation of the forests have decreased where cadastral surveys have been completed. For this reason, cadastral surveys of forests in this region should be completed as soon as possible.
2. The people living in and around the forests are the poorest people in this region. The government should support these people economically to promote economic development, and regional plans and projects should prioritize economic activities such as forestry, agriculture, animal husbandry, handicrafts, and small industrial enterprises. All the physical, technical, legal, economic, social, and cultural measures required to support this goal should be negotiated within the process of creating regional development plans.
3. Between 1970 and 2003, a total area of 5500 ha was afforested in the study area. Such successful efforts have vital importance for forestry in the study region, and funding should be provided to permit continuity in these efforts. Intensive tourism activities are occurring in this region due to the presence of Bartin, a coastal city. The Bartin-Amasra highway, which has been constructed to promote tourism, should be completed, but without damaging the environment as much as has occurred during previous highway construction. In this region, nature can not easily renew itself, so the principle of minimum damage should direct all development activities, even if the cost is high.

REFERENCES

Apan AA (1997). Land cover mapping for tropical rehabilitation planning using remotely-sensed data. Int. J. Remote Sensing, 8: 1029-1049.

Ascıoglu E (2001). Bartin. Chamber of Commerce, Bartin, Turkey.

Christ EP, Kauth RJ (1986). The tasseled cap demystified. Photogramm. Eng. Rem. Sens. 52: 81-86.

Coppin PR, Bauer ME (1996). Digital change detection in forest ecosystems with remote sensing imagery. Remote Sensing Reviews 13: 207-234.

DIE (2004). Republic of Turkey. Prime Ministry State Institute of Statistics, Ankara, Turkey.

Fahig L, Paloheimo J (1988). Effect of spatial arrangement of habitat patches on local population size. Ecology, 69: 468-475.

FAO (2001). Global Forest Resources Assessment 2000 Main Report. Forest and Agriculture Organization, Rome, Italy.

Fernandez R, Martin A, Ortega F, Ales E (1992). Recent changes in landscape structure and function in Mediterranean region of SW Spain (1950-1984). Landscape Ecol. 7: 3-18.

Green K, Kempka D, Lackey L (1994). Using remote sensing to detect and monitor land-cover and land-use change. Photogramm. Eng. Rem. Sens. 60: 331-337.

Haack B, English R (1996). National land cover mapping by remote sensing. World Dev. 24: 845-855.

Hızal A, Tunay M, Gerçek H (1996). Orman alanlarının tarım alanı olarak kullanımın erozyon olusumuna etkileri. In: Zeren Y, Karbeyaz S Tarim-Cevre Iliskileri Sempozyumu, pp. 345-355, Mersin, Turkey.

IIASA/FAO (2002). Global Agro-Ecological Assessment for Agriculture in the Twenty-First Century. International Institute for Applied Systems Analysis (IIASA), Rome, Italy.

Jensen JR (1986). Introductory Digital Image Processing; A Remote Sensing Perspective. Prentice-Hall Englewood Cliffs, New Jersey, USA.

Lambin EF (1996). Change detection at multiple temporal scales: seasonal and annual variations in landscape variables. Photogramm. Eng. Rem. Sens. 62: 931-938.

Lambin EF, Ehrlich D (1997). Land cover changes in sub-saharan Africa (1982-1991): application of a change index based on remotely sensed surface temperature and vegetation indices at a continental scale. Remote Sensing Environ. 61: 181-200.

Lillesand M, Kiefer WR (1994). Remote Sensing and Image Interpretation. John Wiley & Sons Inc, New York, USA.

Locklin CC, Haack B (2003). Roadside measurements of deforestation in the amazon area of Bolivia. Environ. Manage. 31: 774-783.

Meentemeyer V (1989). Geographical perspectives of space, time, and scale. Landscape Ecol. 3: 163-173.

Mendoza JE, Etter RA (2002) Multitemporal analysis (1940-1996) of land cover changes in the southwestern bogota highplain (Colombia). Landscape and Urban Planning, 59: 147-158.

Schowengerdt RA (1997). Remote Sensing Models and Methods for Image Processing. University of Arizona Department of Electrical and Computer Engineering, Arizona, USA.

Singh A (1986). Change detection in the tropical forest environment of northeastern India using landsat. Remote Sensing Trop. Land Manage. 10: 237-254.

TMMOB (1999). 19-21 Mayıs 1998 Batı Karadeniz Seli Nedenleri; Alınması Gerekli Önlemler ve Öneriler. Türkiye Mimar Mühendis Odaları Birligi Orman Mühendisleri Odası, Ankara, Turkey.

Tokala T, Lofman S, Erkkila A (1999) Relative calibration of multitemporal landsat data for forest covers change detection. Remote Sensing Environ. 68: 1-11.

Tunay M, Atesoglu A (2002). Ormandan arazi kazanımı nedenleri üzerine bir arastırma (Bartin yöresi örnegi). In: Yahyaoğlu Z, Güner S Ulusal Karadeniz Ormancılık Kongresi II, pp. 124-133. Artvin, Turkey.

Turner MG (1989). Landscape ecology: The effect of pattern on process. Annu. Rev. Ecol. Syst. 20: 171-197.

Turner MG (1990). Landscape changes in nine rural counties in Georgia. Photogramm. Eng. Rem. Sens. 56: 379-386.

UN (1999). World Population Prospects-The 1998 Revision. New York, USA.

Varjo J (1996). Controlling continuously updated forest data by satellite remote sensing. Int. J. Remote Sensing, 17: 43-67.

Vasconcelos MJP, Mussa Biai JC, Araujo A, Diniz MA (2002). Land cover change in two protected areas of guinea-bissau (1956-1998).

Appl. Geogr. 22: 139-156.
Zonneveld IS (1995). Land Ecology. SPM Academic Publishing, Amsterdam. Netherland.