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DETERMINATION OF VEGETATION CHANGES WITH NDVI METHOD

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Abstract. Remote sensing and geographical information system methods are used frequently in field use, planning and determination of land changes. The data types used in this study vary according to the objective of the study. In this study, the Landsat TM satellite patterns of 1987, 2002 and 2012 years were classified according to NDVI and the changes in the vegetation intensity of the study area were determined. First, rectification of satellite images was carried out after which radiometric correction was made to decrease the negative atmospheric effects. Afterwards, NDVI classification was made which is the most commonly used method for plant classification and separate data was acquired for each image. Accuracy analysis was carried out in order to evaluate the reliability of the acquired data. Within the scope of the study, NDVI classification of Landsat satellite images from the years 1987, 2002 and 2012 was carried out. The highest NDVI values were determined in the year 2002 at the end of the classification. As a result of the accuracy analysis, 78% and kappa index of 0.6903 were determined for the year 1987, 76% and kappa index of 0.6731 were determined for the year 2002 and 80% and kappa index of 0.7085 were determined for the year 2012.

Keywords: NDVI, remote sensing, geographic information system, vegetation.

AIMS AND BACKGROUND

Remote sensing (RS) and geographical information systems (GIS) are among the most common techniques in analysing natural resources and related planning work. RS and GIS data that are used in spatial planning provide answers to various science branches that require information. Additionally, remote sensing data can image the land in different intervals at different resolutions, so they provide the necessary information quickly, and in a trustworthy manner. Especially satellite images, that are the source of remote sensing data, contain many natural and

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cultural data. These data are collected via recording electromagnetic energies through satellite receptors in different bands. Every band has the reflection data it is sensitive to. While more than one band can combine to form images, there are images composed of a single band as well[1]. In order to obtain data from unprocessed satellite images, statistical analysis and interpretation techniques are used. Classification methods are the most commonly used methods to render these data useful and to gather information about the earth surface. These methods differ according to the goal and data types. Flora information, which was impossible to obtain through conventional methods, is now accessible. These advances caused the representation of the flora terrain by remote perception methods[2].

Remote sensing data are commonly used for vegetation mapping and monitoring. Especially, green cover inventory, yield and production forecasting, and vegetation growing assessment are just some of the ways in which satellite imagery has been used. Healthy vegetation cover shows that the peak reflectance can be found in the near-infrared wavelengths because of the internal structure of 'green' leaves, and the greatest absorption is in the red wavelengths because of the presence of chlorophyll[3]. This chlorophyll which is present in leaves ensures the production of organic matter from inorganic matter during light of day. Electromagnetic energy between 0.63–0.69 μm wavelength, generated from the sun, is obtained during this process.

Vegetation density is changed by seasonal and annual dynamics. The daily temporal resolution and globe coverage of satellite sensors (advanced very high resolution radiometer [AVHRR], onboard National Oceanic and Atmospheric Administration satellites) make it possible to monitor vegetation density and healthy at different spatial and temporal resolutions at the regional, continental, and global scales[4].

Normalised Difference Vegetation Index (NDVI) is formulated using near-infrared (NIR) and visible red (R) light to examine the presence of a single band normalised vegetation index by collecting plant. Digital number (DN) and different bands values are used to NDVI calculation. A digital number value occurs from these bands of pixel (Fig. 1).

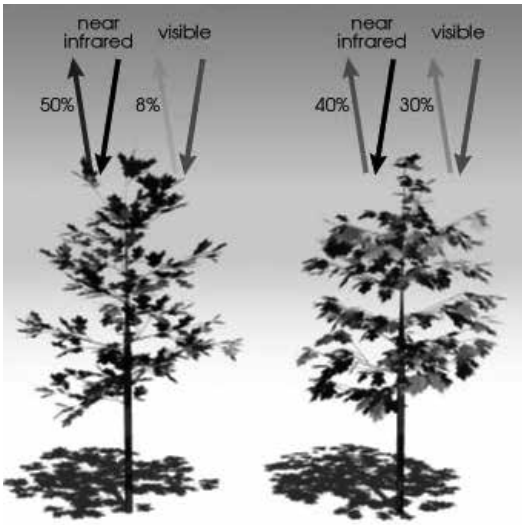


Fig. 1. Healthy plant (left) absorbs a lot of visible light and reflects a large portion of near-infrared light. Unhealthy or sparse vegetation (right) absorbs more visible light and reflects less near-infrared light (illustration by Robert Simmon)[5]

DN is found out from the atmosphere, the radiation which absorbs from surface and from the image sensor. Landsat TM imagery NDVI value is calculated according to the following formula[6]:

$$\text{NDVI} = \text{band 4} - \text{band 3}/\text{band 4} + \text{band 3}.$$

Landsat TM sensor reflects both near-infrared (IR) in band 4 and visible red (R) in band 3. Given this situation, the formula changes as follows[7]:

$$\text{NDVI} = (\text{IR} - \text{R})/(\text{IR} + \text{R}).$$

NDVI calculation method is used with the single bands which occurred just as black and white images. As a result of calculations of the plants values of 0.1–0.6 pixels are obtained. Calculated values of various features according to bands are shown in Table 1.

Table 1. Calculated values of different features according to bands[7]

Class	IR value	Visible red value	NDVI value
Plant	high	low	high
Cloud/water/snow	high	low	negative
Rocks/bare soil	high	high	near zero

In this study, NDVI classification of the Ganos Mountain, which has an important vegetation field of Tekirdag and the Sarkoy district, was carried out. The

classification was done for 3 different years using satellite images. At the end of the study NDVI classification results were assessed.

EXPERIMENTAL

Materials. The main material of this study is the district of Tekirdag, Province Sarkoy. Tekirdag propagated over the Istiranca and Ergene sections of the Marmara region. The surface area is approximately 6218 km^2. Vegetation cover is characterised partly by forests and partly by bushes. The study area is located in the Mediterranean region which has a semi-humid climate according to humidity index. Along the coastal line, the summers are hot, winters are warm. The vegetation of the research area has reached today appearance under the effects of geomorphologic and climate factors. When the current rain data are taken into account, in the regions below the mountainside, it can be said that semi-humid, dry forest areas are seen. Due to the increased rain in the mountainside, the vegetation is richer in terms of species. For this reason, humid forest areas are seen on high ground. The flora of the research area, on the north edge of Ganos Mountains are *Carpinus* sp., *Quercus* sp., *Tilia* sp., and sub-forest flooring, and on the southern edge, due to the lessened rainfall, dry forest and shrubbery are present.

Satellite image. Among the most important materials used in studies regarding remote perception and geographical information systems are satellite images. As there are current data from various times, these data are preferably used. Especially in NDVI classifications, Landsat satellite images are important data types that are used. Within the scope of this study, Landsat TM satellite images from the years 1987, 2002, and 2012 with a spectral resolution of 30 m were used (Fig. 2).



Fig. 2. 1987, 2002, 2012 Landsat TM satellite images

Additionally, a satellite image from the year 2001 was used for geometrical correction. The properties of these images are given in Table 2. Extra attention was paid to chose images of current dates in order to increase the accuracy of research results and the vegetation reflection data. Also, topographical map sheets with scale of 1/25 000 belonging to the General Command of Mapping were used to determine the control points and to perform the geometric corrections.

Table 2. Characteristics of satellite images

Satellite	Date and path/row	Spectral resolution (μm)	Spatial resolution (m)
LANDSAT	11/05/1987 (181/032)	band 1 0.45–0.52	30
		band 2 0.52–0.60	30
	15/05/2001 (181/032)	band 3 0.63–0.69	30
		band 4 0.76–0.90	30
	20/05/2002 (181/032)	band 5 1.55–0.75	30
		band 6 10.4–12.5	120
	07/05/2012 (181/032)	band 7 2.08–2.35	30

Geometric correction. The following remotely sensed data were used in the classification of Land Use Land Covers in the Ganos Mountains through ERDAS IMAGINE 9.1 software: Landsat 1987, Landsat 2001, Landsat 2002, and Landsat 2012. The images were geometrically corrected and geocoded to the Universal Transverse Mercator (UTM). A minimum of 10 regularly distributed ground control points (GCPs) were selected from the images. Re-sampling was performed using a nearest neighbour algorithm. The transformation had a root mean square (RMS) error of < 0.5 pixels indicating that the image was accurate to within one pixel. A nearest neighbour algorithm takes the value of the pixel in the input image that is closest to computed co-ordinate.

NDVI classification. In this study, the classification method, in particular the most widely used in determining normalised plant index (NDVI), was used. The classification of Landsat satellite images 3 and 4 bands was used. Landsat TM sensor reflects both near IR in band 4 and visible red (R) in band 3. Further information is given in the introduction to this classification method.

Accuracy analysis. To conduct inspection of classification been done properly, is necessary to determine the accuracy of the results obtained[8]. Positional accuracy assessment was conducted by using error matrices producers, users, and kappa accuracies were calculated.

RESULTS AND DISCUSSION

Geometrical correction. Before the geometrical correction was done, a datum was chosen for the coordinate system that the satellite image would be converted to, and then the control points were determined. Typically image registration is carried out by tying together points on a target image and a reference image or map (known as Ground Control Points or GCP). The transformation is a least squares solution of the following form[9].

$$X' = a_0 + a_1x + a_2y;$$
$$Y' = b_0 + b_1x + b_2y,$$

where X', Y' – image; x, y – map; a_0, b_0 – for translation; a_1, b_1 – for rotation and scaling in x direction, and a_2, b_2 – for rotation and scaling in y direction.

In this study, the ground control points were chosen from topographical maps with a scale of 1/25 000. In choosing the ground control points, natural details such as lakes and rivers were avoided. Extra attention was paid to distribute the points homogenously across the area. The resulting control points and their RMS values are given in Table 3.

Table 3. Number of control points and RMS errors

Source image	Recorded image	Ground control point	RMS error(±pixel)
2001	1987	10	0.4863
	2002	10	0.5123
	2012	10	0.4963

The RMS values shown in Table 3 are acceptable, so the geometrical correction ended by choosing the UTM coordinate system, WGS 84 datum and 35N zone.

Classification of the images (*NDVI*). The images that were subjected to geometric and radiometric corrections were then subjected to NDVI classification. In order to understand the results better and to make a healthier comparison, the values were reclassified with ArcGIS program. This methodology was applied for each image (Fig. 3).

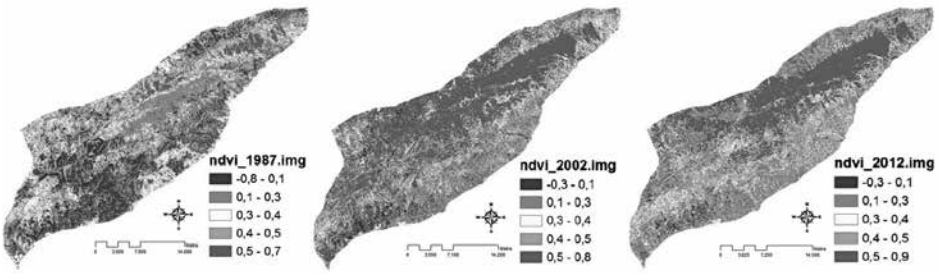


Fig. 3. NDVI classifications of satellite images

After reclassifying the obtained data, the values of condensed vegetation (0.4–0.9) were obtained. The NDVI area values which were obtained as a result of the classification were calculated as count on the ArcGIS program. Since each count is an area of 30 × 30 m^2 in the Landsat satellite image, these values were multiplied by 900 m^2. Thus, the calculation of condensed vegetation for these years are: 20 950.38 ha for 1987; 31 976.73 ha for 2002, and 25 545.01 ha for 2012, respectively (Table 4).

Table 4. NDVI satellite imagery classification results and its covered areas

1987 (Landsat image)			2002 (Landsat image)			2012 (image)		
NDVI value	count	area (ha)	NDVI value	count	area (ha)	NDVI value	count	area (ha)
–0.3–0.1	125864	11327.76	–0.3–0.1	103323	9299.07	–0.3–0.1	102021	9181.89
0.1–0.3	228464	20561.76	0.1–0.3	133654	12028.86	0.1–0.3	192377	17313.93
0.3–0.4	139903	12591.27	0.3–0.4	85211	7668.99	0.3–0.4	111015	9991.35
0.4–0.5	174824	15734.16	0.4–0.5	123521	11116.89	0.4–0.5	108965	9806.85
0.5–0.9	57958	5216.22	0.5–0.8	231776	20859.84	0.5–0.9	174824	15734.16

When the results are assessed, it was determined that at values 0.4–0.9 where the flora is most condensed, the vegetation at the year of 2002 was more. The increased value may be related to the climate changes. Especially the plants that are in early vegetation may result with a wider plant index value. The fact that the plant index values have approached zero in the year 2012 shows that there are no plants at that region. However, the field study revealed condensed vegetation at these regions. Also, as there is a decrease in the plants energy activities, this also reflects the results. When the satellite images of the year 1987 are compared to other images, the increase in the green space index is significant. This increase ranges between 20 and 50%. On the other hand, literature research revealed that in previous years, the vegetation was condensing and decreased. Even though the increase is evident, the growth of the current vegetation and the increase in leaf widths have made the index values high.

Accuracy analysis. As a result of the classifications, 40 reference points were determined for each satellite image. The accuracy analyses for the determined points are shown in Table 5. The main bands used for NDVI classifications of Landsat images are 3rd and 4th bands. As a result of the processes on these bands, the reference values were taken from points where the NDVI values are high (0.5–0.9). These areas are condensed forest areas. The accuracy values of these points were found as acceptable.

Table 5. Accuracy analysis and kappa index

1987 (Landsat image)			2002 (Landsat image)			2012 (Landsat image)		
reference point	accuracy value (%)	kappa index	reference point	accuracy value (%)	kappa index	reference point	accuracy value (%)	kappa index
40	78	0.6903	40	76	0.6731	40	80	0.7085

According to accuracy analysis, RMS gave acceptable value. It is observed that the domain specific values occurred as a result of NDVI classification. According to accuracy assessment, the image of 2012 year has higher accuracy value and higher kappa index than the others. 40 ground control points (GCPs) accuracy values vary between 75 and 80% which are acceptable. Remote sensing is a very useful tool for

identifying greening period and phenology on a large spatial scale[10,11] Comparisons of the various vegetation indices can be found in Refs 12 and 13. Many remote sensing studies utilise vegetation indices to study vegetation, assuming that the properties of the background are constant or that soil variations are normalised by the particular vegetation index used. Landsat data are among the most widely used satellite imagery in ecology and conservation. In this study multi-time Landsat TM satellite images from 1987, 2000 and 2012 were used to determine changes in the flora index in the research area. Landsat images are cheaper and easily accessible than the other satellite images. Moreover, the results showed that NDVI Landsat satellite images are data that can be used in the classification.

The use of satellite-derived NDVI time series for describing phonological changes in vegetation at large scales has been demonstrated in a number of studies[3,4,14,15]. And vegetation dynamics, especially over large scales, can be monitored using remote sensing. These analyses provide a basis for monitoring fluctuations and trends in surface characteristics as driven by inter-annual climate variability, climate change, and other natural and anthropogenic effects that impact the functioning of ecosystems. Of the spectral indices derived from remote sensing which identify vegetated areas and their condition, the Normalized Difference Vegetation Index (NDVI) is still the most well-known and frequently used index. However, NDVI alone was not sufficient to separate the entire collection of plant communities[3,4,16]. For example, lowland forests and some platform forests showed similar NDVI values, making it impossible to separate them on a spectral basis. As a result, topographic information was needed first in order to segment the island into regions with distinct vegetation, corresponding to plateau, cliffs, and coastal plain. NDVI was used within each of these units and allowed to separate the major groups of vegetation, including forests, woodlands, shrub land, and some grasses, by capturing their differences in 'green' structure and canopy closure. This index can not classify green areas and, therefore, the vegetation types can not be determined. The results obtained from such studies should be elaborated with different classification methods[16]. This study was conducted in a rural area where NDVI was easier to be indexed because the study area is located in the forest and maquis vegetation. As seen in other studies on the subject, it is necessary to analyse the absolute accuracy of the index values for NDV. The accuracy of spatial data has been defined by the United States Geological Survey USGS, 1990 as: 'Accuracy assessment or validation is an important step in the processing of remote sensing data. It determines the information value of the resulting data to a user. Productive utilisation of geo-data is only possible if the quality of the data is known. The accuracy of any map may be tested by comparing the positions of points whose locations or with corresponding positions as determined by surveys of a higher accuracy[17]. The kappa index was used in this study. To evaluate the accuracy of the classification system, (40) reference test pixels are identified (each data 1987,

2000, 2012). According to accuracy assessment, image of 2012 year has higher accuracy value and higher kappa index than the others. 40 ground control points (GCPs) accuracy values are between 75 and 80% which are acceptable.

CONCLUSIONS

GIS and remote sensing are now recognised widely as a valuable tool for managing, analysing, and displaying large volumes of diverse data pertinent to many local and regional planning[18]. Tracking the changes in usage and displaying the results are important in landscape planning and area usage planning. With the technological advances in the last years, remote perception and GIS are preferred. There are various classification techniques in remote perception studies. NDVI technique is among the important methods in determining the plant index. Determining the vegetation is easier compared to other field usage studies. In this study, Landsat satellite images that were taken in different years at the same period were used to determine the changes in the plant index values. The areas in the research area that had the highest NDVI values were the areas facing north, which had humid forest trees. In this area *Carpinus* sp., *Quercus* sp., *Tilia* sp. and condense sub-forest vegetation are present. As the rains fall on the north side, this results in humid forest vegetation. Literature studies state that a high amount of *Fagus* sp. and their sub-forest vegetation, holly plants (*Ilex* sp.) were present, but that they were cut down due to demand. In the field studies, a small number of *Fagus* sp. were seen in small amount but holly (*Ilex* sp.) were seen frequently. The fact that an area is depicted as 'Kayinlidere' (a river surrounded with *Fagus* sp.) supports the literature data. On the south side of the research area, drought-resistant and heat-loving shrubbery can be observed. As this vegetation did not show a group property, a net classification could not be done. The NDVI values show changes according to the years. The main reasons of these changes are the differences in vegetation periods, the plant growth and the changes in flora due to area pressure.

REFERENCES

1. C. TARHAN: Remote Sensing in Urban Planning and Integration of Geographic Information Systems Discipline in Urla and Balcova Examples. Plan J, (3),106 (2004).
2. C. DURAN: Vegetation Analysis with Remote Sensing Techniques. Doa J, (13), 45 (2007).
3. M. OZYAVUZ: Analysis of Changes in Vegetation Using Multitemporal Satellite Imagery, the Case of Tekirdag Coastal Town. J Coast Res, **26** (6), 1038 (2010).
4. M. OZYAVUZ, Y. DONMEZ: Monitoring the Changing Position of Coastlines Using Information Technologies, an Example of Tekirdag. J Environ Prot Ecol, **15** (3), 1051 (2014).
5. NASA: Measuring Vegetation. http:/earthobservatory.nasa.gov/Features/Measuring Vegetation/measuring_vegetation_2.php (accessed November 22, 2013), 2013.
6. B. C. BILGILI, O, SATIR, V. MUFTUOGLU, M. OZYAVUZ: A Simplified Method for the Determination and Monitoring of Green Areas in Urban Parks Using Multispectral Vegetation Indices. J Environ Prot Ecol, **15** (3), 1059 (2014).

7. ERDAS: Erdas Imagine Basis Software. Operations Group of Companies, USA, 2013.
8. J. A. RICHARDS: Remote Sensing Digital Image Analyst. 5th ed. Springer Verlag, Berlin, NY, 2012.
9. N. QUARMBY: Landmap Geoknowledge. http://landmap.ac.uk/index.php/Learning-Materials/Image-Processing-for-ERDAS/3.1.-Geometric-Correction, 2014.
10. O. ROJAS, A. VRIELING, F. REMBOLD: Assessing Drought Probability for Agricultural Areas in Africa with Coarse Resolution Remote Sensing Imagery. Remote Sens Environ, **115** (2), 343 (2011).
11. Q. WENG: Remote Sensing of Impervious Surfaces in the Urban Areas: Requirements, Methods, and Trends. Remote Sens Environ, 117, 34 (2012).
12. A. R. HUETE, H. LIU: An Error and Sensitivity Analysis of the Atmospheric- and Soil-correcting Variants of the NDVI for the MODIS-EOS. IEEE T Geosci Remote, **32**, 897 (1994).
13. A. VINA, A. A. GITELSON, N. L. A. ROBERTSON: Comparison of Different Vegetation Indices for the Remote Assessment of Green Leaf Area Index of Crops. Remote Sens Environ, **115** (12), 3468 (2011).
14. J. LIU, X. YANG, H. L. LIU, Z. QIAO: Algorithms and Applications in Grass Growth Monitoring. Abstr Appl Anal, **2**, 1 (2013).
15. I. KLEIN, U. GESSNER, C. KUENZER: Regional Land Cover Mapping and Change Detection in Central Asia Using MODIS Time-series. Appl Geogr, **35** (1–2), 219 (2012).
16. M. OZYAVUZ, O. SATIR, B. C. BILGILI: A Change Vector Analysıs Technique To Monitor Land-Use/Land-Cover in the Yildiz Mountaıns, Turkey. Fresen Environ Bull, **20** (5), 1190 (2011).
17. A. H. M. ADAM, A. H. M. ELHAG, A. M. SALIH: Accuracy Assesment of Land Use&Land Cover Classificiation (LU/LC) Case Study of Shomadi area – Renk County–Upper Nile State, South Sudan. Int J Sci Res Publ, **5** (3), 1 (2013).
18. S. AVDIMIOTIS, E. CHRISTOU: GIS Applications in Tourism Planning. A Tool for Sustainable Development Involving Local Communities. J Environ Prot Ecol, **5** (2), 457 (2004).

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