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Determining of Carbon Storage Using Remote Sensing

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Abstract: Forest ecosystems, which have an important role in the global carbon cycle by storing large amounts of carbon in the above-ground, below-ground and soil, make up about 30 % of all terrestrial ecosystems. Two different methods are used to determine the amount of carbon stored in forests. In both methods, different parameters should be determined by stand measurements. However, new methods are needed because it is time -consuming and costly to do these studies. In this context, the determination of the carbon storage capacity of forest areas by using the data obtained by remote sensing methods has come to the agenda. For this purpose, the stands selected as a study area were determined with the help of measurement data of terrestrial carbon storage levels in the Gazipaşa Central State Forest Enterprise of Antalya Regional Directorate of Forestry in Mediterranean region. In the satellite image (Sentinel), the relationship obtained from the brightness values of various bands and the amount of carbon stored to be determined by various vegetation indices have been established.

Keywords: Carbon storage, Remote sensing, Sentinel.

1. INTRODUCTION

It is not known exactly when the human being in the world begins. However, it is a well -known fact that man is more and more distorting the natural structure of the earth with the activities of the earth. Now human beings are concerned that this increasing deterioration, natural life, and thus the existence of it on earth. The changes observed in the climate since the beginning of the 20th century stem from human activities that increase the greenhouse gas levels in the atmosphere by raising the world's average temperature (Mısır & Mısır, 2018; Yıldız, 2021). The most important of these activities is the burning of fossil fuels that provide carbon dioxide to the atmosphere. According to the data of the National Oceanic and Atmospheric Administration, the amount of carbon dioxide in the atmosphere continued to increase and reached 419.68 ppm as of August 2023 (NOAA, 2023). If the ratio of carbon dioxide and other greenhouse gases in the atmosphere is not reduced rapidly, climate change will have destructive and irreversible effects on the world. In this context, it is important to determine the amount of carbon stored by forest ecosystems, one of the carbon pools in the world. 67 % of the carbon held in terrestrial ecosystems except sedimental rocks and 75 % of the carbon held by vegetation around the world are kept in forests (Mısır & Mısır, 2017). According to the Intergovernmental Panel on Climate Change (IPCC, 2006), the main carbon pools or reservoirs that can be included in the forest carbon sampling program are five:

1. Above-ground
2. Below-ground (roots)
3. Deadwood
4. Litter
5. Soil organic carbon

The most challenging stage of the carbon storage of forests is undoubtedly the most challenging stage. The time consuming and highly cost effectiveness of field studies has directed researchers to methods that do not require field studies. In this study, it is aimed to develop the regression model by taking independent variables of the sample areas determined in the study area, the reflection values of the satellite image of these areas and the vegetation indexes obtained from these bands.

2. MATERIALS AND METHODS

2.1. Study Area

In this study, Gazipaşa Planning Unit was selected as the research area within the boundaries of Gazipaşa Forest Management Directorate of Antalya Forestry Regional Directorate in the south of Türkiye (Figure 1). There are Çamlıca to the north of this planning unit, Demirtaş to the west, Gürçam in the south, Doğanca to the east and Çığlık planning units.

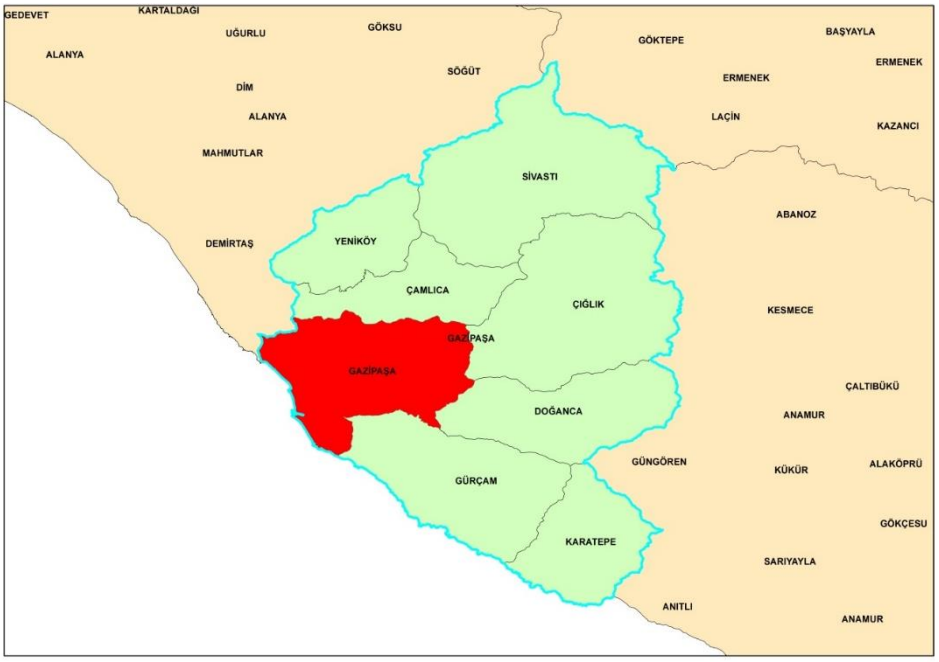

Figure 1. Study area.

Typical Mediterranean climate is seen in Gazipaşa region subject to the study. In this region, summer is dry and hot, and the winter season is warm and rainy. According to the data of the Regional Directorate of Meteorology, the highest temperature of the last 90 years was 45.6 c˚ in August 1958 and the lowest temperature was measured in January 1964 - 8.1 c˚ (MGM, 2023). The vegetation of the region is the typical vegetation of the Mediterranean region. In this region, it is seen on the steep slopes of the areas up to the sea up to 800-1000 meters high. After 800-1200 meters, it is possible to see the pine forests mixed with the *Erica arborea*. Forest vegetation is typical and the dominant tree species include Turkish pine (*Pinus brutia* Ten.), Oak (*Quercus* sp.), Stone pine (*Pinus pinea* L.), Juniper (*Juniperus*), Lebanon cedar (*Cedrus libani* A. Rich.).

2.2. Field Sampling

The paper incorporates sample plots and sample trees data. The results of sample plots include stand type, stand diameter (two type: mean diameter and quadratic mean diameter), stand height, basal area, number of trees, herbaceous biomass, shrub biomass, litter biomass, lying dead wood biomass, herbaceous carbon amount, shrub carbon amount, litter carbon amount and lying dead wood carbon amount. The sample trees' results include diameter at breast height, tree height, stem biomass, branch biomass, foliage biomass, stem carbon amount, branch carbon amount and foliage carbon amount.

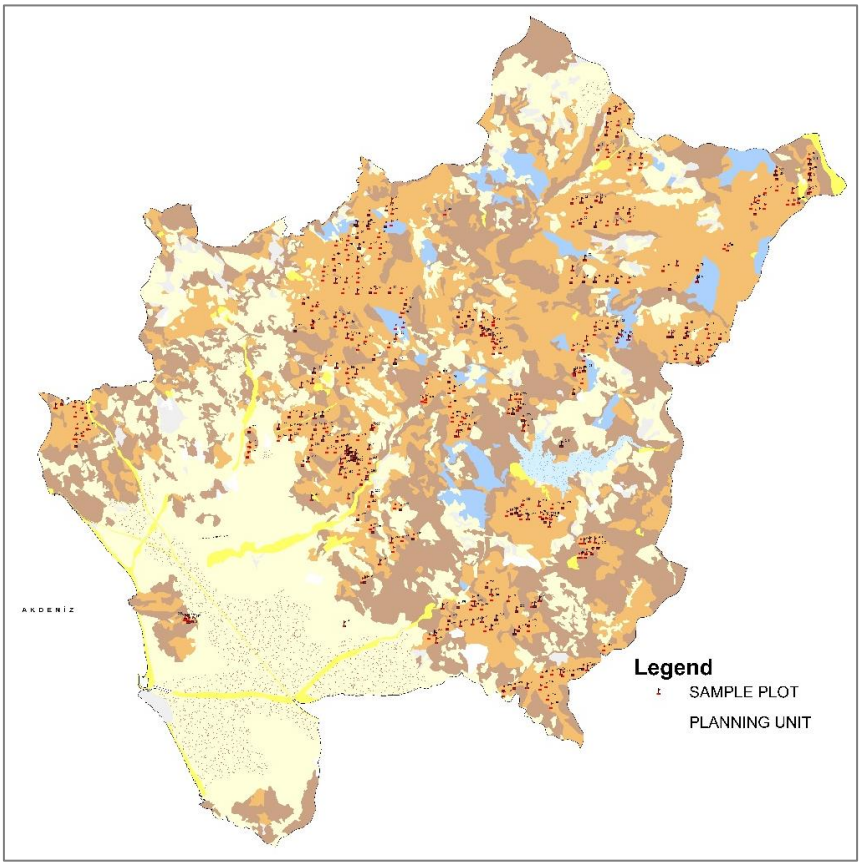

Figure 2. Sample Plots.

2.3. Obtaining of Reflection Values

To obtain the reflection values of all sampling plots, Sentinel 2 satellite images of the research area dated 28.07.2018 were obtained. In the field feature layers, separate reflection values are created for each band. By combining these layers with sample plots, the reflection values of the bands corresponding to the sample plots were found (Figure 3). If there is more than one reflection value falling into the sample plot, the weighted average of the reflection values in the sample plot is determined and a single reflection value is obtained for each sample plot. Various models have been developed by taking independent variables of 14 different vegetation index values as the amount of carbon taken as dependent variables, reflection values of the bands and independent variables. The statistically developed models were decided to be the most appropriate.

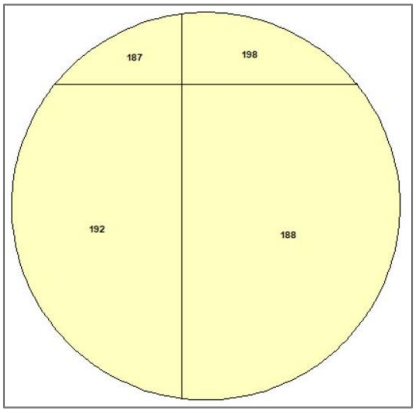

Figure 3. Satellite image reflectance values for the 212th sample plot.

2.4. Relationship Amount of Carbon Storage with Remote Sensing Data

Remote sensing data can provide detailed information about the composition of the stand structures and the species forming the stand. Different stand structures have different spectral reflectance values in different wave lengths (Mısır et al., 2011; Çakır et al., 2017). Therefore, the relationship between stand parameters and remote sensing data also varies. In this study, dependent variable of carbon storage amount; reflectance values for satellite image bands, vegetation indices obtained from different band combinations were using as independent variables, the relationship between the amount of carbon storage in the stands and the remote sensing data was investigated.

3. RESULTS

The statistical values of certain characteristics of the sample plots taken in the research area are given in Table 1.

Table1. Statistical values of all bands and vegetation indexes.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BAND1	369	100,99	42424,17	874,15	3255,06
BAND2	369	67,99	39865,15	924,59	3020,67
BAND3	369	171,98	37763,27	1349,43	2817,26
BAND4	369	111,99	35735,58	1212,83	2682,75
BAND5	369	279,97	35016,68	2010,12	2699,40
BAND6	369	569,95	34275,25	3117,22	2745,22
BAND7	369	634,94	33756,67	3371,60	2756,68
BAND8	369	701,93	33061,50	3667,36	2799,69
BAND9	369	323,97	43601,00	3787,32	3684,73
BAND10	369	10,94	9619,25	294,40	1127,65
BAND11	369	418,96	20062,45	2501,02	1964,17
BAND12	369	283,97	16643,05	1601,02	1533,14
NDVI	369	-0,02	0,58	0,34	0,11
SR	369	0,97	3,77	2,12	0,50
DVI	369	-718,90	6591,53	797,29	543,51
TVI	369	0,48	1,08	0,84	0,11
NLI	369	0,59	0,88	0,78	0,05
SAVI	369	-0,03	0,87	0,51	0,17
ND53	369	-0,04	0,84	0,54	0,16
ND54	369	-0,03	0,58	0,26	0,09
ND57	369	-0,37	0,25	-0,04	0,03
ND32	369	-0,43	0,22	-0,08	0,09
ND73	369	-0,08	0,86	0,57	0,16
NDWI	369	-0,58	0,03	-0,26	0,09
EVI	369	-1,55	1,53	0,67	0,25
IPVI	369	0,49	0,79	0,67	0,06

The relationship between carbon storage amounts, reflection values of satellite image bands and vegetation index values have been tried to be obtained. As described above, the amount of carbon storage, which is dependent variable, is estimated based on the reflection values of the bands and the vegetation index values. The obtained regression model is given in Table 2.

Table 2. Parameters Estimations of the Carbon Model.

	Parameter Estimate (β)	R Square	Std. Error of the Estimate (ton/ha)
Constant	151,396	0.52	18.2
Band10	0,009		
DVI	-0,016		
ND54	-113,082		
EVI	15,223		
ND32	-55,619		

4. DISCUSSION AND CONCLUSION

In this study, to model the amount of carbon stored in the forest areas of the Mediterranean Region, Gazipaşa Planning Unit with a remote sensing method; Carbon storage values obtained from the measurements made in sample plots, the reflection values of satellite image bands and the relationships between 14 different vegetation indexes were examined. As a result of the statistical evaluations, a model was developed to determine the amount of carbon stored in the study area by using satellite images.

Türkiye has a complex climatic structure, especially due to global warming, is one of the countries that will be most affected by climate change. Naturally surrounded by sea on three sides, it has a flawed structure and orographic properties, and different regions of Türkiye will be affected by climate change in different formats and different sizes. The determination of the carbon storage capacity of the forests in Türkiye is therefore of great importance. In addition to the determination of carbon storage capacity, it is important that our country periodically update this data (Mısır et al., 2019).

Satellite images, one of the remote sensing methods, can determine the carbon storage capacity of forest areas at a rapid, easy and minimum cost. In such a study, the difference between the year in which the satellite images were taken and the year in which the data to be received as checkpoints is obtained is important. To see how the year difference affects performance, more accurate information will be obtained by doing similar studies with the latest and long -term data (Mısır et al., 2013).

The results obtained from such studies can be transferred to other working areas with similar conditions and can be used as a guide for the selection of the best spectral band combinations in the work on the work of the bushes. In addition, these results are important for selecting possible bands in classification of the forest cover. It is estimated that these new relationships can be applied to studies using Sentinel, Landsat ETT +, SPOT, MODIS or AVHRR data on a regional or global scale.

Since forests are one of the most important factors affecting global climate change, it becomes increasingly more important to determine the carbon storage capacity of forests. It is of great importance to perform these and similar studies using different satellite images, so that we need to have more information about the carbon storage capacity of our forests.

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