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Analysis of carbon absorption amount of urban forests by spatial interpolation methods

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ABSTRACT

As a result of increasing urbanization as of the 20th century, people's need for green space is increasing. It can be said that the concept of Urban Forest has emerged as a natural result of increasing urbanization both in the world and in our country. In a study conducted by the World Health Organization, it is emphasized that at least 9m² green area per person is necessary for a healthy society. In this context, the concept of urban forests, which provides the opportunity to offer the social functions of forests to people, gains importance day by day. The Urban Forests project started to be implemented in our country in 2003. With this project, a total of 64 urban forests have been established in 55 provinces and 9 districts until the end of 2008. The oxygen produced, the carbon dioxide consumed and the carbon absorption of 64 urban forests that constitute the analysis area of this study were calculated. As a result of interpolation studies carried out in Geographical Information Systems (GIS), maps showing the contribution of urban forests to the environment were created and all these factors were analyzed on a spatial basis.

1. INTRODUCTION

The urbanization of the world population to increase the need of people for green areas in areas close to the city (Konijnendijk, 2003). The concept of urban forestry, which emerged in line with this need, aims to ensure the development of cities in harmony with the natural environment through urban planning (Johnston, 1996). Urban forests are areas created naturally or artificially in and around the city, ensure functional contributions and aesthetics to the city structure, and providing recreational opportunities for people living in the city (Ayaşlıgil, 2007). The purpose of creating urban forests is to improve the urban landscape and provide recreational opportunities for health and sports (Kowarik & Körner, 2005).

In addition to the contributions of urban forests to the social life of people, they also have many effects on nature. Forests help the harmonious functioning of nature with the carbon dioxide they consume and the corresponding carbon absorption amount. Climate change, which causes this function to deteriorate, is proportional to the amount of carbon released into the atmosphere. Today, many measures are taken to reduce carbon emissions. These forests, which increase the air quality, provide absorption by the leaves or the soil surface, the excretion of aerosols and particles on the leaf surface, and the movement of particles in the direction of the vegetation coast as a result of slowing air movements. Transported particles keep carbon dioxide emissions at a significant rate (Öner, N., Ayan, S., Sivacioglu, A., & Imal, B. (2007). This helps prevent air pollution.

Data obtained from the Forest Regional Directorate were used in the study. Assessment of the contribution of 64 urban forests to the environment established by the ministry constitutes the purpose of the study. In this context, the oxygen produced by the forests, the carbon dioxide consumed and the carbon absorption amount maps were created. The average carbon absorption amount of urban forests was calculated as 642.93 tons. Considering the resulting data, Antalya Urban Forest was determined as a forest area with a higher absorption amount of 15000 tons of carbon.

2. METHOD

The changing habits of people cause urbanization problems, food crises, decrease in natural resources such as soil, water and climate change. One of the reasons of climate change is the gases that accumulate in the atmosphere and cause greenhouse effect. Carbon

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emissions as the main cause of climate change mainly arises as a result of diffusion into the atmosphere of these gases, especially carbon dioxide. Increasing green areas helps reduce carbon emissions. As of 2019, there are 22.3 million hectares of forest in our country. In addition to these areas, there are 64 urban forests that form the scope of this study with the Urban Forests project developed by the Forest Regional Directorate.

In the study, the carbon dioxide consumed by urban forests, the corresponding carbon emission and the amount of oxygen produced were visualized in the GIS. Inverse Distance Weighted (IDW) technique, which allows analysis on spatial basis, was used in the creation of maps. Maps produced with this technique reveal the contribution of urban forests across the country to the environment. In addition, as a result of the analysis made using the data of the existing forests, the amount of oxygen produced by the areas near the forests, the rate of carbon dioxide consumption and the amount of carbon emission can be estimated.

Carbon dioxide consumption and oxygen production shown with different colors in GIS are effective factors in determining carbon absorption. When the map created as a result of the analysis is evaluated, the parameter that has more effect on the amount of emission on the basis of the region and the province was determined.

2.1. Inverse Distance Weigthed (IDW) Interpolation Method

IDW, which is a non-geostatistical method, is frequently preferred in studies. It is used to determine the value of unknown points based on known points. Estimates are made taking into account the distance function. The estimated values are a function of the distance and size of the nearby points, and the importance and effect on the cell to be estimated decreases with increasing distance (Taylan, E & Damçayırı, D. 2016).

IDW has been the common form in GIS systems, although a variety of weighted functions are used. IDW is a complete intermediate value generator (interpolator) such that it consolidates the values of the data. The IDW estimator is as follows (Loyd C.D., 2007; Demircan, Alan, & Şensoy, 2011).

$$Z(X_0) = \frac{\sum_{1=1}^{n} z(X_i).d_{i0}^{-r}}{\sum_{i=1}^{n} d_{i0}^{-r}} \qquad (1)$$

The location X_0, where the predictions are made is a function of n neighboring measurements giving the number of neighboring measurements. ($z(X_i)$ and i=1,2,…,n,); r is the exponential value that determines the assigned weight of each of the observations, and d_{i0} is the distance that separates the observation location X_i and the prediction location X_0. As the exponent grows, the assigned weight of observations far from the prediction location shrinks; increasing the denominator indicates that the forecasts are very similar to the nearest observations (Demircan, Alan, & Şensoy, 2011). The formula was calculated in ArcGIS, and as a result, relevant maps were created.

3. RESULTS & DISCUSSION

In the study, 64 urban forests created within the scope of the Urban Forests project carried out by the Forest Regional Directorate were handled. IDW interpolation method was used to determine the spatial models of the variance that emerged in the contribution of these forests to the environment. Maps were obtained that reveal the created models effectively.

On the maps, oxygen production and carbon dioxide consumption, which are factors affecting carbon emissions, are visualized by interpolating with GIS.

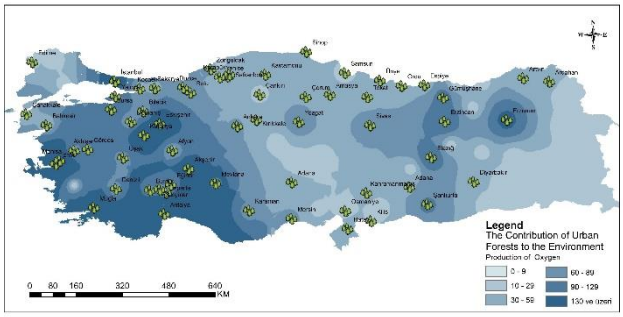

Figure 1. Oxygen Production Map of Urban Forests

Fig. 1 contains the oxygen production map of urban forests. When the map is examined, it can be said that the amount of oxygen production is high, especially in the southwestern part of the country. In the inner and eastern parts of the country, the amount of oxygen produced by urban forests is lower than other regions. On the other hand, Erzurum Urban Forest, which is established on an area of 717 hectares, stands out in that region with 600 tons of oxygen production. Antalya Urban Forest is the forest with the highest contribution to the ecosystem with 8367 tons of oxygen production. On the other hand, Yenice Urban Forest located in Karabük with 0.8 tons was the forest with the lowest oxygen production.

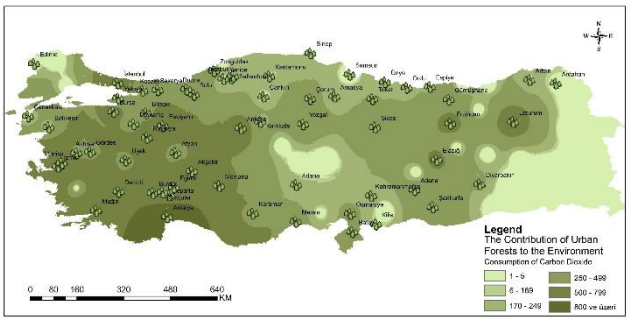

Figure 2. Carbon Dioxide Consumption Map of Urban Forests

In Fig. 2 there is a map showing the carbon dioxide consumption of urban forests. When the map is interpreted, it can be said that the marine urban forests in the southwestern part provide a higher rate of carbon dioxide consumption. The urban forest with the highest carbon dioxide consumption is the Antalya Urban Forest with 55000 tons of consumption. The least consumption amount was Karabük Yenice Urban Forest with 6 tons. This situation is similar to the oxygen production map in Fig. 1. The insufficiency of urban forests in the eastern

parts of the country can also be observed in the carbon dioxide consumption rate map.

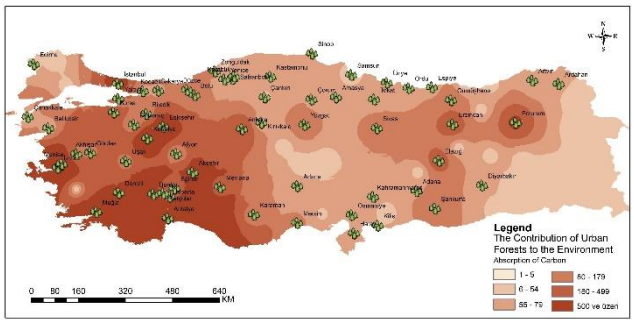

Figure 3. Carbon Absorbation Map of Urban Forests

The carbon absorption amounts of the Urban Forests are given in the map in Fig. 3. Carbon dioxide consumption rate is one of the important parameters affecting carbon absorption. This situation causes the maps in Fig. 2 and Fig. 3 to be similar.

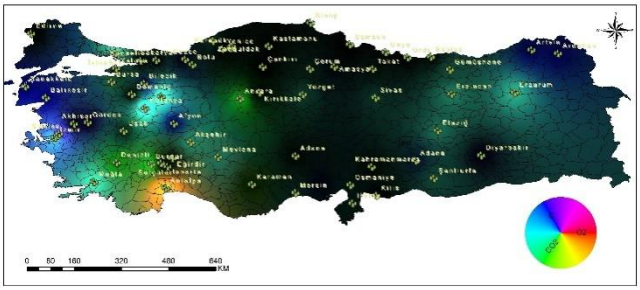

Figure 4. Carbon Absorption Map by Oxygen Production and Carbon Dioxide Consumption of Urban Forests

Urban forests control the carbon dioxide and oxygen balance, which are important for the world ecosystem, resulting from carbon absorption and fossil fuels (Nowak 1993). The global carbon cycle is defined as one of the biogeochemical cycles that enable the concentration of carbon dioxide, one of the greenhouse gases, to balance in the atmosphere. Forests play a role in this global cycle. Urban forests, which store carbon in soil and vegetation, exchange carbon with the atmosphere through photosynthesis and respiration (Brown 1997).

The map in Fig. 4 was created in order to determine the parameter affecting carbon absorption more on the basis of urban forests by evaluating the oxygen production and carbon dioxide consumption amounts together.

4. CONCLUSION

Problems such as the acceleration of population growth, urbanization, and traffic increase the need for natural habitats of people. Urban forests, which are areas where people who want to get away from their stressful lifestyle can interact with nature, gain importance day by day. In our country, the Urban Forests project has been put into effect by the Forest Regional Directorate. 64 urban forests have been established so far within the scope of the project, and this number is planned to be increased in the coming years. Urban forests have many contributions to the environment. Forests that increase oxygen production help to maintain carbon balance by reducing carbon dioxide consumption.

The total oxygen production of urban forests, which have an average oxygen production of 330.59 tons, evaluated within the scope of the study, is 21158 tons. Forests whose total carbon dioxide consumption was 55000 tons, the average consumption amount was determined as 148.79 tons. In forests where a total of 41148 tons of carbon is stored, an average of 642.93 tons is absorbed. The forest with the highest amount of carbon storage was the Antalya Urban Forest. 15000 tons of carbon is stored in this forest. The lowest absorption amount among urban forests was determined as Yenice Urban Forest in Karabük with 2 tons.

Reasons such as industrialization, population growth and the use of fossil fuels cause an increase in greenhouse gases consisting of carbon dioxide, methane and ozone. The main reason for global warming is these gases released into the atmosphere. By regulating the carbon balance of forests in the city atmosphere, it makes it possible to slow down global warming. 64 urban forests contribute to the global cycle. In addition, the number of urban forests in the Eastern and Southeastern Anatolia Region is quite low. Establishing urban forests in these regions is important in terms of their contribution to the natural environment.

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