Araştırma Makalesi / Research Article

Uzaktan Algılama Metodu İle Nazik Gölü İçin Taşıma Kapasitesinin Tahmini

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Öz
Nazik Gölü deniz seviyesinden 1856 metre yukarıda, 380 51' N 420 14' E koordinatları içerisinde yer almaktadır. Bu çalışmada, aylık klorofil-a değerlerinin belirlenmesinde ENVISAT/MERIS uydu görüntüleri kullanılmıştır. Aylık yüzey suyu sıcaklık değerlerinin belirlenmesinde MODIS/Aqua uydu görüntüleri kullanılmıştır. Gölün taşıma kapasitesi 24100.21 ton/yıl, yıllık ortalama klorofil-a değeri 7.12 mg/m^3 olarak bulunmuştur. ENVISAT/MERIS uydu görüntülerinden elde edilen klorofil-a konsantrasyonu, en yüksek 30.071 mg/m^3 ile Eylül ayı içerisinde, en düşük 3.727 mg/m^3 ile Ocak ayı içerisinde gözlemlenmiştir. MODIS/Aqua uydu görüntülerden elde edilen yüzey suyu sıcaklık değerleri, en yüksek 22.89 C^0 Ağustos ayında, en düşük 2.33 C^0 Aralık ayında gözlemlenmiştir.

Anahtar kelimeler: Taşıma kapasitesi, Nazik Gölü, Uzaktan Algılama, Klorofil-a, Trofometrik İndeks

The Estimation of Carrying Capacity for Lake Nazik with the Remote Sensing Method

Abstract
Lake Nazik is located in 1816 m above sea level and in 380 51' N 420 14' E coordinates. In this study, to identify the value of monthly chlorophyll-a, ENVISAT/MERIS satellite images were used. On the other hand, MODIS/Aqua satellite images were also used to identify the value of monthly surface water temperature. Carrying capacity of lake was identified as 24100.21 tons/year, and an annual average chlorophyll-a value was found out as 7.12 mg/m^3. Using data on ENVISAT/MERIS satellite images, it has been observed that the chlorophyll-a concentration in Lake Nazik reached its highest value of 30.071 mg/m^3 in September, while dropping to its lowest value of 3.727 mg/m^3 in January. Using data on MODIS/Aqua satellite images, it has been observed that the maximum value of water surface temperaturewas 22.89 C^0 in August, while the minimum value was 2.33 C^0 in December. Furthermore, it was found out that theannual average value for water surface temperature during the study was 14.9 C^0.

Keywords: Carrying Capacity, Lake Nazik, Remote sensing, Chlorophyll-a, Trophometric Index

1. Introduction

There have been many problems due to the overuse of natural resources, and these problems have been spreading steadily. Natural resources are sustainable; however, they are not limitless. Therefore, while using natural resources, the carrying capacity estimation is one of the basics of sustainability. The carrying capacity has been defined as the maximum population size of biological species/individuals to maintain their normal functions that are able to be supported by an environment or ecosystem [1]. If the applications which do not pay attention to carrying capacities continue, these applications will lead to problems that are impossible to be solved. In that sense, it is important to note down that fish stock in

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Geliş Tarihi: 17.03.2019, Kabul Tarihi: 25.07.2019

inland waters has a tendency to welcome problems. Turkey is a rich country in terms of inland waters. However, limited studies deal with the total carrying capacity and stock estimation of these resources. highlights that carrying capacity of Kesikköprü Dam Lake is 3335 tons/year [2]. On the other hand, highlighted that Almus Dam Lake has the capacity for trouts about 5530 tons [3]. A study in a similar vein, Ataköy Dam Lakes has capacity about 3309 tons/year [4]. Lake Nazik with its surface area of 46.6 km^2 is the largest fresh water lake of Lake Van Basin. To utilize water resources in a sustainable manner for fish production, we should primarily know more about the carrying capacity of these areas [5]. Lake Nazik, in which year-long fishing can be actively done, has great importance for economy of the region. In the lake, common carp (*Cyprinus carpio*), siraz (*Capeota capeota*), the pearl mullet (*Alburnus tarichi*) and crucian carp (*Carassius carassius*) are available. Despite ongoing intensive fishing activities, studies about the lake are not numerous and are conducted mainly on the biological characteristics of the fish living in the lake [6]. The main objective in the identification of total carrying capacity is to benefit optimally from fish stocks that are the products of aquatic ecosystem utilized by people. Not only to be able to benefit from fish stocks optimally but also to identify the carrying capacity of the resources, biological data regarding overall product and stock are needed. Therefore, stock assessment is required not only for each stock but also for the identification of the carrying capacity for resources. The basic parameter to be taken in renting cages for fish farming, particularly in the dam lakes of Turkey, is the size of the surface area. However, the carrying capacity of the resources, such as the lake and the dam, changes in line with lots of parameters; namely, the altitude of the resource, surface area, coastal line length, annual chlorophyll-a average (mg/l), mean temperature (C^0), the amount of nutrients and the mean depth. The models are required for the estimation of the density, production and overall size of the fish populations for sustainable use of these populations in lakes and reservoirs [7]. Fish seed releasing activities done without knowing the total carrying capacities of ecosystems like lakes and dams, in which artificial populations were created with fish seed releasing, may fail. Therefore, different prediction models have been developed to identify total carrying capacities of resources such as lake, dam lake and pond by various researchers from the past to the present. These models have identified the total carrying capacity and productivity of the lake in terms of physical (mean depth, coastal line length, surface area etc.), chemical (nutrients) and biological (primary production) characteristics of the lake. Up to now, researches have been done by scientists via using different parameters on the carrying capacity efficiencies of the lakes and dam lakes. The average depth and morpho-edaphic index [8], (total dissolved solids in mg/liter divided by mean depth in meters), trophometric index [7] (TMI), coastal line length, average amount of chlorophyll-a (primary production), the size of the area used by fish activelythe amount of total phosphorus budget [9], surface area and volume [10], the amount of nutrients [11], primary production [12]. Among the most important factors, identifying the total carrying capacities of resources and the primary production located on the bottom rung of the food chain are of high importance. The remote sensing method is the most widespread method in identifying the primary production of areas such as lakes and dam lakes that havea large surface area. In a study conducted by [13], the amount of annual average chlorophyll a and the carrying capacity for Lake Ercek have been measured respectively as 2.83 mg/l and 21331.452 tons/year by using remote sensing and TMI. With this study, chlorophyll-a concentration and surface water temperature values of Lake Ercek, which are really significant for the region's economy, have been monitored on a monthly basis with the remote sensing method, and the total carrying capacity of the lake has been shed light onto via TMI method.

2. Material and Method

Lake Nazik (Figure 1), which is located at coordinates of 380 51' N 42014' E in Lake Van Basin, is a fresh water lake with an altitude of 1816 m. The lake was formed through volcanic damming. It has a surface area of 46.6 km^2, a maximum depth of 16 m and an average depth of 12.37 m, a volume of 576.376 $hm^3$and a coastal line length of 36.13 km. TMI, which was developed by [7], was employed in order to identifythe carrying capacity of Lake Nazik. TMI takes into consideration the following things particularly; Chlorophyll a concentration (primary production), surface area, volume, coastal line length and a sufficient percentage for the volume of water to support life. TMI is calculated by the following equation:

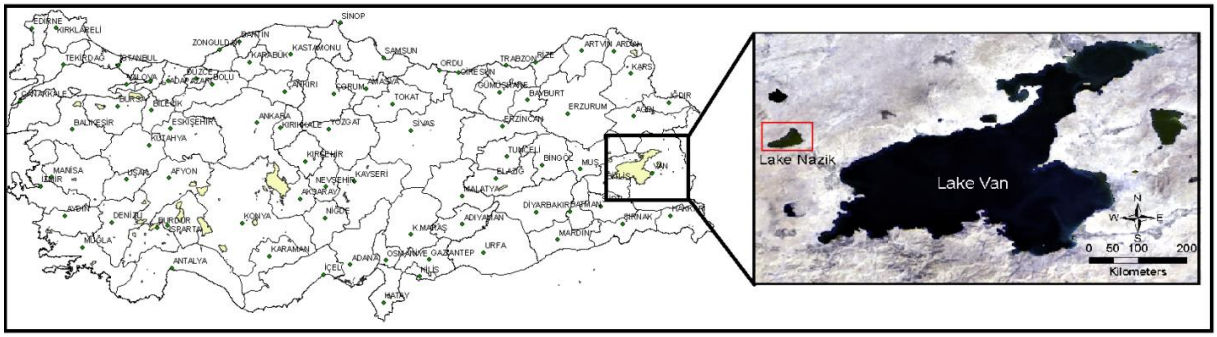

Figure 1. Lake Nazik

$$TMI = IF * ln\ C * VOAP\ (\ ln\ Cl\ /\ ln\ Pe) \quad (1)$$

IF = Surface Area (km^2) / Volume (hm^3), C: Conductivity, Cl: Chlorophyll-a concentration, Pe: Coastal line length (Perimeter), VOAP: a sufficient percentage for the volume of water to support life. Carrying capacity is calculated when TMI value, whichwas calculated through the above mentioned formula, is put into the equation below.

$$C.C = -342.607 + 200.201 * TMI \quad (2)$$

Images from ENVISAT/MERIS, which is Europe's biggest earth observation satellite, are used in order to identify Chlorophyll a concentration in Lake Nazik by remote sensing. Beam 4.9 packaged software was utilized in image processing. Algal_2 algorithm was used in calculating chlorophyll a concentration by deciding that Lake Nazik was in case 2 group waters (affected by land based discharges). Algal_2 has a structure in the form of a natural neural network. Therefore, Chlorophyll concentration in water is calculated in Log_{10} (mg/m^3) by this algorithm. Images from MODIS/Aqua (11μ) were used in calculating Sea surface temperature (SST) values of Lake Nazik. On the other hand, SST values were obtained with NLSST algorithm. NLSST algorithm, which is a derivative of CPSST (cross-product SST), uses nonlinear methods in atmospheric correction [14].

3. Results and Discussion

Chlorophyll a values, between April and December of 2013, were calculated by using images of ENVISAT/MERIS satellite. No images were obtained because surface of the lake was covered with ice for three months (January, February and March). Beam 4.9 was used to process images. An average of Chlorophyll a concentration which was calculated monthly and surface water temperature values are presented in Table 1, Figure 2, Figure 3. Average Chlorophyll a concentration in the lake was found out as 12.07 mg/m^3. Monthly Chlorophyll a concentration in Lake Nazik was found out as below average in April, May, June, July, November and December and above average in August, September, October. Chlorophyll concentration in the lake was identified as 8.609 mg/m^3 in April, as 5.591 in May and as 3.430 mg/m^3 in June, which was the lowest value annually. Chlorophyll concentration decreased from April to June. After July, a sudden increase took place, and the concentration reached to a value of 16.633 mg/m^3. When the peak value is assessed, it can be said that Chlorophyll concentration reached to a value of 30.071 mg/m^3 as the peak value. On the other hand, after September, Chlorophyll concentration followed a decreasing course and was measured as 24.190 mg/m^3 in October. A sudden decrease was observed after October, and the value was measured as 11.993 mg/m^3 in November and as 3.727 mg/m^3 in December.

Table 1. Monthly chlorophyll-a and water surface temperature values

		Mean
Months	**Chl-a (mg/m^3)**	**Surface Temperature (C^0)**
April	8.609 ± 0.59	5.24 ± 0.44
May	5.591 ± 1.20	16.1 ± 1.56
Jun	3.426 ± 0.56	16.13 ± 2.12
July	4.176 ± 0.96	21.88 ± 1.96
August	16.633 ± 1.72	22.89 ± 2.43
September	30.071 ± 2.11	19.75 ± 1.96
October	24.190 ± 1.94	17.2 ± 1.54
November	11.993 ± 1.45	11.1 ± 2.3
December	3.727 ± 0.50	2.33 ± 0.98

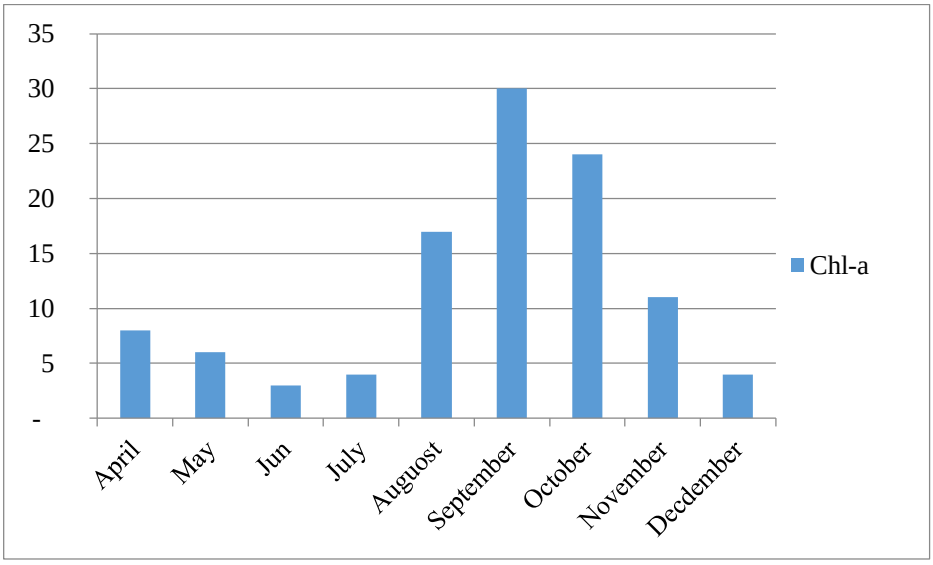

Figure 2. Monthly average of chlorophyll a

Chlorophyll concentration in the lake was found as 5.591 mg/m^3 in May, as 3.430 mg/m^3 in June after it was measured as 8.609 mg/m^3 in April. Various hydrologic situations such as initially nutritional elements, temperature and light are effective on primary production in lakes. It is thought that the decrease in Chlorophyll a concentration from April to June results from the lack of nutritional elements in environment as well as the lack of light transmission. A constant decrease was observed in Chlorophyll a concentration while water temperature is higher compared to one in April throughout these two months. This demonstrates that other factors (nutrients, light, etc.), which have an important effect on primary production in aquatic ecosystems, provide energy transfer through food chains. Primary production occurs depending on the nutrients such as temperature, light, phosphorus and nitrogen [15]. Primary production takes place when they are subjected to density of planktonic groups [16]. One of the factors that determines monthly change and amount of primary production carried on planktonic organisms in lakes is the amount of nutrients in the environment. The amount of nutrients in the environment has a direct impact upon seasonal changes in primary production [17]. [18] expressed that phytoplanctonic organisms are very sensitive to changes in environment, and thus they react to these changes rapidly.

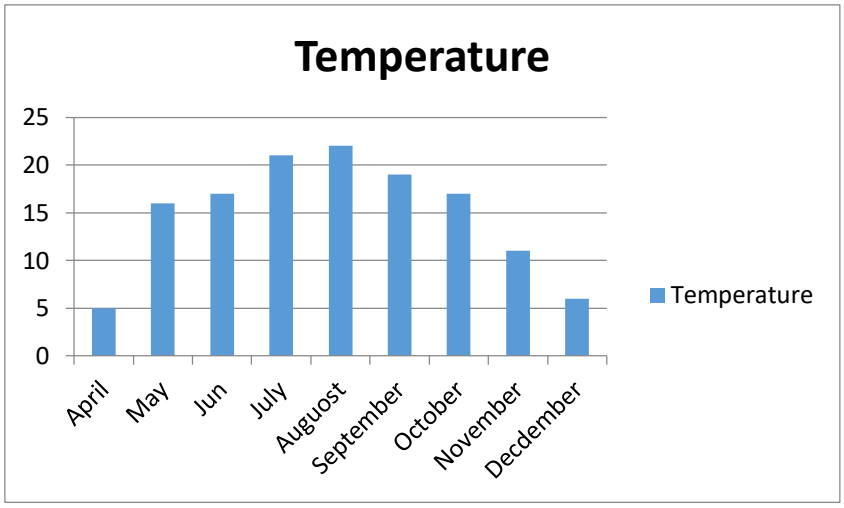

Figure 3. Monthly values of surface temperature (C^0)

It can be seen that the warmest month is August with 23.88 C^0, and the coolest month is December with 2.33C^0 annually when temperature values are examined. Average annual temperature was calculated as 14.986 C^0. The temperature was identified as 5.24 C^0 after the layers of ice melted completely. Temperature values in May and June were close and nearly about 16 C^0. In July, temperature reached to 23.88 C^0 which is the annual peak value. The temperature followed a slowly decreasing course and was measured as 17.2 C^0. It was measured as 11C^0 in November and as 2.33 C^0 once it showed a tendency of a dramatic decrease after October.

IF: Surface area of the lake (km^2) / Volume (hm^3) (3)

Total surface area is used as an important parameter in yield estimate studies [10]. MEI (Morpho-edaphic index), widely used in identifying yield in lakes, uses mean depth instead of surface area. However, surface area, itself, is a powerful tool for estimation. Since bodies of water, having large surface areas, have larger mean depths than those of bodies of water having small surface areas. Because of this, they tend to be more fertile. IF value for Lake Nazik was calculated as follows:
IF= 46.6 (km^2) / 576.376 hm^3
IF=0.08

Conductivity (C) is a measure of its ability to conduct electricity. Higher the concentration of ions, the greater the conductivity is [19] [20]. Due to this reason, an increase in amount of nutrients such as nitrogen and phosphorus that have a positive impact on yield will increase conductivity directly. The value of conductivity was reported as 292.19 µS cm^{-1} as a result of studies of one year. VOAP is defined as percentage by volume of water with enough oxygen to support life. It is a necessary parameter that should certainly be taken into account in order to calculate correctly in estimate studies. Living beings of an aquatic ecosystem can take the benefit of a definite part of the ecosystem, definitely not the whole of it, in accordance with their biological needs. As a result of oxygen measurements made until depth of 14 m, the lowest amount of oxygen was reported as 6.0 mg/l [6]. This reported value is suitable for species of the family cypriandae to be able to live. According to [21], carps survive under a condition of dissolved oxygen of 0.5 mg/l. It was concluded that fishes could use the part of the lake from surface to a depth of 14m actively inasmuch as values reported in measurements made from surface to a depth of 14m in Lake Nazik are excessively higher than this value. The part from surface to the depth of 14 m comprises the 87, 5 % of the lake. [22] stated that there is a linear relationship between fish yield and Chlorophyll a concentration; hence, finding out Chlorophyll a concentration level will make estimation process easier in terms of guessing the carrying capacity of the lake.
TMI= 0.08* 5.67*87.5*(2.490/3.587)
TMI = 27.544

It was found out that by [7] after having calculated TMI value for Lake Nazik.

C.C= -1259.59 + 143.97 * TMI
C.C= -342.607 + 200.201* 27.544
C.C= 5171.72 kg /ha^{-1}/year

The obtained value represents the total biomass for per hectare annually. Carrying Capacity was found as 24100.21 ton/year when this value was converted to ton/year unit. The value was calculated as 4.17 mg/m^3 for Chlorophyll a in July, and the same value was calculated as 30.07 mg/m^3 in September. These sudden changes demonstrate that the lake has a quite sensitive structure from the point of eutrophication. As a result of a 5 years long study conducted by [16] in Khadakwasla Reservoir of India between 2004 and 2009, it was reported that there was a dramatic rise in yield of the lake, and this made the lake more vulnerable to eutrophication. Between July and December, a similar course was observed in terms of Chlorophyll a and temperature. Chlorophyll concentration in the lake increased depending on the temperature rise in July and August. Chlorophyll a concentration reached its annual peak of 30.071 mg/m^3, showing a continuously rising schedule despite some small decreases in temperature. However, Chlorophyll a concentration was observed to decrease in temperature after October. Low temperatures and light intensity in winter have a limiting effect on the production of phytoplanktons. Phytoplanktons' growth rate and biological activity increase as temperature rises to optimal level, however they decrease at temperatures over the optimal one. Optimal temperature for most of sea and sweet water phytoplanktons is between 18 °C and 25 °C [23]. [7] conducted a study in seven lakes which have the same properties as Lake Nazik, and they found out the carrying capacity. When the results were examined, it was found out that six lakes have lower carrying capacity compared with Lake Nazik. It is assumed that the primary reason for the fertility of Lake Nazik when compared with other six reservoirs is that its Chlorophyll a concentration is higher than those of other six reservoirs. Since being the lowest trophic level, primary production in aquatic ecosystems identifythe amount of biomass for living beings which eat primary producers. Primary production in reservoirs is more efficient on fish yield than other variables. Due to this, models for estimating fish, which take primary production in the lowest trophic level of ecological pyramid, yield better results [24]. The variable, which has the most powerful effect on fish yield in terms of the relationship between fish yield in resources and environmental factors [25]. In addition, [26] stated that there is a close link between primary productivity and fish yield in ponds, and fish yield changes directly and proportionally in line with the fluctuations in primary production.

4. Results and Recommendations

Consequently, the carrying capacity of Lake Nazik was calculated as 24100.21 ton/year. Finding this capacity fulfilled the gap for the lake that is really significant for the economy of the region in this area. Moreover, the use of remote sensing technology in identifying the values of Chlorophyll a concentration and water temperature, which has a critical importance for aquatic ecosystems, was also another significant outcome. The color of Lake Nazik changes as green, blue or brownish green according to the wave, sunlight, plankton density. However, the outstanding color of the lake is green. In a previously conducted study, it was found out that the average secchi disk depth of the lake was 192.2 ± 10.7 cm [27]. Since Lake Nazik has a capacity to mix up rapidly, the algae density, which rises to a maximum level, goes on in winter months as well [28]. In the present study, it was revealed that chlorophyll-a levels were in accordance with the abovementioned studies for September. Therefore, it is expected that plankton density in lakes would rise up in autumn months. Despite high algae density, no fish death was observed in the lake. This situation is thought to result from the presence of the species belonging to the family of Cyprinidae, which are resistant to low oxygen levels and bad environmental conditions.

Since aquatic ecosystems are hard to study due to the fact that the field conditions are harsh, and the labs, in which analyzes such as Chlorophyll a identification remade, are remote. Remote sensing is a critical way in monitoring Lake Nazik and similar resources in terms of overcoming these hardships.

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