From the Past to the Present: Footprint of Urban and Forest Ecology in Istanbul

Geçmişten Geleceğe: İstanbul'da Kent ve Orman Ekolojisinin Ayak İzi

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ÖZ

İstanbul, geçmişten günümüze nüfusu sürekli artış gösteren önemli bir şehirdir. Bu artış beraberinde yeni yerleşim alanlarının ortaya çıkmasına dolayısıyla yerleşmenin sınırlarının sürekli genişlemesine yol açmıştır. İstanbul şehrinin çekirdeğini günümüzde sur içi diye tabir edilen tarihi bölge oluşturmaktadır. 1950'li yıllara kadar yerleşme genel olarak bu bölgede ve yakın civarında toplanmıştır. Boğaz içine ilk köprünün yapılmasına kadar geçen sürede nüfus genel olarak kıyı kesimi ile D100 karayolu arasında toplanmıştır. 1973 yılında birinci köprünün yapılmasının ardından yerleşmenin sınırları D100 karayolunun kuzeyine doğru kaymaya başlamıştır. 1988 yılında boğaza ikinci köprü (Fatih Sultan Mehmet) yapıldığında yerleşmenin sınırları daha kuzeye doğru genişlemiştir. Bu yıldan itibaren köprü ile birlikte yapılan II. Çevre Yolu (TEM) ile D100 karayolu arasında kalan bölge yoğun bir yerleşmeye sahne olmuştur. Kırsaldan kente yaşanan göçün en yüksek dönemini oluşturan bu yıllarda (1970-1990) İstanbul'un nüfusu iki kattan fazla artış göstermiştir. Üçüncü boğaz köprüsünün (Yavuz Sultan Selim) yapılmasına kadar geçen sürede yerleşme TEM yolunun kuzeyine doğru hızlı bir genişleme yaşamıştır. Geçmişinde aynı periyodik süreci iki defa yaşayan İstanbul, üçüncü köprünün yapılmasıyla tekrar yaşamaktadır. Bu sefer kentin sınırları Karadeniz'e doğru kesintisiz bir şekilde genişleme devresine girmiştir. Yaşanan bu süreçlerde kentin yeşil alanları hızlı bir şekilde gerileme sürecine girmiş, kentsel alanlar ise sürekli artmıştır. Yaşanan bu değişimin periyotlar halinde tespit edilmesi için dönemlik uydu görüntüleri CBS ve Uzaktan Algılama programları aracılığıyla sınıflandırılarak yeşil alanların değişimi ortaya çıkarılmıştır. Elde edilen bulgular 1975 yılından günümüze kadar yeşil alanların sürekli azaldığını ve bunun köprü ve bağlantı yollarıyla yakından ilişkili olduğunu ortaya koymuştur. Şehrin geçmişinde yaşadığı sürecin yeni yapılan köprüyle tekrar yaşayacağı ve bu sefer sürecin daha hızlı olacağı ortaya konulmuştur. Bu dönemde kentin yeni sınırını Karadeniz oluşturacaktır. Bu bize kentin genişleme sınırlarını zorladığını ve yeni yeşil alanların fonksiyonunu yitireceğini göstermektedir.

Anahtar Kelimeler: İstanbul, Green Space, Urban, Ecology, GIS and Remote Sensing

ABSTRACT

Istanbul is an important city whose population has been increasing continuously from the past to the present. This increase has led to the emergence of new residential areas, and therefore, to the constant expansion of the boundaries of the settlement. Today's core of the city of Istanbul is the historical region called the city wall. Until the 1950s, the settlement was mainly concentrated in this area and its immediate vicinity. There were more industrial facilities outside this region. In the time leading up to the construction of the first bridge into the Bosphorus, the population was generally gathered between the coastal and the D100 highway. After the construction of the first bridge in 1973, the boundaries of the settlement began to shift to the north of the D100 highway. When the second bridge to the Bosphorus (Fatih Sultan Mehmet) was built in 1988, the boundaries of the settlement expanded further north. Since this year, the bridge has been built together with the II. The area between the Ring Road (TEM) and the D-100 highway has been the scene of a busy settlement. During these years (1970-1990), which constituted the highest period of migration from the countryside to the city, the population of Istanbul increased more than twice. In the time leading up to the construction of the third Bosphorus bridge (Yavuz Sultan Selim), the settlement experienced a rapid

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expansion to the north of the TEM road. Istanbul, which has experienced the same periodic process twice in the past, is experiencing it again with the construction of the third bridge. This time, the city's borders have entered a continuous expansion circuit towards the Black Sea. During these processes, the city's green areas have rapidly declined and the urban areas have continuously increased. In order to detect this change in periods, periodic satellite images were classified through GIS and Remote Sensing programs and the evolution of green areas were revealed. The findings revealed that the green areas have been decreasing continuously since 1975 and this is closely related to the bridges and connection roads. It has been revealed that the process that the city has experienced in the past will live again with the newly built bridge, and this time the process will be faster. In this new period, the Black Sea will form the new border of the city. This shows us that the city is pushing the boundaries of expansion and that the new green spaces will lose their function.

Keywords: Istanbul, Green Space, Urban, Ecology, GIS and Remote Sensing

INTRODUCTION:

World population was estimated as 7.592 billion in 2018 according to United Nations and World Bank data. Of this population, 4.195 billion (55%) live in urban areas (World Bank, 2019). In Türkiye, 75% of the population which reached 83.614 million people in 2020 lives in cities (ÇŞİDB, 2019). Back in 1960, 33% of the world's population lived in urban areas, and this ratio was 32% in Türkiye (World Bank, 2019). According to the studies carried out in line with the United Nations Sustainable Development Goals, the world population is expected to reach 8.548 billion in 2030, 9.735 billion in 2050 and 10,874 billion in 2100. It is estimated that more than 70% of this population will be living in cities (UN, 2019). It is predicted that the population will increase all over the world in the coming years, and as a result of the developments, the population of low-income countries will concentrate more in cities. The increasing population and the problems encountered in the cities lead to the interruption of basic services (water, infrastructure, transportation, housing, health) in urban areas and make it necessary to overcome many difficulties. This process also negatively affects people's quality of life. Stability has been achieved to a certain extent in countries with sound economies (such as the USA and EU countries), which have largely completed their work in terms of urbanization and sustainability. However, in countries such as Türkiye, which has a very sensitive and fragile economy, no significant progress has been made in the functioning of this process. The excessive growth of population, which has accumulated in many large cities, especially in Istanbul, has brought about squatting. The rapid population growth that started in Istanbul in 1960 continued thereafter, and a sustainable and ecological planning of the city has still not been implemented.

The urban population, which is in a constantly increasing trend, reveals problems in the planning of inner-city areas. The disproportionate and unbalanced economic growth and the deterioration of urban areas impose restrictions on the sustainable management of the city. At the end of these processes, uncontrolled urban expansion, loss of vegetation and transportation investments in Istanbul caused environmental problems (such as new settlement areas, pollution, and loss of forest) and paved the way for the emergence of further issues. The most important of these is the increase in the loss of forest areas in Istanbul and eventually the formation of ecological pollution. Transportation projects such as the new bridge to Istanbul, the Northern Marmara Highway and the airport have led to a major change in the structure of the northern forests. This situation can be clearly observed in the examinations made with satellite images. In addition, the Istanbul Canal Project, which is in the planning stage, will both change the use of urban areas and apply extreme pressure on aquatic and terrestrial ecosystem elements. These projects, which continue on the northern shores of Istanbul, have enabled the expansion of residential areas. Many sites within the project area have been included in the zoning plan, and new mass housing areas and hotels have been opened. After the completion of the canal project, the current urbanization process of the northern part of the Çatalca, Arnavutköy and Sarıyer line will accelerate. This situation emerges as the biggest threat to environmental sustainability in Istanbul, especially in terms of drinking water resources, forest areas and agricultural zones.

This study aims to reveal the negative effects of the ecological problems that have arisen and will emerge as a result of the above-mentioned developments on the process of building sustainable cities and green spaces. The changes in the land use of the city of Istanbul will be analyzed by using Geographical Information Systems and Remote Sensing methods over the periods. In this way, it is aimed to reveal the place of environmental indicators that change with human activities in sustainable development, to draw a road map, and to provide some recommendations as to what needs to be done. In this process, satellite images of Istanbul for the years 1975, 1988 and 2021 were analyzed. Analyzes were performed by digitizing the images in a controlled manner based on the similarity of the cellular values of the images.

CONCEPTUAL FRAMEWORK:

Today, geographers carry out two types of activities to reveal the relationship between society and environment (Johnston & Sidaway, 2016). The first is the description of the environment and the examination of its traditional geographical structure. In this way, the environment is examined from a more general perspective and considerable attention is paid to the physical environmental problems of urban areas (Manners & Mikesell, 1974; Detwyler & Marcus, 1972; Berry & Horton, 1974; Berry BJ, 1974; Douglas, 1983; Douglas, 2013). The second type of studies is directly on environmental problems (O'Riordan, 1971a, 1971b). Such studies are carried out mostly to show the reaction of the society in the face of economic growth and environmental dangers (Kates, 1972). Changes made on the environment as a result of increasing demands for tourism and entertainment industries have been extensively studied and critically examined in this process (Patmore, 1970,1983; Owens, 1984).

The environment has been studied and examined by different disciplines, therefore it has been handled from different perspectives. As a result, definitions vary depending on the field of interest (Daramola & Ibem, 2010). According to the geographer Hagget, the environment has been defined as "the sum of all the conditions surrounding a person at any point" (Efobi, 1994). Bain, a sociologist, defined environment as external and impersonal conditions that affect the well-being of people in a region (Bain, 1973). According to the Ministry of Environment and Urbanization, the environment is "the physical, biological, social, economic and cultural environment in which living things maintain their relations and interact. In other words, the environment that emerged with the first living thing on earth is the environment or conditions in which an organism exists" (ÇŞİDB, 2020). According to these definitions, environment is a system that ensures the existence, development and continuity of living and non-living, physical and non-physical elements, and also establishes its sustainability by increasing the interaction between them (Johnson, 1992; Muoghalu, 2004).

Sustainability (Wiedenhoeft, 1981; Padisson, 2001), which is basically achieved by the balance of three sub-systems (economic, social-cultural, environmental) (Padisson, 2001), means that the potential of meeting the needs of future generations is not at risk (Daramola & Ibem, 2010, Potts, 2003). In this direction, sustainability refers to the capacity to meet and carry the basic needs of the ecological, economic and socio-cultural components of the environment. Environmental degradation worldwide poses a serious threat to the sustainability of the bearing capacity of the ecosystem/environment (Marcuse, 1998). For these reasons, environmental sustainability has become a priority in housing, infrastructure, planning, land use and urban development (Aribigbola, 2008).

Urban areas are the centers of innovations in education, entertainment, culture, service and technology. From this perspective, application of environmental and urban sustainability will make sure that these areas perform their functions in the future in the best manner. Performing functions exceeding the bearing capacity of cities to provide better living conditions is one of the factors restraining sustainability. Today ecological "footprints" of cities (Luo et al., 2018) are spread to a wider area than ever before (Peters, 2000). Changes witnessed in ecology, increasing population, and rapid

consumption of natural resources due to lack of control of overcrowded settlements are responsible for the ecological footprint of urban areas (Stoel, 1999; Hales, 2000). People have always tried to dominate the environment since the day they existed. Especially after the period of scientific developments and the industrial revolution, the balance between people and the environment began to deteriorate (Keleş, Hamamcı, & Çoban, 2012). As a result of these deteriorations, environmental problems began to emerge. The human being, who is a part of the environment, has started to pollute the soil, water and air as a result of the change experienced with urbanization and industrialization day by day. The current and potential state of the natural environment, which is the most important component of the ecological footprint, and the number of people determine the degree of the footprint. Ecological footprint, which shows the need for natural resources, is felt more in urban areas where consumption is high (Sagır, 2012).

With the increase in the population in Türkiye, the population density also increases. İn Istanbul, Türkiye's largest city, the population increases above the country average every year (Avcı, 2010), which has brought along various problems (Yulu, 2017). As of 2021, 18.7% of the country's population lives in Istanbul, which is the most vibrant city in Türkiye in terms of population dynamics (Yiğit & Kanat, 2017) and the population density of the city is 2900 people. Rapid population growth of urban areas causes them to grow beyond their borders. From this point of view, it is seen that the city of Istanbul does not have the capacity to handle further population growth. However, the city attracts more population with new transportation investments made and others planned to the northern part where there is no or limited settlement. In such a case, the sustainability of urban areas will become almost impossible, and there will be an increase in environmental pollution and ecological problems. This imbalance between the population and the environment will reduce the ecological bearing capacity, worsen the living conditions and cause a decrease in the livability index.

MATERIAL AND METHOD:

The study basically consists of three stages. At these stages, the construction times of the Bosphorus bridges, which constitute the turning points in the spatial development of Istanbul, were taken as a basis. First of all, the land use and spatial development of Istanbul in 1970 and before will be revealed. Secondly, the change experienced between the year the first bridge of the Bosphorus (Bosphorus Bridge/15 July Martyrs Bridge) was built and the second bridge, Fatih Sultan Mehmet Bridge, was built in 1988, will be revealed by Geographical Information Systems and Remote Sensing methods. In the third stage, the changes made between 1988 and 2016 will be taken into account. The reason why 2016 was chosen as the turning point here is that it is the opening date of the third bridge, which is one of the transportation investments made in Istanbul and is believed to affect the spatial development of the city the most. Yavuz Sultan Selim Bridge and the changes experienced in the period after it will be examined in the third section. It is very important in terms of future planning that many transportation investments made in this period have a great impact on the urban development, ecological structure, land use and sustainable management of Istanbul. In addition, the impact and risk potential of the Istanbul Canal project, which will lead to various ecological changes in Istanbul, will be discussed.

The data sources of the study are the data obtained by digitizing the satellite images. The accuracy and reliability values of the data produced by GIS and Remote Sensing methods will be taken into consideration and the changes in green and urban areas will be revealed. (Figure 1-2) In this way, the general situation will be analyzed by establishing a connection between the spatial change that emerged as a result of anthropogenic processes and the ecological footprint in Istanbul.
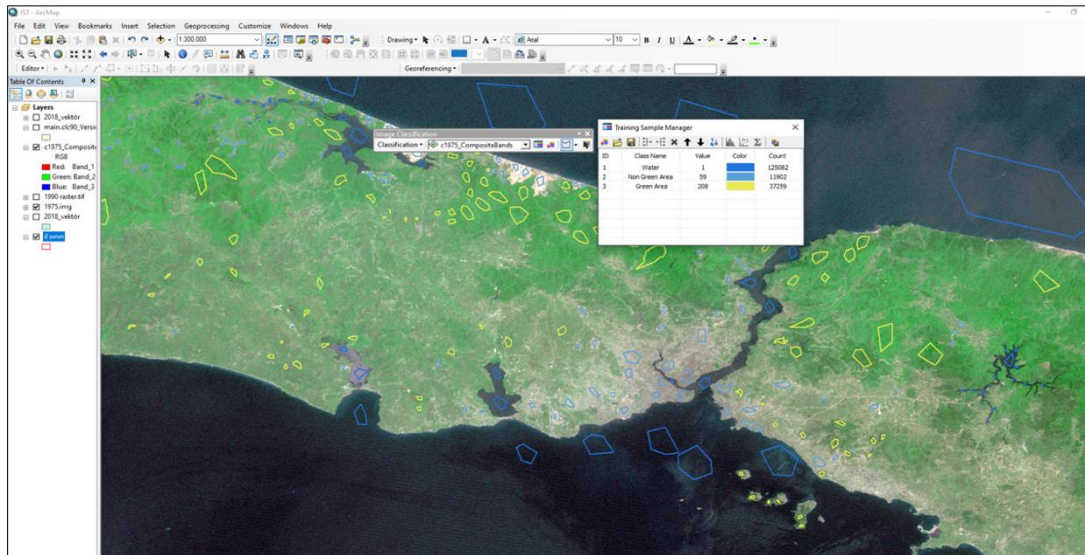
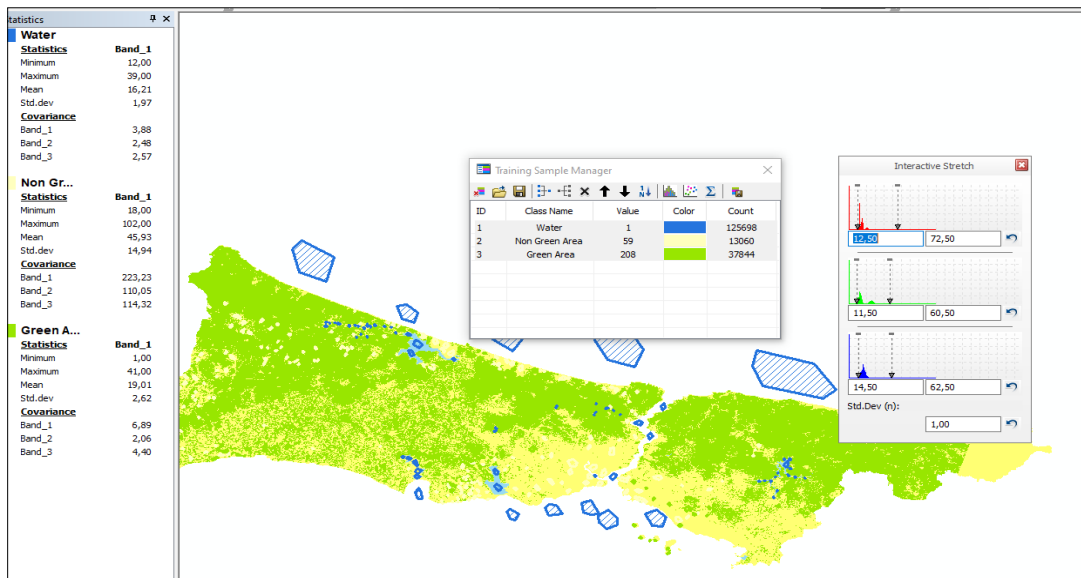Figure 1: Data generation phase from the sample satellite image

Figure 2: Raster data set generated from the sample satellite image in Figure 1

RESULT:

Main Sources and Effects of Environmental Problems in Istanbul

In Istanbul, the entire population (99% in 2010, 100% in 2020) lives in urban areas. The continuous increase in the urban population (28.1% of the country's population) has led to a growth in human pressure on a daily basis. For this reason, urban and forest ecology and sustainability in the city are under serious threats. The slums and unplanned urbanization caused by this process are at the forefront of these problems which also form the basis of other problems.

Rapid urbanization in places with intense immigration brings along many problems (Bookchin, 1999; Sağır, 2012). The rapid urbanization experienced in our country after 1950 (Yıldırım, 2004) occurred as a result of migration from rural areas to cities and natural population growth. Rapid urbanization, which has many different dimensions, has revealed several different intangible and tangible problems such as environmental pollution, lack of housing and infrastructure, problems in land management and

control, economic and social problems, and the bearing capacity of the city (Deniz, 2009). In this way, the environment in Istanbul entered a period of rapid deterioration. Social areas, which are insufficient in the face of rapid population growth, limit the sustainability of the environment and turn cities into artificial habitats where crime rates are high, environmental degradation occurs rapidly, and people suffer from loneliness.

Population growth leads to the uncontrolled expansion of urban areas, which means that more areas are opened for settlement. Increasing urban areas with the decrease of green areas reduce biodiversity and increase environmental pollution. In this way, mistakes in land use cause ecological pollution (water, soil, air). Increasing industrial and human activities which are widespread in cities worsen the extent of pollution in the aquatic and terrestrial ecosystems.

As mentioned above, the basis of urban environmental pollution in Istanbul is the fact that the region has a population above bearing potential and an intense industry. In this process, the relationship with nature cannot be established in sufficient harmony to meet the needs. In particular, policy makers and administrators fail to realize projects based on community needs and see the future negative effects of changes in urban and forest ecology. While the continuous increase in the urban population forces new lands to be settled, social needs arise concurrently. The most important of these are wastewater treatment plants (WTP), garbage collection and disposal services, and drinking water transmission. Waste water treatment, which has been in the form of well storage and discharge to streams and sea for many years in Istanbul, is performed in the form of dispatch to the sea through deep discharge by pre-treatment at WTP facilities that have been increased in number. Population growth not only increases the demand for infrastructure, but also causes changes in the natural environment (environmental problems such as flood, erosion, pollution) and negatively affects the ecological balance. At the beginning of the solutions produced for this situation, the floor heights were redecided by making amendments in the zoning plans of the houses, and then it was desired to transform the northern parts of the city into attraction centers that would draw more the population. In this direction, projects such as the New Istanbul Airport, the third bridge and the Northern Marmara Highway (NMH) have been implemented. In addition to these, the opening of the "The Istanbul Canal" as a new waterway that will connect the Marmara Sea and the Black Sea has been planned and the works have been launched. In support of all these studies, it has been stated that cities with a population of more than 500,000 will be established around these project areas, and some plans have been made.

From the past to the present, the expansion of the urban area in Istanbul has revealed new transportation lines and new bridges have been built according to the needs. In all these processes, green and semi-green areas and agricultural zones of the city have decreased continuously. In the northern forests of Istanbul, especially in 2010 and later, a process has been witnessed in which biological diversity and ecosystem were negatively affected as a result of transportation investments and settlement. Large forest areas in the region have been partially swept to open new roads and settlements. This situation becomes the steps of the urban and economic footprint that will complicate a sustainable environmental management for Istanbul.

First Period *(Spatial Change in Istanbul before 1970)*

The immigration wave that started in the 1950s accelerated the urbanization and industrialization process of Istanbul (Garipağaoğlu, 2001). While highway and industrial establishments had an active place in the development of the city in the mentioned years, uncontrolled housing (slums and shared land construction) started to be built around these areas afterwards. Those who came to the city in the 1950s formed slums around the Golden Horn, Kağıthane and Zeytinburnu (Terzi & Bölen, 2010).

While there were 8500 slums throughout Istanbul in 1951, this number reached 26,000 in 1957 only in Zeytinburnu. These settlements, which were established in the form of slums, later turned into districts. The construction of industrial facilities concentrated on the shores of the Golden Horn slowed down with the Istanbul Industrial Plan (1955), and new facilities began to shift to Rami, Topkapı and Levent. This situation increased construction activities in Kağıthane, which was already densely populated. On the Anatolian side, squatting in the industrial environment accelerated in the areas on the outer periphery of the city (Maltepe, Kartal) (İBB, 2009; Kubat & Hazar, 2018). Until 1970, these industrial areas were filled with settlements. The region between the area up to Gaziosmanpaşa, Kağıthane, Alibeyköy, Bahçelievler, Esenler, Bağcılar, Güngören, Maltepe, Kartal and Pendik and the coast was concentrated in terms of population. On the shores of the Bosporus, a retrograde expansion process was entered. As of this year, the natural structure of the city entered the process of deterioration (Kılıçaslan, 1981; Terzi & Bölen, 2010; Döker, 2012; Şenol, 2012, 2015; Kanbak, 2013)

Before the bridges brought the two sides of Istanbul together, the settlements were concentrated in areas close to the sea. The population concentrated in the coastal area between Üsküdar and Tuzla on the Anatolian side was sparser in the interior. In the area between Üsküdar and Beykoz, the settlements gathered along the coastal road were located on the slopes facing the sea. The settlement, which was concentrated in the historical peninsula, Karaköy and its surroundings on the European side, was concentrated between the coast between Bakırköy and Avcılar and today's D-100 state highway. The shores of the Golden Horn, which include historical settlements, constitute another important area, which is one of the places where the densest settlement is seen. Between Karaköy and Sarıyer, mostly along the road, village settlements developed. The urban population, which has been in a continuous increase since the 1950s, has naturally affected settlement, land use and transportation. Until this year, the predominance of railway and seaway in the transportation plans of the state ensured that the settlements were close to the coasts. Therefore, especially until the years 1950-1960, the coastal areas became more concentrated in terms of population, and the highway used for urban transportation developed in this direction. Changes in transportation policies after 1950 led to the expansion of the highway network throughout the country, especially in Istanbul. In this way, the emphasis was placed on highways in urban transportation until the year the first bridge was built. This situation continued until the construction of the bridge in 1973.

The population size of the Anatolian and European sides was quite different from today. While the majority (898.901) of Istanbul's population, which was 1,166.477 in 1950, resided on the European side, the rest (267.576) lived on the Anatolian side. In 1980, 3,264,363 of the 4,741,860 population of Istanbul lived on the European side, while 1,477,497 lived in Anatolia. As a matter of fact, with the building of the first bridge in 30 years, the population imbalance between the continents has partially decreased. While 77% of the city's population lived in Europe in 1950, this rate decreased to 68% in 1980. On the Anatolian side, the ratio, which was 23% in 1950, reached 31% in 1980. While the migration that took place in the period was more effective in the increase in the population of the Anatolian Side, the bridge was mainly effective in the decrease in the population of the European side. Before the first bridge was built on the Bosporus, transportation between the two sides was provided by ships carrying passengers, cargo and vehicles on the seaway. In this period, the population of the city was quite low compared to today, and it did not cause environmental problems in terms of settlement. Therefore, it did not directly affect the settlement plans.

Second Period *(Spatial Change between 1970 and 1988)*

Shortly after the first Bosphorus Bridge, which was included in the plan in the 1970s, was completed and put into service in 1973, it is seen that there were changes in the direction of the city's development. The population, which is concentrated in certain places in Anatolia and Europe, has

started to develop in the east-west and north axis since the 1980s with the construction of the Bosphorus Bridge (15 July Martyrs Bridge) and connection roads (Terzi & Bölen, 2010) (Doğan & Doğan, 2020). This growth process, which started after the first Bosphorus bridge, spread to a wider area with the second bridge. In this way, the growth of the city accelerated and started to reach the saturation point and the spatial use entered a rapid change process (Taşdemir & Batuk, 2010). The end of the second period and the 1990s appear as the most intense turn in the urbanization of Istanbul. In these years, the industry started to move out of the city slowly and new plans were made for the Istanbul metropolitan area. The construction of the second bridge and the partial concentration of industrial facilities in one area directed the distribution of the population. With the bridge stretching between Üsküdar (Beylerbeyi) and Mecidiyeköy (Ortaköy), settlements began to intensify on the Beylerbeyi, Kuleli and Kandilli line on the Anatolian side, and Ortaköy, Gayrettepe, Esentepe, Etiler, Mecidiyeköy, Ulus, Fulya, Levent, Okmeydanı, Halıcıoğlu line on the European side, and the population began to intensify in a short time on this line. This process led the city to experience radical change. Bridges and ring roads, which form the backbone of the city's transportation network, have affected transit transportation within the city. In the continuation of this period, there was a rapid increase in the number of vehicles crossing the Bosphorus in the city of Istanbul. At the same time, this transportation network, which increased the rate of individual automobile ownership, began to threaten forest areas by moving the settlement borders further away. (Map 1).
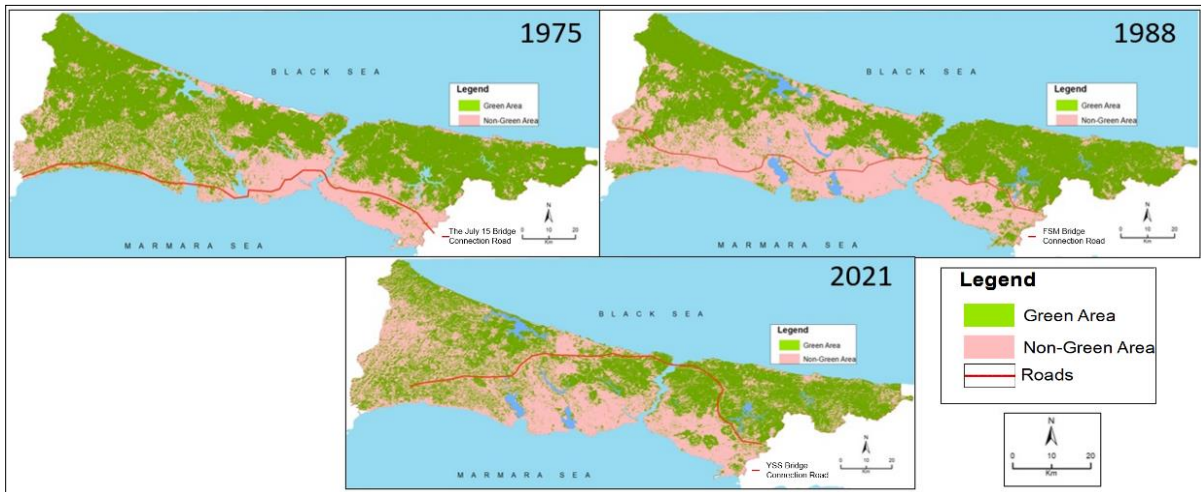
Map 1: Change of Green Space in Istanbul by Years

As a result of increasing migration (Şahin, 2015) and the ease of passage between continents, illegal construction developed very rapidly in Esenler, Güngören, Şişli, Kağıthane, Maltepe, Kartal and Pendik during the 1970-1980 period, and between Ümraniye and Sultanbeyli as well as between Arnavutköy, Habipler and Sultançiftliği in the 1990s. This spread, which threatens forests and water basins, is even more severe today (Kılıçaslan, 1981; Terzi & Bölen, 2010). While 75.5% of the urban population resided on the Anatolian side in 1970, the rate of those living in Anatolia was around 24.5 percent. Until 1990, the opening of the second bridge alongside the first bridge increased the ratio of the people living in Anatolia to 34%, while it decreased the ratio of the people living in Europe to 66 percent. Despite the continuous increase in the population of the city, there has been a decrease in the share of the European side population in the total population. As a result of this mobility initiated by the bridge and connection roads, large areas were opened to settlement until the year the second bridge was built. (Map 1).

Third Period *(Spatial Change between 1988 and 2022)*

The construction of Istanbul's second Bosphorus Bridge (Fatih Sultan Mehmet-FSM) between Kavacık and Rumelihisarı in 1988 (Garipağaoğlu,1997) redefined the speed and direction of the population and the development of the city. The TEM highway and connection axes built together with the FSM bridge accelerated the process of transforming the drinking water basins, agricultural and forest areas and rural areas in the north of the city into residential areas in a short time. The northern region, which came under the pressure of rapid construction, also revealed irregular and unplanned urbanization as a result of intense migration. Bridge and TEM road triggered density in new residential areas such as Ümraniye, Çekmeköy, Sultanbeyli, Kavacık, Beykoz, Sarıyer, Zekeriyaköy, Maslak, Anadolu Hisarı, Kağıthane, Gaziosmanpaşa, Bağcılar, and Esenler in a short time. In this period, it is noteworthy that the settlement activity in the area between the first bridge and the FSM bridge developed faster than normal. It is seen that the population of these districts increased very rapidly between 1970 and 1990. The population of Beykoz increased from 76,385 to 134,787, Gaziosmanpaşa's population increased from 125,667 to 291,715, Sarıyer's population increased from 67,902 to 147,503, and Kartal's from 168,822 to 386,864. In addition, in most of the settlements of the districts (Çekmeköy, Arnavutköy), the population doubled. The immigration movement, which intensified throughout the city in the 1980s, increased the population of the city by almost half within ten years. The population, which was 4 million 741 thousand in 1980, reached 7 million 309 thousand in 1990 and exceeded 11 million 76 thousand in 2000. The fact that the city reached a population of more than 6.3 million (2.5 times) in such a short time led to the transportation networks falling short and the rapid urbanization process of the northern line of the FSM bridge. In this period, in which squatting and unplanned urbanization were most prevalent in Istanbul, major problems arose in urban transportation. Connection lines built after these years began to take shape according to settlements. In the above-mentioned situation, it turns out that the connection lines in transportation in Türkiye are determined by the settlements, not the administration. In fact, what should be done is to plan a region, complete all the infrastructure and superstructure, including transportation, and then open it to urbanization. However, unfortunately, a region in our country is first opened for settlement, and then other plans are carried on with great difficulties. (Map 1).

After the FSM bridge, the population and settlement in Istanbul started to shift towards the north of the city in the east-west direction. The industrial zones located in these areas where the population has expanded have been moved and left their place to the commercial and service sectors and residences (TMMOB, 2010). The most important period in which the industry went out of the city in Istanbul was the late 1990s and the 2000s. While the industry in the center of the city moved out of the city, the vacant areas were built into housing and service sector structures. As a result, the process of fringing towards the city periphery was entered in Istanbul (Kanbak, 2013, Yaman Kocadağlı, 2020). In Istanbul, which has grown around the historical city since the past, the imbalance between land use and transportation investments and faulty policies lead to the continuation of the increasing expansion towards the north today. Especially in this process in which these two bridges and ring roads played a role, the water basins in the north, forests, agricultural zones and important plant sites as well as biodiversity suffered the most in the city. By making irreparable interventions on this ecosystem, the natural environment is exposed to huge destruction. It is necessary to carry out joint studies and minimize the damage for a more balanced and sustainable development that will compensate for such erroneous urban development policies and practices of Istanbul to a certain extent (TMMOB, 2010; Karahan, 2019; Kubat & Hazar, 2018; Terzi & Bölen, 2010).

While urban development in Istanbul was concentrated around the coast and the railway line before the bridges were built, it shifted between the first bridge and then the coast and the D-100. After the FSM bridge was built, it further shifted between the D-100 and TEM (Yiğit & Kanat, 2017). By 2000,

human population mainly tended to move away from the center of the city to the outer parts (Karahan, 2019). Although each period has a unique density, the FSM bridge has created the most impact in the urban area in Istanbul. The above-mentioned population data clearly demonstrates this situation. It is seen that the urban development in Istanbul has changed direction since 2000. The construction of the second bridge over the Bosphorus and the rapid migration to the city caused the residential areas to shift towards the northern part of the TEM highway.

While the FSM bridge was preparing an environment for a rapid change in the settlement, the construction of the third Bosphorus bridge (Yavuz Sultan Selim) in 2016 and the statement that two new urban areas would be built caused the settlement activities to enter the process of changing direction for the second time. The settlement, which concentrated in the south of Kartal, Pendik, Sultanbeyli and Beykoz lines on the Anatolian side and Sarıyer, Arnavutköy, Başakşehir and Silivri lines on the European side until 2016 (between TEM-D100), started to shift towards the north of this line. It is observed that the housing construction activities within these districts have increased rapidly and concentrated especially on the Çekmeköy, Sancaktepe, Poyrazköy, Garipçe, Kayabaşı, Tayakalın, Dursunköy, Arnavutköy, Göktürk and Zekeriyaköy lines. New investments to the north of Istanbul, as well as the YSS Bridge and the new railway line that will carry freight and passengers between KMO and Izmit-Edirne, will follow this route and contribute to the rapid development of the region. The connection of the city's airports (Istanbul, Atatürk and Sabiha Gökçen Airports) with Marmaray and other rail systems will increase the vitality of the region and expand the boundaries of the urban area. (Map 1).

CONCLUSION:

Istanbul's vital ecological regions such as forests, water basins and agricultural areas are located in the north of the city. This region has come under intense pressure mainly in the last decade. The rapid change in land use and settlement areas constitutes the most important pressure factor on the natural ecosystem. In the 1/100,000 scale Environmental Plan for a planned design of the city in Istanbul, these issues are highly emphasized; however, there are differences in the implementation phase. The northern forest area, which is of vital importance for the city, should be treated sensitively for the sustainability of the environment, and the northward movement of the city should be controlled. However, it is understood from the spread of today's cities that this controlled management method is not applied. It is known that in the districts on the NMH route (Büyükçekmece-Esenyurt-Başakşehir-Arnavutköy-Eyüp-Sarıyer-Beykoz-Çekmeköy-Sancaktepe-Sultanbeyli-Kartal-Pendik-Tuzla), which have a significant population in the region, the population is increasing rapidly, and housing development permits are given especially to the lands on the route of Istanbul Canal and NMH. As a result, more and more forest areas are swept in different ways such as building roads, airports, subways, housing, and hotels. It is seen that the northern forests are facing a serious threat in the process after the YSS bridge and NMH were built. This is quite clear in the light of the data obtained from the satellite images of the study area. It is seen that the green areas of the city have been downsized since 1970. Especially after 2010, this contraction is more evident in the northern forests (Map 2). This indicates that the current situation will worsen in the next ten years. The density of the human footprint in the ecological regions of the forests of Istanbul will continue to increase on a daily basis.
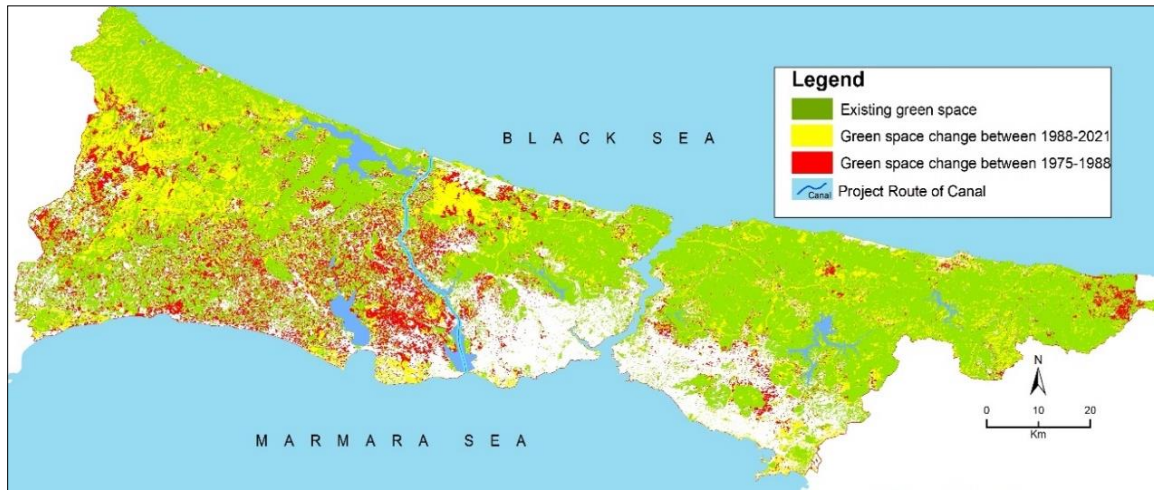
Map 2: Change of Green Space in Istanbul by Years

The 3rd bridge and connection roads increase highway mobility in the northern part of the city, accelerating access within the region, thus increasing construction and affecting the natural ecosystem. In today's world, where population and land use change very rapidly, a burden that the natural environment cannot bear is emerging. This burden, which tends to increase with the population, firstly threatens water basins, agricultural areas and forest areas. It is likely that important changes will be seen in these areas, especially in Arnavutköy, Eyüp, Sarıyer, Beykoz, Sancaktepe and Sultanbeyli in the coming years. The pressure on the Terkos, Büyükçekmece, Alibeyköy, Sazlıbosna, Elmalı, Ömerli, Darlık and Bentler regions, which provide the water sources of Istanbul, will increase further. Despite the creation of protection zones around the dams, the pollution of the sources may cause the water collection basins to turn into risky areas.

Cities are proud of their green spaces as these areas produce clean air by filtering the pollutants of the cities. It balances the heating and cooling of the city in different seasons, and provides protection against the wind. Therefore, forest areas directly affect the quality of human life. The forest area in the north of Istanbul (Istranca Mountains (Çilingoz), Belgrade, Beykoz, Polanezköy and Aydos Forests) and nature parks constitute the most important ecological regions of the city. This is the only forest region used by the city with a population which exceeds 15 million.
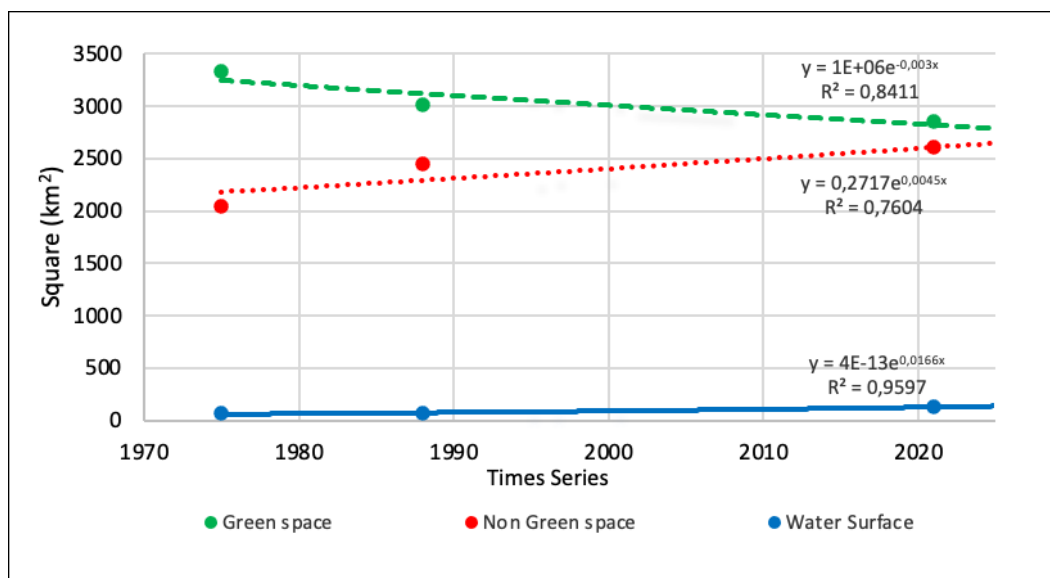

Figure 3: Change in Natural Environmental Conditions

According to the information obtained throughout Istanbul, the expansion of urban areas and the shrinking of forests are increasing every single day. The share of the city's forest areas in the total land use was around 61% in 1975. This rate decreased to 54.5% in 1988 and to 51% in 2021. While non-forest usage areas were around 38% in 1975, it reached 44% in 1988 and 46% in 2021. In the regression analysis performed in the time series from 1975 to 2021, the coefficient of determination (R^2) was at a level that confirmed each other. In the estimation process based on real data points, R^2 is in the range of 0.760-0.959. The time series models estimated in exponential form are shown in linear form, and the detection coefficients determined the regression points well. These values, which show a high level of positive correlation, show that R^2 is strong. When the same process is applied to the future, it is seen that the forest and non-forest areas of the city will be at the same level in the next ten years (2030-2035) (Figure 3). Therefore, this result shows that anthropogenic effects on the ecological footprint of the city will increase continuously. The urban expansion brought about by the bridges and connection roads brings the settlement areas closer to the Black Sea. In this process, essential green spaces of the city are being destroyed by misuse. Therefore, the sustainability of the city's green spaces and water basins is now at risk.

Compliance with Ethical Standard

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