

## **Nevşehir City Center Spatial Analysis of Noise Pollution by Using Geographical Information System**

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### **Abstract**

Nevşehir province in Turkey, which constitutes the study area, is a city located at the center of the Cappadocia region and has a history of about five thousand years. In this study, the precautions that might be taken in order to determine the level of noise pollution caused by traffic in main arterial roads of Nevşehir city center and to minimize negative effects of this experienced noise pollution on people were indicated. In total, the coordinates of 60 measurement stations were determined with the Magellan Explorist 710 Map handheld GPS receiver. Noise measurements were made with Svantek 971 brand Type 1 noise level meter. Noise pollution of the city center of Nevşehir was evaluated as positional through Geographical Information System (GIS) and maps showing noise pollution were prepared at morning, noon and evening hours. Since the results obtained from the measurements made in the main arteries are detrimental to human health, the precautions to be taken are briefly mentioned. The immediate implementation of identified measures can aid in reducing the level of noise pollution benefitting the Nevşehir city and the health of the people residing in it.

**Keywords:** Noise pollution, Cappadocia, Nevşehir, Traffic, Noise map, GIS.

## **Nevşehir İl Merkezinde Gürültü Kirliliğinin Coğrafi Bilgi Sistemi ile Mekânsal Analizi**

### **Öz**

Çalışma alanını oluşturan Nevşehir ili, yaklaşık beş bin senelik bir târihî geçmişi olan ve Türkiye’de Kapadokya bölgesinin merkezinde bulunan bir kentdir. Bu çalışma ile Nevşehir il merkezinde trafik kaynaklı gürültü kirliliği seviyesinin tespit edilmesi ve yaşanan gürültü kirliliğinin insan sağlığına olumsuz etkilerinin en az seviyeye indirilmesi için alınabilecek önlemler belirlenmiştir. Toplamda 60 adet ölçüm istasyonunun koordinatları Magellan Explorist 710 Map el tipi GPS alıcısı ile tespit edilmiştir. Gürültü ölçümleri ise Svantek 971 marka Tip 1 gürültü seviyesi ölçüm cihazı ile yapılmıştır. Nevşehir kent merkezinin gürültü kirliliği Coğrafi Bilgi Sistemi (CBS) aracılığıyla konumsal olarak değerlendirilerek sabah, öğlen ve akşam saatlerinde gürültü kirliliğini gösterir haritaları hazırlanmıştır. Ana arterlerde yapılan ölçümlerden elde edilen sonuçlar insan sağlığı açısından zararlı olduğundan, alınacak tedbirler kısaca belirtilmiştir. Tespit edilen önlemlerin bir an önce uygulamaya geçirilmesi; gürültü kirliliği seviyesini azaltarak, Nevşehir kent merkezinde yaşayan insanların sağlığının korunmasında son derece yarar sağlayacaktır.

**Anahtar Kelimeler:** Gürültü kirliliği, Kapadokya, Nevşehir, Trafik, Gürültü haritası, CBS.

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## 1. Introduction

Noise pollution is one of today's major environmental problems as it is a disturbing, undesirable, disgruntled subjective structure that increases in parallel to social and industrial development of society, which affects people's hearing health and perception negatively, negatively impacts physiological and psychological balances, reduces work performance, disrupts the calm of the environment (Korkmaz and Bursalı, 2003). Transport noise is an increasingly prominent feature of the urban environment, making the noise pollution an important environmental public health issue (Clark et al., 2006; Baubonyte and Grazuleviciene, 2007). Exposure to traffic noise towards the end of the sleeping period has a critical effect on sleep disturbance (Münzel et al., 2020). Non-hearing effects such as activity, sleep and communication disorders can trigger a range of emotional reactions, including nuisance and subsequent stress, increased blood pressure and dyslipidemia, increased blood viscosity and blood sugar, and activation of the blood coagulation factor (Münzel et al., 2018; Injaian et al., 2018). Epidemiological studies have shown that traffic noise increases the frequency of arterial diseases, hypertension and strokes as well as vascular dysfunctions (Ullmann et al., 2017). The matter of noise became acute issue in 1950s in Turkey. Transforming researches have been done to reduce the noise from the noise (Dursun and Ozdemir, 1999). Noise pollution in all countries has become a public health problem, therefore the there has been a relatively high increase in the number of studies related to noise pollution in Turkey in the recent years (Kalıpcı et al., 2007; Kalıpcı and Dursun, 2009; Ozdemir et al., 2011; Kalıpcı and Arslan, 2007; Ilgün et al., 2010; Oden and Bilgin, 2019; Sari et al., 2014).

Noise pollution health risks do not emerge rapidly, but one should not fail to notice that during the recent century, many large cities have been facing this problem and its consequences. Therefore, during the recent years there has been an increasing interest in the application of the Geographic Information System (GIS) in noise pollution studies. Noise mapping has been developed in Europe and has been extensively applied and developed since the Environmental Noise Directive (Monazzam et al., 2015; Caı et al., 2015).

Noise maps can be used to assess and monitor the effects of noise. Noise pollution maps have not been prepared so far in the province of Nevşehir, which is the cultural and tourism center chosen as the study area. With this study, measurement of the roads on existing highways and main arteries in the city center of Nevşehir province were determined and measured by highway traffic noise level noise measurement device. As a result of the measurements, mapping of noise levels with the help of GIS and spatial analysis of morning, afternoon and evening noise levels were made. In this study, the noise measurement results were evaluated according to 'Environmental Noise Assessment and

Management Regulation' of Republic of Turkey Ministry of Environment and Urbanization. Furthermore, the precautions that should be taken to minimize noise pollution were also discussed.

## 2. Materials and Methods

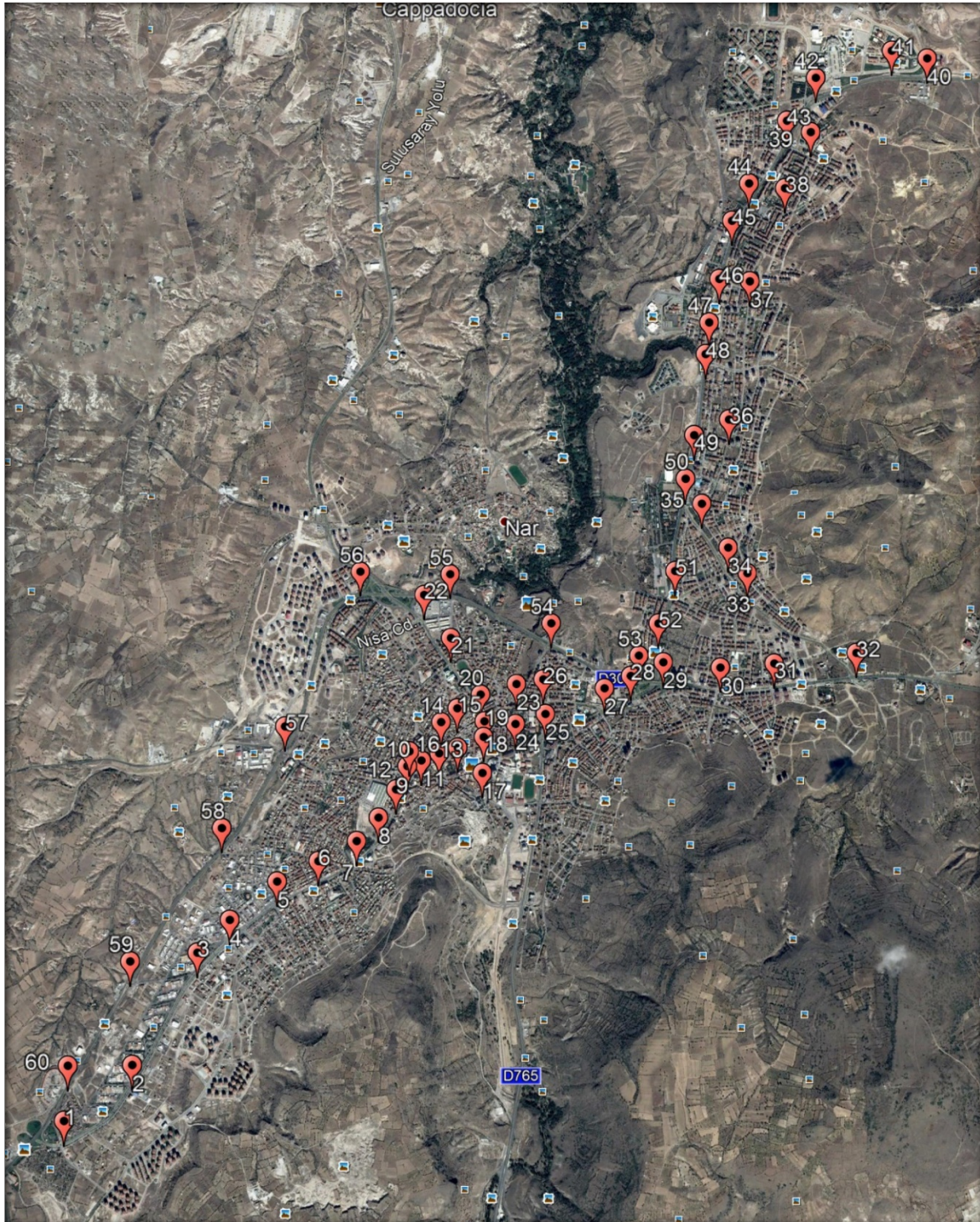
Nevsehir province (Turkey), is located between  $38^{\circ} 12'$  and  $39^{\circ} 20'$  northern latitudes in Central Anatolia and between  $34^{\circ} 11'$  and  $35^{\circ} 06'$  east longitudes, is determined as the study area (Figure 1). In order to determine the noise levels originating from traffic, 60 different measurement stations were determined on the main roads, intersections and connection roads where workplaces and traffic are concentrated in the city center of Nevsehir. The measurement stations are shown in Figure 2.



**Figure 1.** The location of the province of Nevsehir city.

The coordinates of the measurement stations for noise measurement were determined with the Magellan Explorist 710 Map handheld GPS receiver. The  $Leq$  value (dBA), which expresses the equivalent noise level, was measured as the noise level in the study. For the noise level measurement, a Svantek 971 brand Type 1 noise level meter, calibrated with Svantek SV 33 calibrator, was used. Noise measurements were made at 60 measurement stations in total in the autumn of 2016 (October-November), winter (January-February), spring (March-April-May) and summer (June-July). Each measurement point was measured 6 times (for each in the morning, noon and evening hours) during 10 minutes and their averages were taken. Measurements were made at a distance of 1.5 meters above the ground level of the pavement at the edge of the road or junction where the noise level will be

measured. Koushki et al. (1999), Baaj et al. (2001) measured from a height of 1.5 meters, while Onuu (2000) and Leong Shinge and Laortanakul (2003) measured from a height of 1.2 meters in the city center. The measurements were taken between 07.00-09.00 hours in the morning, between 12.00-14.00 hours in the noon and between 19.00-21.00 hours in the evening. Because, Nevsehir city center traffic is heavy on weekdays and weekends on busy streets and boulevards where the noise of motor vehicles.



**Figure 2.** The noise measurement stations.

In recent years, geographic information systems have been used extensively in studies in different disciplines to interpret data effectively (Baser, 2019; Dereli et al., 2015; Baser et al., 2016; Dereli and Polat, 2018; Kalıpcı and Baser, 2019). GIS enables creation of individual maps instead of constant, two-dimensional and traditional maps and they can be combined as graphics, databases and multi-media (Rüstemov, 2014). For this reason, GIS methods are being used predominantly in noise assessment studies. In the course of our study, station coordinates from hand GPS were processed on the map plane with the help of Google Earth Pro program and spatial analyzes of noise measurement values were made with Spatial Analyst module in ArcMAP included in ArcGIS 10.3.1 software. Spatial analyzes were performed using the IDW (Inverse Distance Weighted) interpolation method. Spatial analysis has also been tried with Spline and Kriging analysis methods, but is not preferred because standard deviations are very high.

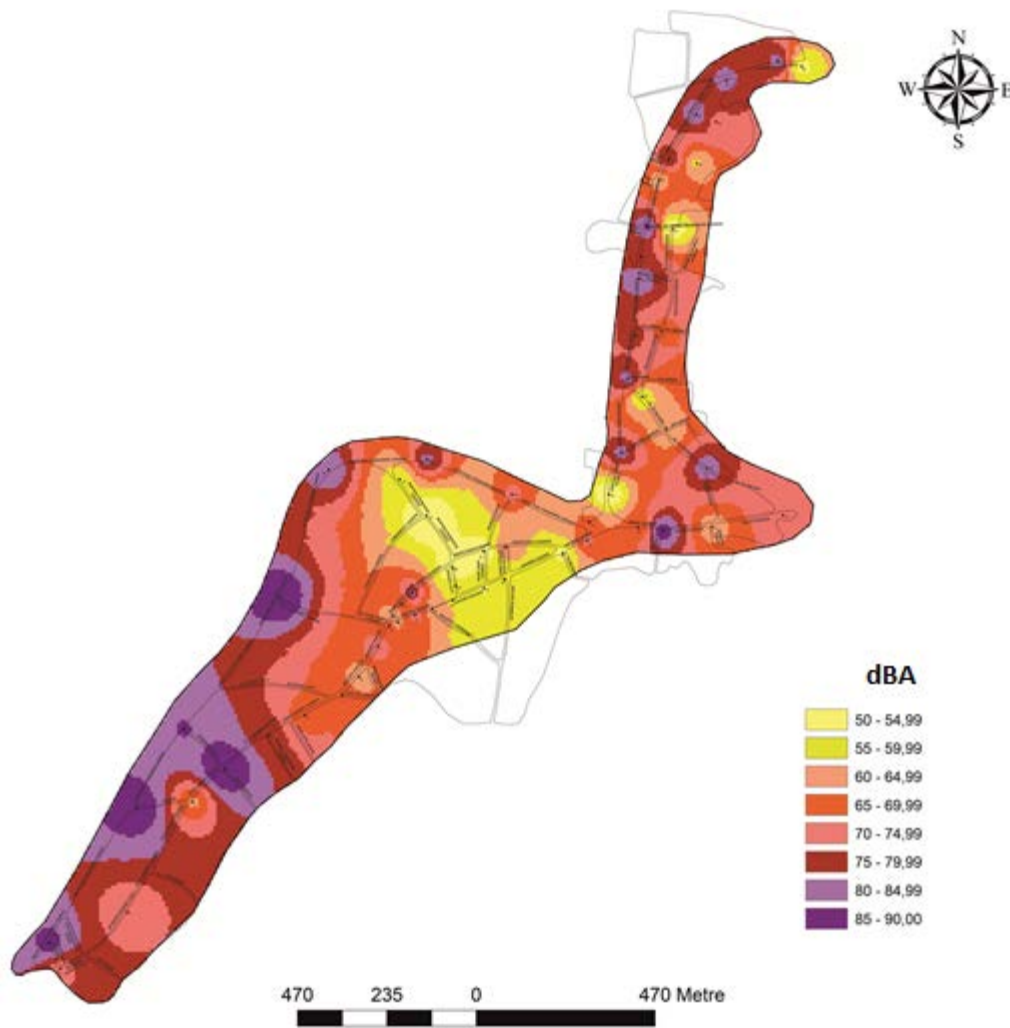
### **3. Results and Discussion**

There are various factors that contribute to increase noise levels in urban areas. One of the factors is the increase in urban population, which contributes to high traffic volume combined with increased intensity (Subramani and Sounder, 2016). Since there is no public transportation system in Nevsehir province center, it is only provided by road and transportation is provided by commercial taxis and minibuses. In the city, the increase of daytime transportation, the use of highways and various land transportation vehicles to a great extent increased the severity of the traffic noise. In the city center, the main noise source is primarily the traffic noise. In the center, especially in the main streets, the road widths are relatively low in all of the existing streets. The adjoining structures of the buildings are echoing effect for the noise caused by the traffic and they do not have any meteorological advantages.

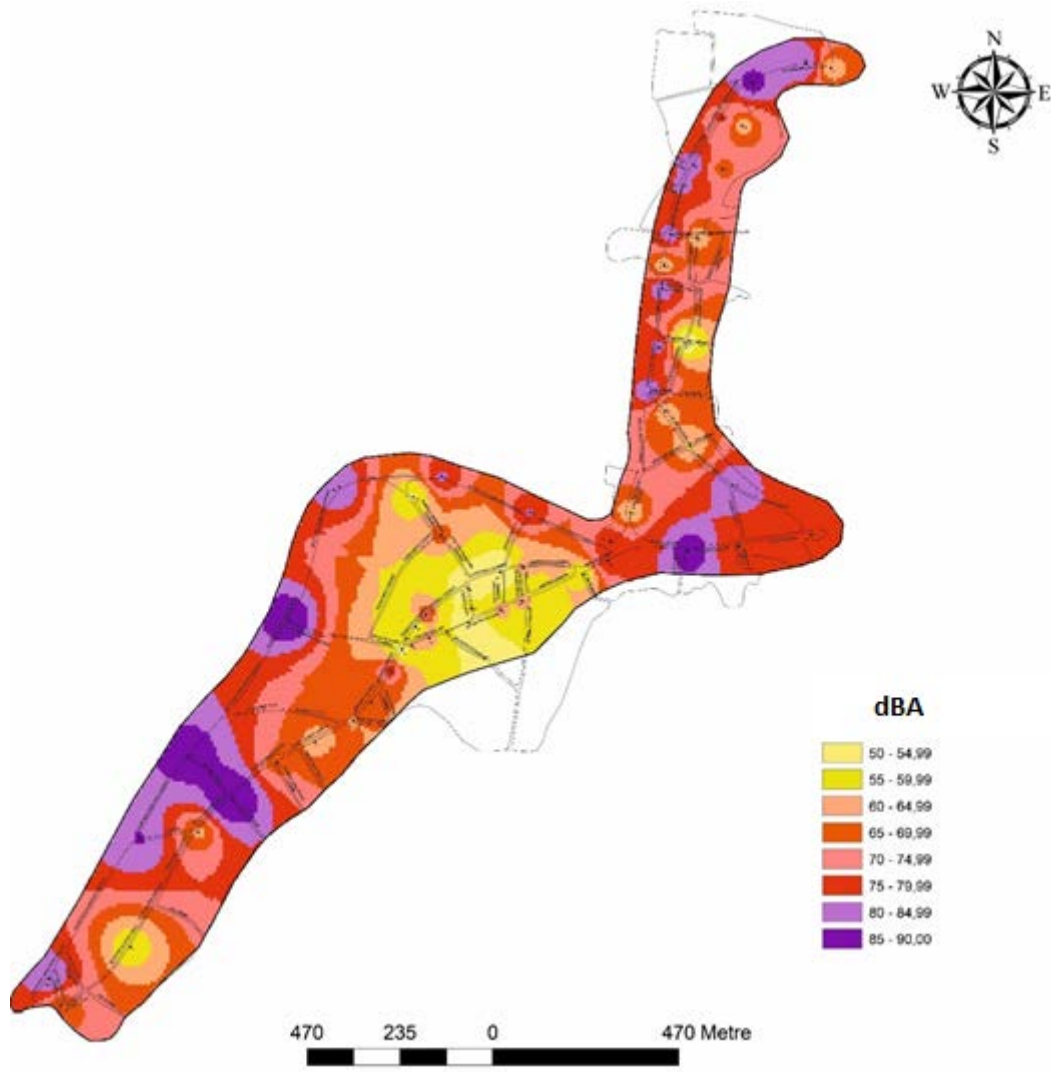
As the density of passenger and commercial vehicles in the city center is high, traffic noise due to traffic interruption and unnecessary honking has increased in recent years as vehicles are parked on the side of the road due to lack of street width. Due to the lack of sufficient parking in the city center, it can be said that the vehicles contribute to the air pollution by randomly parking on the streets and in the squares or by going unnecessarily to park and increasing both noise and fuel consumption. Since the afforestation in the center of the city is too small to be tried, the advantage of noise absorption is not available. No barrier or ventilation studies have been done to reduce the noise effect on the highway edges where the noise level is high in the whole city. In addition to some of the developing neighborhoods (2000 Evler Venue, Güzelyurt Neighborhood), the noise occurring from construction excavation was not constant in the center and the effect on the environment was less disturbing than other noise sources. The noise levels in the settlement areas vary according to the

streets, places where the businesses are concentrated. People go to picnic areas, tea gardens, gazinos, restaurants, etc. to find peace, to relax in the entertainment facilities. This is either the unconsciousness of the business owner or the fact that people who are insensitive to the environment, especially when they are listening to music, make the voice open to the end cause thenoise pollution to increase.

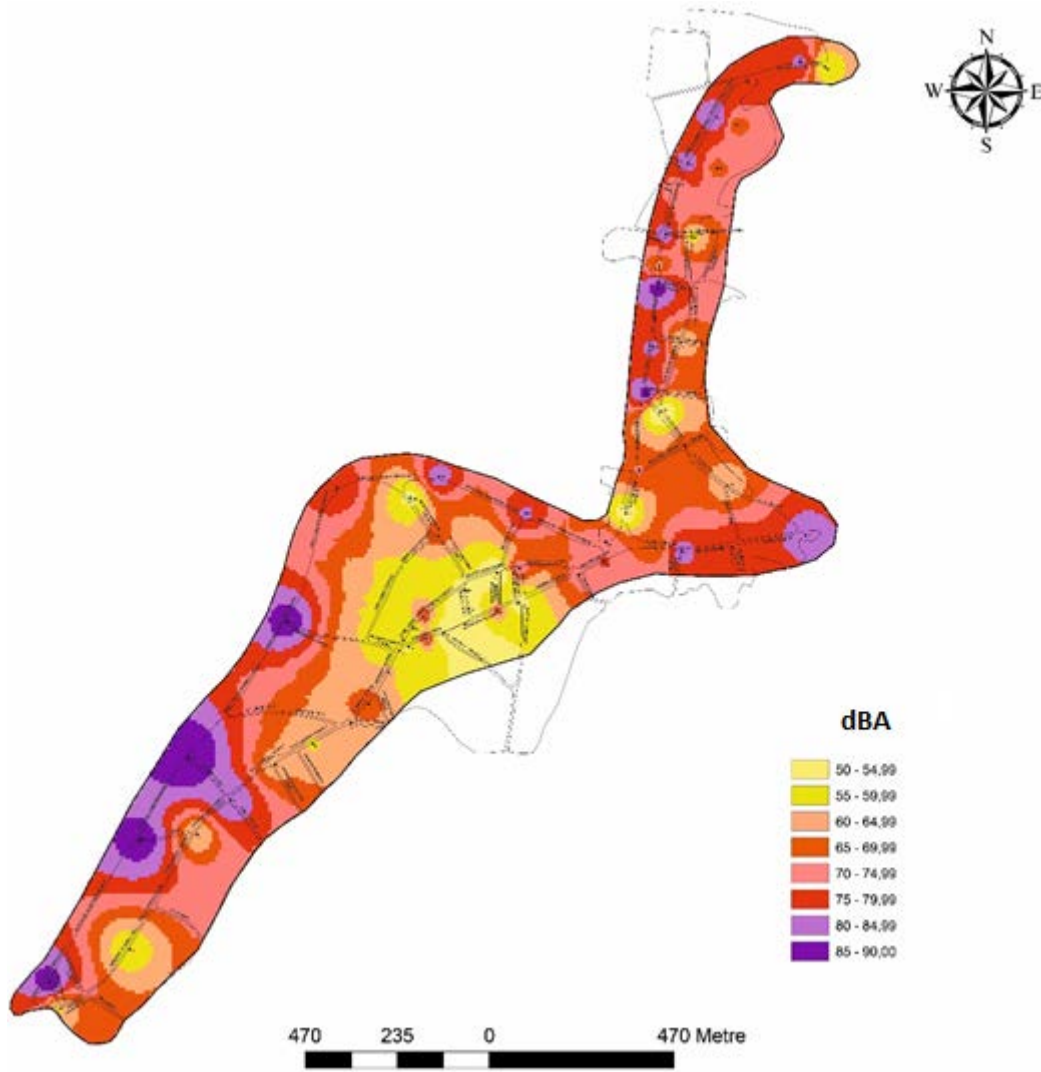
Figure 3- Figure 5 shows the noise pollution maps prepared in the GIS environment based on the average values of the in-situ measurement results regularly performed for 360 days at the morning, afternoon and evening times during one year and four seasons from 60 measurement stations.



**Figure 3.** Noise Level Spatial Distribution Map (Morning).



**Figure 4.** Noise Level Spatial Distribution Map (Noon).



**Figure 5.** Noise Level Spatial Distribution Map (Evening).

When the noise map prepared for morning noise measurements is examined; it was determined that the noise level from the southern part of the province to the north and to the west along the provincial center is 75-85 dBA. There is no application on the edge of the perimeter of the road that would prevent it from reaching noisy settlements such as noise barriers, afforestation, etc., so the sound can reach the inner parts easily. It has been observed that the average noise values change between 60-75 dBA in the measurements taken in the inner part of the city center and the noise level average values increase as the distance goes from the center to the north. The reason for this may be the fact that the hospitals in Nevşehir and the districts with high population density are located in the regions to the north of the city center. In addition, the presence of Nevşehir Hacı Bektaş Veli University, located in the north of the province center and established in 2007, also contributed significantly to the young population density of the region. It is clear that the noise levels that are created due to adverse effects created may cause physiological reactions in humans based on the



annual mean values of the measurements made between 07:00 and 09:00 in the morning. In addition, when taking into account 'Highway Environmental Noise Limit Values' in Table 1 of Annex-VII 'Environmental Noise Assessment and Management Regulation' (ENAMR) published in the Official Gazette dated 04.06.2010 and numbered 27601, it is observed that all measurements made in the daytime limit values - max 70 dBA.

When the spatial analysis map for noise level measurements at noon is examined; it is observed that the noise level in the industrial zone in the southern part of the provincial center is 75 - 85 dBA. Much of the vehicle traffic in this area increases the noise level. The noise level decreases from the south towards the center of the province. Noon values were found to be lower than morning measurements due to low traffic intensity causing noise in city center during noon hours. Another increase in noise levels was seen in the area where the university settlements were located in the north of the province. There are many dormitories and cafeterias that meet the needs of the students in the region and the young population is more. Parallel to population growth, there is a remarkable increase in the noise level of the zone. The highest density in the college campus of students is in the afternoon. According to the grading of the noise levels and the adverse effects created, it can be said that the physiological reactions are caused by the residents living here based on the annual mean values of the measurements made between 12:00 - 14:00 noon. In addition, when the road environmental boundary values stated in ENAMR are taken into consideration, it is seen that average analysis values for evening hours exceed the limit values (min 55 - max 67 dBA) in the table.

When the noise map prepared for the evening time is examined; it is seen that the noise values at the exit of the Urgup road east of the provincial center and at the exit of the ring road junction starting from the upper pass of Alacasar village to the south of the provincial center are at 75-85 dBA level. It has been observed that the increase in the noise level at the exit of Ürgüp District road is due to traffic. The fact that the traffic is concentrated in this area is the reason why one of the routes to the tourist cities passes through this area. Tourist transport and the surplus of social areas in the district centers increase traffic intensity in this region. Heavy-duty vehicles use provincial roads because of the prohibition of access to the province center. The increase in the level of noise from the Alacasar village overpass to the surrounding road bridges is due to traffic. The cafes and social areas in the northern part of the province increase the level of noise. Roadside cafes cause intense traffic. The commercial enterprises located in the inner parts of the provincial center prematurely terminate their activities. For this reason, the noise level is lower than other parts of the provincial center. According to the grading of the noise levels according to the adverse effects created, the average values of the measurements made between 19:00 - 21:00 hours in the evening cause physiological reactions in the people living in this region. In addition, when the roadside environmental boundary values in ENAMR are taken into consideration, the annual mean values of the measurements made exceed the

dBA of all evening / night values (min 55 - max 65) in the table. As a result of the noise measurement studies, it is seen by the noise maps that noise levels in the residential region does not complied with the noise level limit values of the regulation. The results of this study show parallels with research conducted in other cities in Turkey (Savaş, 2019; Köse, 2019; Kalıpcı and Dursun, 2009; Bayramoğlu et al., 2014; Özen, 2017).

In order to prevent noise pollution which is an important environmental pollution in the province of Nevsehir and to reduce its effects to a minimum level that will not affect human health, it is very useful to pass the following solutions as soon as possible. It is too difficult to find suitable land for housing in the Nevsehir province because of the area of the archeological site. For this reason, urban planning is extremely distorted and unplanned. As the streets are not wide in the adjacent residential areas, the noise echoes and the people living in the area are more affected by the noise. It is necessary to avoid planningless construction and to allow as much as possible the residences built in adjacent order. Since the plantation in the center of the city is too small to be planted, the advantage of noise absorption is not available. Also; no noise barriers and plantation studies were carried out to reduce the noise effect on the highway edges where the noise level was high, and construction planning buffer areas were not placed. In this respect, the negative effects of noise should be reduced by planting and planting trees and / or noise barriers around the settlement areas. In new buildings, more attention should be paid to isolation and the use of sound insulation materials should be ensured and encouraged during the construction phase of the buildings. Municipally buildings should be carefully checked for the use of materials to provide sound insulation.

Areas sensitive to noise, such as schools, classrooms, hospitals, hotels and recreational facilities, should be constructed in places remote from noise. Establishments that cause noise (bread factories, cafes, restaurants, car wash places, entertainment places and similar businesses) should not be allowed to be located on the lower floors of houses or near houses. Noise insulation should be provided within the existing workplaces. Because there is not enough parking in the city center, the vehicles are unnecessary to park in streets and squares and play a role of in the increasing noise pollution. In particular, a number of parking lots should be built in the city center. On the lower floors of the new buildings, the obligation to build underground garages for the vehicles should be introduced. Provincial Security Directorate in the city within the team should ensure that in the weddings, soldiers' festivals, in games, vehicles should be prevented from creating noise pollution by taking out convoys and honking, throwing explosives and guns, and should not be allowed to listen to loud music. It is not permitted to take out outdoor processions of the weddings to the street and burst fireworks. Because the roads in the city are neglected, there are too many small pits, the vehicles suddenly break and cause noise pollution. In this respect, roads need to be improved by carrying out renovation works immediately in the cities.

Land vehicles without noise suppression and silencer systems are quite common in traffic. Taxi, minibuses need to be prevented from unnecessary honking, and the vehicle must be carefully controlled during the visa inspection. In addition, during these checks, especially to get the sound of the vehicle exhausts, such as whistles, it is also necessary to ensure that the known devices and horns, such as air horns, are removed from the vehicles. Programs to raise public awareness about noise pollution on local television channels or local radio stations are also extremely important for reducing noise pollution.

It is necessary for the managers of the plant, especially the operators and workers who cause the noise, to inform the public about harmful effects on human health and to give environmental education and to mobilize civil society organizations on this issue. In particular, such an environmental education should be initiated from primary education and it should be ensured that individuals are maintained throughout the whole educational experience and become a behavioral form.

#### **4. Conclusions**

When a general assessment of the results of the study is made, it is assumed that the equivalent noise measurement levels ( $L_{eq}$ ) in the roads covering the provincial center are above the environmental noise limit values specified in the 'Environmental Noise Assessment and Management Regulation' (ENAMR), that threatens the health of people. It has been determined that the mean values of the measurement levels made on the streets, which are located relatively farther from the main arteries, are in accordance with the ENAMR. When the spatial distribution maps of the noise level are generated in the GIS environment and are examined, it is observed that the noise level increases as the number of settlements and the number of commercial areas increase as the city approaches towards the inner part. It is clear from the distribution maps that there is population increase in the area where the university is located as well there is an increase in the number of commercial enterprises. In connection there is an increase in the noise pollution level as a result of the construction activities going towards the rapidly growing university settlement north of the provincial center. However, in order to ensure a sustainable and healthy urbanization, the necessary measures must be taken in the direction of the related regulations against the negative effects of the noise by reducing the worst sources of noise, ensuring cooperation between the sectors and establishing a sufficient level of consciousness. Immediate implementation of the measures that have been presented in the discussion section and thereby reducing the level of noise pollution, Nevsehir city center will benefit in protecting the health of the people living in that area.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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