Planlama 2024;34(2):134–149 | doi: 10.14744/planlama.2024.17136

ARTICLE / ARAŞTIRMA

Inequalities in Residential Exposure to Noise in Mersin Metropolitan Area, Turkey

Mersin Metropoliten Alanında Konut Bölgelerinde Gürültüye Maruz Kalma Eşitsizlikleri, Türkiye

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ABSTRACT

The aim of this study is to show whether there is any relationship between noise exposure and the socioeconomic status of people living in Mersin metropolitan region and the direction of this relationship if it exists. For this purpose, with the noise maps produced within the scope of the project carried out within the framework of a protocol signed between Mersin Metropolitan Municipality and The Scientific and Technological Research Council of Turkey (Marmara Research Center), a group of variables (building density, land use type, socio-economic status of the people living in the region, urban macro-form development periods) was examined to reveal the relation between them. As a result of the study, it was found that 2/3 of the population (649.000 people) living in the Mersin Metropolitan Region is exposed to daytime noise of more than 50 dB. It is observed that there is an inverse relationship between socioeconomic status and exposure to daytime noise; as the building density (floor area ratio) increases, the level of exposure to daytime noise increases; the level of exposure to daytime noise has decreased in newly developed areas of the city; the level of exposure to daytime noise increases as the transition from residential use to mixed-use. In other words, it has been manifested that there is a direct relationship between daytime noise exposure and socioeconomic status. This finding is consistent with examples investigated abroad, especially in the USA and North America.

Keywords: Environmental inequalities; environmental noise; Mersin; socioeconomic status.

ÖZ

Bu çalışmanın amacı, Mersin metropoliten bölgesinde yaşayan insanların sosyoekonomik durumları ile gürültü maruziyeti arasında bir ilişki olup olmadığını ve varsa bu ilişkinin yönünü ortaya koymaktır. Bu amaçla Mersin Büyükşehir Belediyesi ve TÜBİTAK (Marmara Araştırma Merkezi) arasında imzalanan bir protokol çerçevesinde yürütülen proje kapsamında üretilen gürültü haritaları ile bir grup değişken (bina yoğunluğu, arazi kullanım türü, bölgede yaşayanların sosyo-ekonomik durumu, kentsel makroform gelişim dönemleri) incelenerek aralarındaki ilişki ortaya konulmaya çalışılmıştır. Çalışma sonucunda Mersin Büyükşehir Bölgesinde yaşayan nüfusun 2/3'ünün (649.000 kişi) gündüz 50 dB'den fazla gürültüye maruz kaldığı tespit edilmiştir. Sosyoekonomik durum ile gündüz gürültüsüne maruz kalma arasında ters bir ilişki olduğu; bina yoğunluğu (taban alanı oranı) arttıkça gündüz gürültüsüne maruz kalma düzeyinin arttığı; kentin yeni gelişen bölgelerinde gündüz gürültüsüne maruz kalma düzeyinin azaldığı; konut kullanımından karma kullanıma geçildikçe gündüz gürültüsüne maruz kalma düzeyinin arttığı gözlenmiştir. Başka bir deyişle, gündüz gürültüsüne maruz kalma ile sosyoekonomik durum arasında doğrudan bir ilişki olduğu ortaya çıkmıştır. Bu bulgu, yurt dışında, özellikle ABD ve Kuzey Amerika'da araştırılan örneklerle tutarlıdır.

Anahtar sözcükler: Çevresel eşitsizlikler; çevresel gürültü; Mersin; sosyo-ekonomik statü.

Received: 28.03.2024 Accepted: 05.07.2024
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1. Introduction

The term "environmental noise" refers to outside sounds produced by human activity that are unwanted or damaging, such as noise from vehicles, trains, planes, and factories. The main source of neighborhood noise in urban settings is traffic noise, which poses a serious environmental problem to a sizable population worldwide (Havard et al., 2011). In addition to traffic noise Brainard et al. (2004) notes that the biggest differences in population noise exposure come from differences in airport noise. According to the World Health Organization, the biggest environmental health risk is noise (WHO, 2018). Noise's detrimental impacts on health can be both physiological and psychological (Muzet, 2007). Within this framework, Passchier-Vermeer and Passchier (2000) draw attention to that noise pollution has significant harm to public health. Similarly, Dregger vd. (2019) notice that being one of the top environmental health concerns, environmental noise is a significant public health issue. In societies, however, the cost of noise exposure appears to be unevenly distributed.

The European Union released a draft framework directive on the assessment and reduction of environmental noise in 2000 (CEC, 2000) as a result of subsequent developments, including discussions with member countries (CEC, 1999). According to the Directive, all European conurbations with a population of more than 250.000 must have noise maps by the year 2005, and metropolitan areas with a population of more than 100.000 must have equivalent maps by the end of 2009. The proposed regulation also requires municipal governments in charge of these conurbations to create action plans that analyze noise maps and describe desired corrective actions. According to the European Commission Green Paper, mapping noise levels within local settings should be done to function as a planning tool and as a contribution to ongoing policy discussions.

Similar to the European Union, to avoid activity interference and annoyance, the World Health Organization (2009) and US Environmental Protection Agency (1974) suggest daytime noise levels not exceeding 55 dB(A) and day-night noise levels not exceeding 55 dB(A), respectively. Similar to this, the US Environmental Protection Agency (1974) advises individuals to avoid hearing loss by keeping their own 24-hour equivalent noise levels under 70 dB(A).

2. Theoretical Framework

2.1. Size of The Population Under the Threat of Noise Pollution

According to a European Commission Green Paper in the 1990s (CEC, 1996), around 20% (or 80 million) of the population in the European Union lives with noise levels that are thought to be harmful to human health. Another 42% of European Union citizens were thought to live in so-called "grey areas," where noise pollution, if not harmful to human welfare, is severe enough to occasionally cause significant annoyance. Additionally, the WHO (1999) estimates that 20% of the population of the European Union is exposed to noise levels above 65 dB(A) and that approximately 40% of the population is exposed to noise levels surpassing 55 dB(A) during the day. Both the general public and European policymakers are becoming increasingly concerned about noise since it has a negative impact on human health and well-being. Scientists and health professionals have determined that road traffic noise levels are unacceptable for at least 100 million individuals in the European Union (WHO, 2018). According to Hammer et al. (2014) 145.5 million Americans (45% of the total population) are exposed to noise levels that are higher than those that are considered to be healthy for the public's health.

Considering the size of the population under the threat of noise pollution, WHO (2011) stated that ambient noise is responsible for more than 1 million disability-adjusted life years lost each year in Western Europe, mostly owing to annoyance and sleep disruption. In a more recent study, WHO (2018) noted that road traffic noise alone costs western Europe at least 1.6 million good years of life per year. There were 0,6 million good years lost increase between 2011 and 2018.

2.2. The Health Effects of High Noise Levels

The effects of high noise levels can be analyzed both on adults and children separately. High noise levels have the potential to negatively impact human welfare in a number of ways, such as annoyance, disturbed sleep patterns, hearing loss, perceptions of ill health, loss of quality of life, and impaired mental health (Brainard et al., 2004). Similarly, according to Ng (2000), exposure to construction site noise is directly correlated with adult sleep disruption, attention difficulties, and relaxation problems. Basner et al. (2014) state that chronic exposure to noise has been associated with a number of negative impacts, including annoyance, disturbed sleep, decreased cognitive function, and the development of cardiovascular diseases. Additionally, it is indicated that nighttime traffic noise can cause interruption of sleep and psychological stress (Halonen et al., 2012).

Within general health outcomes of high noise levels, cardiovascular problems are strongly emphasized by some researches. Academic studies have shown that adult cardiovascular risk factors are impacted by noise from traffic and other sources. According to Babisch et al. (1999), men who lived in residences with a lot of traffic noise for a long time had a higher relative risk of ischemic heart disease. Babisch (2008) also says that long-term residential exposure to traffic noise is linked to heart health problems connected to stress.

Even while people are asleep, the human body initially responds to noise by activating the central nervous system. This may cause the release of stress hormones and an increase in cardiac output, blood pressure, and heart rate (Evans et al., 1995; Lercher, 1996). Hypertension (Van Kempen & Babisch 2012), type 2 diabetes (Sørensen et al., 2013), cardiovascular disease (Gan et al., 2012), and reduced birth weight (Gehring et al., 2014) have been also linked to exposure to high level noise levels.

In terms of health and comfort, the noise causes negative impacts to human health due to the following effects;

1. Physical effects,
2. Physiological effects,
3. Psychological effects,
4. Performance effects.

Among physical effects, hearing loss emerges in severe sound formation of 65−90 dBA and shows its effect in psychological and performance of people (Özçetin et al., 2021).

High noise levels have negative impacts on not only adults but also children. Children who attended nursery schools located in locations with excessive traffic noise (>60 dB(A)) had higher mean systolic and diastolic blood pressures and lower mean heart rates than kids in quiet neighborhoods, according to the research by Regecova and Kellerova (1995). Evans et al. (2001) observed the effects of exposure to local road and rail transport noise on baby cardiovascular health in a study of Austrian villages; children in the noisier regions had raised resting systolic blood pressure and higher levels of stress hormones in urine samples.

According to Haines et al. (2002), children who attended schools in high aviation noise locations displayed signs of decreased reading comprehension and extreme noise irritation. Additionally, research by Evans and Maxwell (1997) revealed that children aged 6 to 8 who were repeatedly exposed to airplane noise were more likely to experience linguistic problems. Moreover, exposure to ambient noise has been related to a number of mental reactions, including a reduction in children's cognitive development (Stansfeld et al., 2005). In other research, impaired cognitive performance (Clark et al., 2012) and behavioral problems in children (Hjortebjerg et al., 2016) have been linked to exposure to high level noise levels.

However, the effects of noise can change according to strength, duration, and frequency of noise just like other exposures (Casey et al., 2017). The time of day may also be important factor because connections between noise exposure and health outcomes are greater at night (Basner et al., 2014). In addition to the source of the noise and its characteristics, the individual characteristics, noise sensitivity or the degree of responsiveness to the same amount of noise might vary individually (Janssen et al., 2011; Van Kamp et al., 2004).

2.3. Socioeconomic Status (SES) And Inequality at Exposure to Environmental Noise

2.3.1. Negative Correlations

Various studies have discovered various kinds of relationships—or lack thereof—between socioeconomic level and exposure to environmental noise. According to Hammer et al. (2014) noise is not distributed equally across communities, and certain populations may be more sensitive to noise than others (van Kamp & Davies 2013). Health disparities that exist in the United States and abroad may be influenced by the unequal spatial distribution of noise exposure (Casey et al., 2017). Casey et al. (2017) also state that the average level of daytime and nighttime noise was higher for people and families living in metropolitan areas with lower SES. Overall, Asians, Blacks, Hispanics, and those with lower SES were the groups with the greatest assessed noise levels.

For example, according to Ogneva-Himmelberger and Cooperman (2010) the findings indicate that the population "paying" for the cost of noise from Logan International Airport in Boston, USA, is minorities and people of lower income living in the noise-affected with lower housing prices neighborhoods. The study established that minorities are overrepresented in locations with noise pollution. It is observed that in comparison with quiet areas the proportion of Hispanics in the noise-affected neighborhoods was twice as high in 1990 and it was roughly three times greater in 2000. Additionally, it is indicated that the established spatial trends and patterns did not significantly change between 1990 and 2000.

Additionally, there may be variations among the ethnic groupings. According to Brainard et al. (2004) in Birmingham, UK, the Indian and Pakistani subgroups tend to experience exposure levels that are somewhat lower than the city average, while Blacks tend to experience exposure levels that are slightly higher. It is suggested that these differences in noise exposure are greater between ethnic groups. It is noted that black populations have higher estimated noise exposures than other ethnic groups due to their closer proximity to the city center and the related traffic noise, and the Indian and Pakistani communities are sufficiently away from the airport and high-density roadways, so they are less impacted by noise. In other words, it is stated that Blacks were more likely than other ethnic groups to be exposed to noise, especially that produced during the day. However, SES is still an important factor explaining differences in noise exposure. In the UK also, Haines et al. (2002) calculated the noise exposure at 123 schools close to Heathrow Airport and discovered that there was a correlation between noise exposure and the percentage of pupils who qualified for free lunch.

There are instances from other countries that display analogous trends in addition to the USA and the UK. Lower neighborhood SES or a higher percentage of minority racial/ethnic groups were linked to higher noise levels, according to studies conducted in Montreal, Quebec, Canada (Carrier et al., 2016; Dale et al., 2015). Lower SES individuals reported increased neighborhood noise, according to research from Germany (Kohlhuber et al., 2006) and Wales (Poortinga et al., 2008). Similar results were seen for socially disadvantage groups in Hong Kong (Lam & Chan, 2008). In sum people with low socioeconomic position are more prone than others to complain about noise disturbance (Evans & Kantrowitz, 2002).

2.3.2. Positive Correlations

However, there are also evidences of a contrary correlation i.e., more exposure for wealthy populations (Brainard et al., 2004). For example, people living in socially advantaged neighborhoods (in terms of education, home value, and nation of citizenship) were likely to be exposed to higher noise levels than their counterparts in disadvantaged neighborhoods in Paris (Havard et al., 2011). According to another research from the Netherlands in the Rijnmond area, affluent districts have the greatest levels of ambient noise exposure (Kruize & Bouwman, 2004). Cesaroni et al. (2010) observed that residents of high-traffic locations in Rome were of higher socioeconomic status.

Havard et al. (2011) emphasize that positive correlation between noise level and wealth is related with how the road network is spatially organized throughout Paris. The louder high-traffic arteries are located close to wealthier commercial and tourist neighborhoods. These are distinguished by large proportions of educated residents, high property values, high percentages of residents from affluent nations, and low percentages of residents from developing nations. On the other hand, quieter neighborhoods are typically found farther from the busy roadways and frequently have lower socioeconomic conditions. Due to their wealth, affluent populations may opt to live in city centers where access to employment opportunities, cultural activities, commercial services, and other amenities is better and where the busiest and largest road arteries are located, rather than in quieter areas that are probably less appealing and less centrally located (Havard et al., 2011).

It should be noted that studies displaying positive correlation between wealth and noise exposure were carried out in Europe, where urban structures frequently diverge from those in North America. In Western Europe, the inner city is frequently wealthier than the suburbs. It is clear that studies examining the relationship between socioeconomic status and environmental exposures need to be carefully examined in local contexts (Dale et al., 2015).

Despite the fact that wealthy populations were more exposed to road traffic noise in their residential environment, it should be noted that they are likely to experience less noise annoyance than their less fortunate counterparts because they can afford to soundproof their homes with features like double- or triple-glazed windows (Havard et al., 2011).

Furthermore, Dreger et al. (2019) state that there may be two main reasons for the differences in the relationship between noise exposure and people's socioeconomic status: firstly, there are significant methodological differences between studies, making it difficult to make generalizations; secondly, studies examine different populations, use different social indicators and use different ways of measuring noise exposure.

2.3.3. Non-linear Relations

Some studies did not find a linear relationship between socioeconomic status and exposure to noise. At the census-block level in Marseilles, France, authors found a non-linear relationship between the potential road noise exposure indicators (PNEIs) and the deprivation index. The highest levels of noise exposure were found in the intermediate categories of this index (Bocquier et al., 2012). Similarly, a study of environmental injustices related to air pollution in Strasbourg, France, discovered a nonlinear relationship between air pollution levels and deprivation, with the intermediate census blocks experiencing the highest exposure (Havard et al., 2009).

2.3.4. Difference in Exposure with Respect to the Noise Source

When taking into account the source of the noise, disparities in noise exposure between socioeconomic groups also exist. Compared to those in the lowest income group, people in the highest household income group have a higher likelihood of residing within a 50 dB(A) contour of Heathrow (London-UK) airport airplane noise. However, Black participants have higher likelihood of residing in a 50 dB(A) rail noise contour than do white participants (Tonne et al., 2018).

2.4. Power Relations in Environmental Risks

Prior research conducted in the United States has linked increased racial segregation to higher levels of air pollution (Bravo et al., 2016; Jones et al., 2014), ambient air pollutants (Morello-Frosch & Jesdale 2006; Rice et al., 2014), and less tree canopy cover (Jesdale et al., 2013). Similarly, according to a corpus of environmental justice research from the United States indicate that the poor, and those with low levels of education may be more exposed to air pollution and hazardous waste, (Bell & Ebisu 2012; Hajat et al., 2015; Mohai & Saha, 2007).

Researchers conceive that communities of color and the poor are disproportionately exposed to environmental risks in the United States. This is because of a number of factors, such as weak regulatory enforcement in underserved areas and a lack of capacity to participate in land use decision-making. Because the distribution of political power along racial, ethnic, and economic lines is unequal in highly segregated urban areas in the United States (Casey et al., 2017). As more powerful citizens can influence decisions about the placement of unwanted land uses in ways that benefit them, these power discrepancies may result in variances in environmental hazards exposure, including noise (Cushing et al., 2015; Morello-Frosch & Lopez, 2006).

Communities of color and residents of working-class neighborhoods are spatially bound by segregation due to the concentration of poverty, lack of economic opportunity, and discriminatory housing development and financing policies (Massey & Denton, 1993). Segregation can also facilitate the displacement of hazardous land uses onto underprivileged populations where laws may not be consistently upheld, which can result in increased pollution overall (Ash et al., 2013). Concurrently, according to social epidemiology, noise may exacerbate social health disparities by unequally dispersing exposure across socioeconomic groups (Braubach & Fairburn, 2010).

3. Material and Method

3.1. Data

3.1.1. Noise Level

The noise maps of Mersin Metropolitan Area were produced within the scope of the "Preparation of Strategic Noise Maps of Residential Areas" Project, which was signed between the Ministry of Environment, Urbanization and Climate Change (MOEU) and The Scientific and Technological Research Council of Turkey (Marmara Research Center) in 2015.

Within the scope of the project, noise maps have been prepared for residential areas with a population of more than 100,000 and a population density of more than 1000 per square kilometer throughout Turkey.

In those settlements, ISO 9613−2 standard was used for industrial facilities and entertainment venues-borne noise; the French national calculation method (NMPB-Routes-96) was used for noise caused by road traffic; and for railway noise, the Dutch national calculation method (Reken-Meervoorscrift Railverkeer Slawaai-96) was used.

Within the scope of the project, mapping was carried out using standard calculation methods with the SoundPLAN program. SoundPLAN is a software for the fast and precise preparation of noise maps in accordance with the European Directive 2002/49/EC. With the use of the program, the noise emitted from highways, railways, airports, and industrial and entertainment facilities can be modeled.

Noise maps are obtained by calculating noise levels one by one for each calculation point located at a sufficient frequency in Mersin metropolitan area (approximately 3200 points) and then by creating noise contours. Calculation points and the distances between them are determined in a certain order, taking into account the geographical features and settlement plans of the land. For this reason, one of the most important steps during the preparation of noise maps is the determination of physical environmental data. These data consist of the location and height of the buildings, number of floors, ground floor usage, topographic features, and natural and artificial obstacles.

Modeling the land by creating a geographical database is the initial stage of the modeling study. Digital maps in the UTM coordinate system and at a scale of 1/1000 or 1/5000 are utilized in land modeling. Coordinates, land elevations [x, y, z (height of the building)] and building information system data (building's purpose of use, number of floors, number of apartments, population residing in the building, etc.) are included in the data. The second data source for the area where land modeling is done is population information. Information about the noise sources to be modeled is defined as the third data set. Noise sources are classified under three headings as mentioned above transportation (airports, highways, and railways), industrial usage, and entertainment facilities.

The noise contributions to the receiver points are estimated using the calculation methods included in the standards defined in the Regulation on Evaluation and Management of Environmental Noise. To prove the validity of the modeling output, model validation is carried out. Model verification is achieved by comparing the outcomes of modeling with measurement results. 21 control points were identified based on the distribution of noise sources in the metropolitan area, and noise levels were measured for the whole day. At almost 82% of the receiver points, the discrepancy between the measurements and the model results derived for all time periods was less than 3 dB(A). Consequently, it was determined that, by the standards outlined in globally recognized sources, the model outputs fell within satisfying and reliable ranges.

In 2018, noise maps were produced for the Mersin metropolitan area (population is about 970.000), which is a settlement that meets the criteria defined above. The noise data of his study were obtained from this highlighted study (Fig. 1).

3.1.2. Socioeconomic Status

Socioeconomic status was calculated at the neighborhood scale. Three variables were used to determine socioeconom-

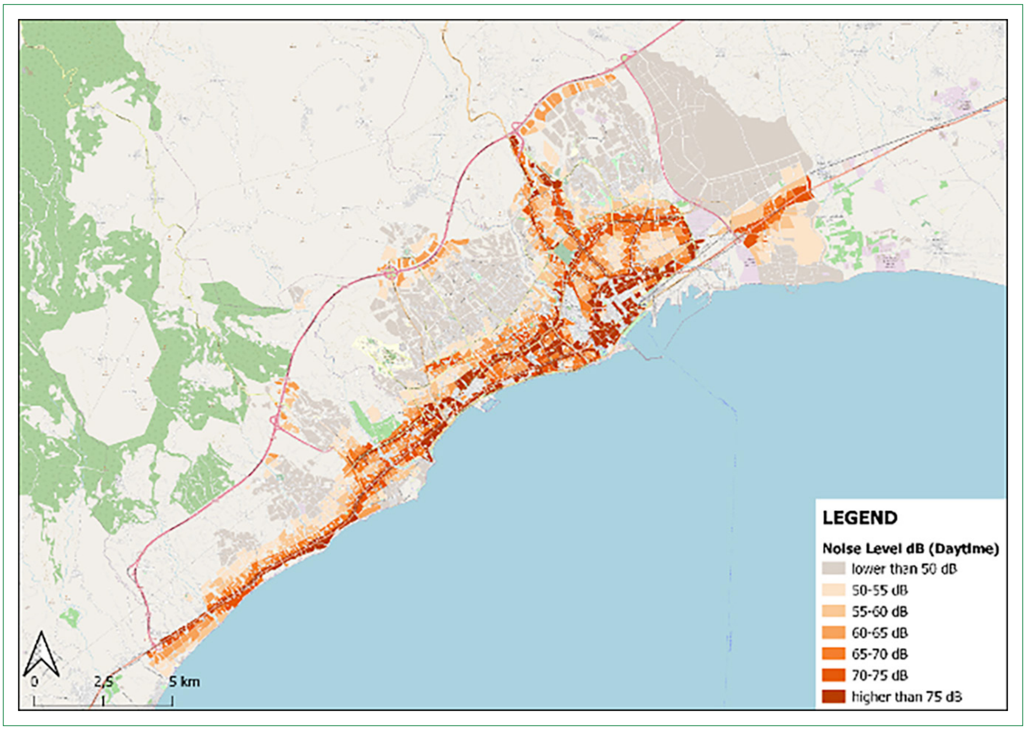

Figure 1. Daytime noise levels.

ic status. These variables are automobile ownership ratios, residential square meter values (TL), and population growth rates. The population growth rate was calculated using the data obtained from the Address Based Population Registration System of the Turkish Statistical Institute for the period 2013–2022. Residential square meter values (TL) were obtained from the Endeksa website. Endeksa is a predictive real estate data analytics and insights platform offering value-added services on location optimization). Car ownership data were obtained from Mersin Metropolitan Municipality, Department of Transportation. Using these three data obtained at the neighborhood scale, neighborhoods were subjected to hierarchical clustering analysis (method: Ward's method; interval: Euclidean distance) using the SPSS package program and 13 socio-economic status clusters were defined. The neighborhoods with the lowest socioeconomic status are represented by the areas marked "1," while the neighborhoods with the highest socioeconomic position are represented by the regions marked "13" (Fig. 2).

3.1.3. Building Density (Building Coverage Ratio) and Land-use Types

Building density (floor area ratio) and land use types data were obtained from Mersin Metropolitan Municipality, Department of Construction and Urbanization. The basis of the data is the 1/5000 scale spatial development plan of Mersin metropolitan area (Figs. 3, 4).

3.1.4. Urban Macroform Development Period

The development pattern of the urban macroform for Mersin metropolitan area was determined for the years 1990, 2000, 2006, 2012, and 2018 by using the Corine Land Cover data, and the development/growth areas of the urban macroform were revealed by years by finding the differences between two periods (Fig. 5).

3.2. Method of Analysis

All spatial analysis was made in QGIS 3.26 Buenos Aires version. In the basis of the study, the construction density (per/ha) vector data, containing 2412 building blocks, obtained from Mersin Metropolitan Municipality was used. Then all data converted to the UTM coordinate system. The land use map was combined in 4 categories (housing, housing-trade, housing-trade-tourism, and logistics and industry). Density analysis was made according to the construction density of the building blocks. While creating SES maps, neighborhood boundaries and building blocks were intersected. The analysis at the neighborhood scale was added to these parts as a layer. Method of natural breaks was used for the representation of SES maps. The period of urban growth map was created by extracting the artificial surfaces class of the Corine LULC dataset of 1990–2000–2006–2012 and 2018. These development zones were transected with the building blocks also. The noise level data dataset for daytime obtained from Mersin Metropolitan Municipality overlapped by building blocks.

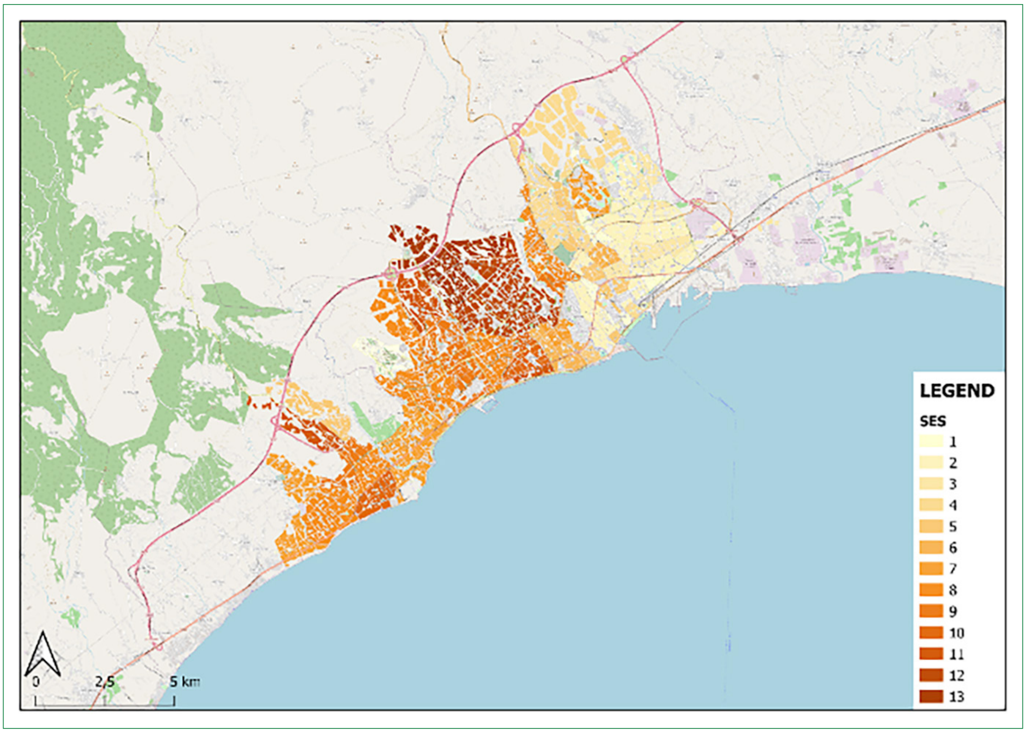

Figure 2. Socioeconomic status levels.

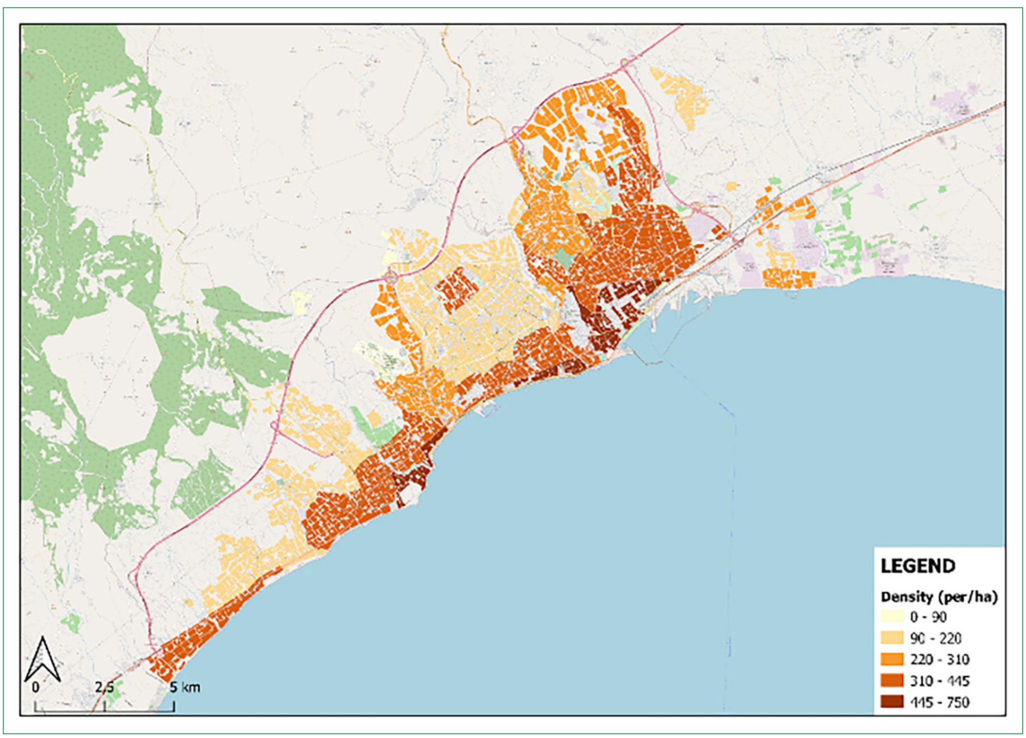

Figure 3. Building density.

The aim of the study is to determine which variables are closely related to the level of noise exposure in the metropolitan area of Mersin. The correlation method was used to investigate the relation between the dependent variable (noise level) and the independent variables (land-use type, building density, socio-economic status, and macroform development period). Giving an overall trend of the relationship between the dependent and independent variables is the aim here. To investigate the

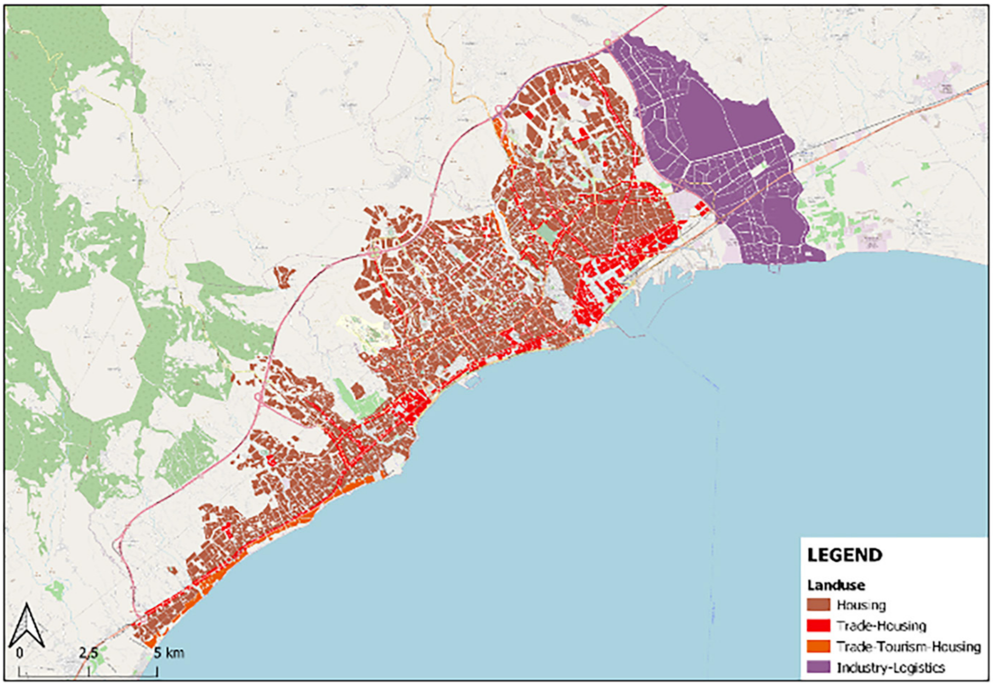

Figure 4. Land-use types.

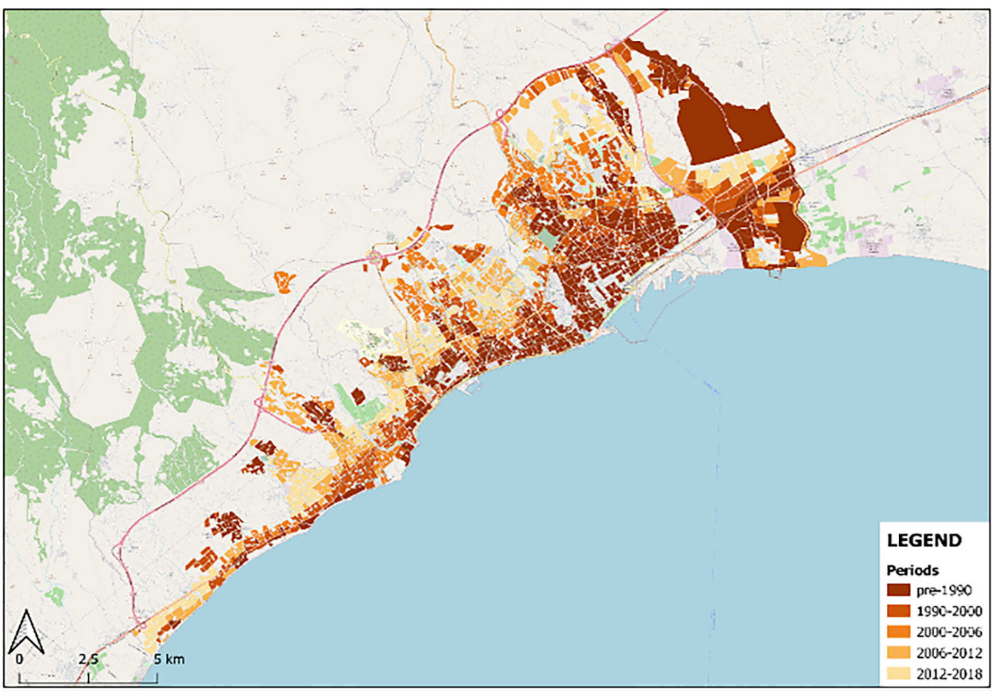

Figure 5. Urban macroform development period.

correlation between qualitative (categorical) data, contingency coefficient (nominal data and ordinal data), and Gamma (ordinal data and ordinal data) statistics were used by the help of SPSS program. Table 1 below shows the relationships examined and the test statistics used in the form of a cross-tabulation.

As explained in the section on noise data, different noise measurement methods were used for industrial facilities and entertainment venues, noise from road traffic, and railroad noise. Therefore, in order to ensure consistency in the analysis part of the study, only the residential areas were focused on.

Table 1. Variables used for correlation analysis

	Daytime noise (ordinal data)	Daytime-evening noise difference (ordinal data)
Land-use types data (nominal data)	Contingency coefficient statistics	–
Building density data (ordinal data)	Gamma statistics	Gamma statistics
Socioeconomic groupings (ordinal data)	Gamma statistics	Gamma statistics
Macroform Development Period (ordinal data)	Gamma statistics	Gamma statistics

Table 2. Population distribution according to daytime noise levels

	Lower than 50 dB	50–55 dB	55–60 dB	60–65 dB	65–70 dB	70–75 dB	Higher than 75 dB	Total
Population (*1000)	321	189	163	114	70	50	63	970
Population (%)	33.1	19.5	16.8	11.8	7.2	5.2	6.5	100.0

Table 3. Land use * Daytime noise cross-tabulation

	Daytime noise							Total
	Lower than 50 dB	50–55 dB	55–60 dB	60–65 dB	65–70 dB	70–75 dB	Higher than 75 dB	
Land use								
Housing	548	216	184	186	148	105	67	1454
Trade-housing	167	88	70	25	60	53	451	914
Trade-tourism-housing	3	4	3	6	5	7	16	44
Total	718	308	257	217	213	165	534	2412

Symmetric measures

	Value	Asymp. standard error[a]	Approx. T[b]	Approx. sig.
Nominal by nominal				
Contingency coefficient	**0.473**			0.000
N of valid cases	2412			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis.

4. Results

In Mersin metropolitan area approximately 1 million people live and 2/3 of that population live under noise levels that is harmful to human health (Table 2).

It is noted that there is a positive correlation between land use functions and daytime noise level (contingency coefficient is 0,473). It is observed that the noise level is lower in areas with only residential use, but higher in areas with mixed-use (Table 3). Since the areas planned for trade and tourism functions are also the fields of work for the service sector, a high noise level can be regarded as normal in those places. On the other hand, trade and tourism activities are typically found along the major transportation axes. It is typical to observe high noise levels in regions with non-residential usage because vehicle traffic noise is one of the main sources of noise.

It is observed that there is a positive correlation (gamma coefficient is 0,567) between population density (person per hectare) and daytime noise level. While population density increases in regions, the level of noise increases also (Table 4). Inevitably, the increase in population density brings about the intensification of noise-creating factors. Additionally, it is noticed that there is an inverse relation between population

Table 4. Density (per/ha) * Daytime noise cross-tabulation

	Daytime noise							Total
	Lower than 50 dB	50–55 dB	55–60 dB	60–65 dB	65–70 dB	70–75 dB	Higher than 75 dB	
Density (per/ha)								
90	4	2	0	1	0	0	0	7
135	57	15	7	8	0	0	0	87
150	40	0	0	0	0	0	0	40
170	0	2	6	2	1	0	0	11
180	0	2	0	0	0	0	0	2
200	356	80	28	38	22	9	2	535
220	1	7	8	5	17	1	0	39
250	52	6	15	14	2	4	13	106
270	20	28	8	0	0	0	2	58
275	36	19	11	2	1	2	0	71
280	1	9	10	15	18	8	3	64
300	8	0	0	0	0	0	0	8
310	14	33	42	24	24	32	43	212
325	40	8	0	0	0	0	0	48
335	27	28	47	51	63	45	150	411
350	52	13	20	8	3	8	0	104
355	1	5	6	8	11	7	39	77
375	3	41	29	20	24	25	52	194
400	0	3	11	11	7	1	19	52
445	0	1	0	4	9	7	44	65
500	0	0	0	2	4	2	31	39
535	0	2	4	1	5	4	52	68
580	0	0	0	2	1	6	27	36
650	0	1	2	1	1	2	35	42
700	0	0	0	0	0	0	10	10
750	6	3	3	0	0	2	12	26
Total	718	308	257	217	213	165	534	2412

Symmetric measures

	Value	Asymp. standard error[a]	Approx. T[b]	Approx. sig.
Ordinal by ordinal				
Gamma	**0.567**	0.013	45.039	0.000
N of valid cases	2412			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis.

density and socioeconomic status (SES) levels as population density increases SES levels decreases.

There is a negative correlation (gamma coefficient is -0,253) between socioeconomic status (SES) levels and daytime noise levels. The higher the SES the lower daytime noise (Table 5). In other words, the wealthy people can escape from the negative effects of noise by moving out of trade or other kinds of business and work activities.

Table 5. Socioeconomic status levels * Daytime noise cross-tabulation

	Daytime noise							Total
	Lower than 50 dB	50–55 dB	55–60 dB	60–65 dB	65–70 dB	70–75 dB	Higher than 75 dB	
SES								
1	3	4	8	3	3	7	18	46
2	26	26	34	23	24	28	86	247
3	29	25	13	5	6	5	10	93
4	34	21	26	21	13	21	38	174
5	21	12	8	18	5	12	50	126
6	0	7	8	12	9	9	42	87
7	56	16	14	12	30	14	75	217
8	93	87	58	54	58	26	81	457
9	57	30	22	15	14	9	39	186
10	5	1	6	10	11	17	29	79
11	39	8	2	3	0	3	5	60
12	135	19	15	14	15	4	10	212
13	33	2	3	10	0	0	0	48
Total	531	258	217	200	188	155	483	2032

Symmetric measures

	Value	Asymp. standard error[a]	Approx. T[b]	Approx. sig.
Ordinal by ordinal				
Gamma	**−0.253**	0.019	−13.327	0.000
N of valid cases	2032			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis.

It is observed that the older or early developed section of the urban macroform is noisier than newly developed parts (Table 6). This finding is consistent with the relationships presented earlier in the text. because the density of construction (person per hectare) is planned lower in the newly developing areas of the city and accordingly, more affluent segments of the society can afford to find a place in those areas.

It is observed that there is an inverse relationship between socioeconomic status and exposure to daytime noise; as the building density (floor area ratio) increases, the level of exposure to daytime noise increases; the level of exposure to daytime noise has decreased in newly developed areas of the city; the level of exposure to daytime noise increases as the transition from residential use to mixed-use. The direct relationship between daytime noise exposure and socioeconomic class position of people is very clearly apparent within the context of Mersin Metropolitan area.

Another area where socioeconomic differences can be measured in terms of exposure to noise can be considered as the difference between day-time and evening noise levels. It has been found that the difference between daytime and evening noise levels has a negative connection with population density (persons per hectare) (gamma coefficient: -0,316). It implies that as population density (people per hectare) declines, regions get noisier at night (Table 7). Lower-density residential regions experience an increase in noise in the evening when the city centers become deserted.

There is a positive correlation (gamma coefficient is 0,301) between socioeconomic status (SES) levels and difference between daytime noise and evening noise levels. The higher the SES the noisier the area (Table 8). While the noise level decreases in the city centers due to the decrease in the activity level in the evening hours, the noise level increases due to the revival of leisure activities in the regions where wealthy families live. The main reason for this is that wealthy families have more disposable income than ordinary people that they can allocate the entertainment sector. Due to their high-income level, it is also possible that wealthy families attract activities that can

Table 6. Urban macroform development period * Daytime noise cross-tabulation

	Daytime noise							Total
	Lower than 50 dB	50–55 dB	55–60 dB	60–65 dB	65–70 dB	70–75 dB	Higher than 75 dB	
Period								
Pre-1990	158	102	78	64	75	64	287	828
1990–2000	93	60	46	35	45	44	131	454
2000–2006	140	33	43	43	23	22	51	355
2006–2012	164	53	64	47	43	17	16	404
2012–2018	163	60	26	28	27	18	49	371
Total	718	308	257	217	213	165	534	2412

Symmetric measures

	Value	Asymp. standard error[a]	Approx. T[b]	Approx. sig.
Ordinal by ordinal				
Gamma	**−0.292**	0.019	−13.327	0.000
N of valid cases	2412			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis.

make noisy in the evening such as coffees, bars, fitness centers, and restaurants to their living places. These kinds of activities also serve as a sign of spatial segregation because they are out of reach for average households due to costs.

It is observed that the newly developed section of the urban macroform is noisier than older section of the city in evening (gamma coefficient is 0,323) (Table 9). This finding is consistent with the relationships presented earlier in the text. It has been emphasized before that the wealthy sections of society take the noise with them in the evenings to the places they go. The affluent segment of society resides in both lower-density and newly developing areas of the city. In line with this situation, the newly developed parts of the city are noisier in the evenings than the old parts of the city.

Socioeconomic income level not only affects the exposure to noise during the daytime but also affects the difference between daytime and evening noise levels. The fact that the areas where the wealthy parts of the society live are noisier in the evenings may seem difficult to understand at first glance, but it should be noted that exposure to this noise is not an involuntary exposure, but a desired/preferred noise. Therefore, there is a qualitative difference between the two noises. While one is involuntary exposure to noise, the other is a preference.

7. Conclusions

It is observed from the case study that this environmental risk is not distributed equally among the population and risk burdens are much more on the shoulder of lower socioeconomic status (SES) groups. These lower SES groups live near the city center or close to working places, and in highly dense areas generating probably high noise. Due to affordable housing prices, locating around high noise-producing activities is not a choice but a necessity for them. People having lower socioeconomic status are not only subject to high noise levels but also going to have health problems resulting from high noise levels. Social inequalities among people persist not only in tangible and visible conditions but also in intangible areas.

Areas with greater socioeconomic disadvantage appear to have higher levels of environmental noise exposure (Dale et al., 2015). Stokols (1992) states that living in underprivileged areas can be harmful to one's health for any or all of the at least five factors: a person's environment may serve as a 1) vehicle for the spread of disease, 2) stressor, 3) source of safety or danger, 4) facilitator or inhibitor of healthy behavior, and/or 5) supplier (or not) of health resources. Additionally, those who are disadvantaged may have fewer options for housing and are frequently compelled to live in subpar homes close to more environmental stressors such industrial sites, toxic waste dumps, and highways with heavy traffic (Braubach & Fairburn, 2010).

The poor are forced to live in noisy neighborhoods. However, the process does not end here. Noise also causes the poor to concentrate in noisy neighborhoods, as it reduces the value of housing. Investigations covering the years 1967

Table 7. Density (per/ha) * Evening-daytime noise difference cross-tabulation

	Evening-daytime noise difference			Total
	Quieter	**Same**	**Noisier**	
Density (per/ha)				
90	2	5	0	7
135	7	79	1	87
150	0	40	0	40
170	0	9	2	11
180	0	2	0	2
200	15	480	40	535
220	9	29	1	39
250	12	94	0	106
270	0	55	3	58
275	9	62	0	71
280	4	51	9	64
300	0	8	0	8
310	65	145	2	212
325	1	45	2	48
335	66	329	16	411
350	4	97	3	104
355	16	61	0	77
375	33	160	1	194
400	17	35	0	52
445	20	45	0	65
500	11	28	0	39
535	5	60	3	68
580	11	25	0	36
650	7	34	1	42
700	2	8	0	10
750	10	16	0	26
Total	326	2002	84	2412

Symmetric measures

	Value	Asymp. std. error[a]	Approx. T[b]	Approx. sig.
Ordinal by ordinal				
Gamma	**−0.316**	0.029	−10.132	0.000
N of valid cases	2412			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis.

to 1976 all discovered a sizable reduction in home prices as a result of excessive noise levels, ranging from 0.40 to 1.10 percent (O'Byrne et al., 1985). Other research that looked at how noise pollution affected neighborhood characteristics all came to the same conclusion: noise pollution negatively affected residential housing market values (Baranzini & Ramirez, 2005). and property values (Hui et al., 2006). In 1990 and 2000, when noise levels rose, the typical household income and home value fell (Ogneva-himmelberger & Cooperman, 2010). Is sum, segregation may result in the spatial fragmentation of communities, workplaces, and essential services, which would differentiate the level of noise that people are exposed to (Ash et al., 2013; Morello-Frosch & Jesdale, 2006).

Table 8. Socioeconomic status levels * Evening-daytime noise difference cross-tabulation

	Evening-daytime noise difference			Total
	Quieter	**Same**	**Noisier**	
SES				
1	8	38	0	46
2	46	197	4	247
3	11	82	0	93
4	46	128	0	174
5	33	92	1	126
6	27	60	0	87
7	30	179	8	217
8	44	376	37	457
9	4	166	16	186
10	12	67	0	79
11	3	54	3	60
12	12	185	15	212
13	7	41	0	48
Total	283	1665	84	2032

Symmetric measures

	Value	Asymp. std. error[a]	Approx. T[b]	Approx. sig.
Ordinal by ordinal				
Gamma	**0.301**	0.031	9.057	0.000
N of valid cases	2032			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis. SES: Socioeconomic status; Std.: Standard.

Urban planning can play an important role in reducing the environmental risks faced by the less well-off sections of society. However, urban planners' efforts to lessen social segregation and spatial inequality have decreased. In fact, it may be claimed that since 1980, the planning system has actually

Table 9. Urban macroform development period * Evening-daytime noise difference cross-tabulation

	Evening-daytime noise difference			Total
	Quieter	Same	Noisier	
Period				
Pre−1990	158	652	18	828
1990−2000	72	373	9	454
2000−2006	50	293	12	355
2006−2012	23	361	20	404
2012−2018	23	323	25	371
Total	326	2002	84	2412

Symmetric measures

	Value	Asymp. std. error[a]	Approx. T[b]	Approx. sig.
Ordinal by ordinal				
Gamma	**0.323**	0.036	8.620	0.000
N of valid cases	2412			

[a]: Not assuming the null hypothesis; [b]: Using the asymptotic standard error assuming the null hypothesis. Std.: Standard.

operated in a way that has worsened the circumstances of disadvantaged groups and contributed to the rise of poverty, social polarization, and inequality (Davoudi & Atkinson, 1999). For socioeconomically disadvantaged people, spatial planning to identify priority locations for noise reduction, construction design, and protection and promotion of quiet spaces may play a role in bettering living circumstances and pollution levels (Harris & Pinoncely, 2014). Designing urban spaces can have a good impact on noise reduction which may help to lessen disparities in ambient noise exposure. According to Margaritis and Kang (2016) green areas, building characteristics, and road qualities all have an impact on how noise is distributed in cities.

In summary, in the Mersin metropolitan area, the daytime noise level is low in low-density and new development areas of the city where only "residential" use is planned. People with high socio-economic status mostly live in such areas. In other words, the daytime noise level is high in mixed uses (residential + commercial), high density and old parts of the city. In such regions, mostly people with low socio-economic status live. Considering all these findings, it can be stated that the situation observed in Mersin has similar characteristics to the USA and North American cities. In other words, Turkey's urbanization and urban planning practices follow the same path as the US and North American cities.

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