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Railway Noise Pollution: An Investigation of Rail Systems in Terms of Noise Pollution Regulations and Land Usage

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Abstract

Noise pollution caused by transportation has become a problem for societies with increasing traffic volumes and the development of cities day by day. In European countries and Turkey, transportation-related noise pollution has caused health problems and reduced the living standards of the people. It is necessary to carry out detailed studies in order to determine the problems caused by noise pollution, especially in the regions where industry and the labor force are concentrated, and to solve these problems. The city of Izmir is one of the cities where the noise caused by the railway needs to be investigated. As a result of the studies carried out in the research area, the railway noise pollution map was created with the IDW method with the data obtained from 8 different points. Afterwards, the effect of railway systems on the land use types of cities, noise pollution problems, and the period between 2000 and 2018 was examined. The adverse effects of noise pollution caused by the railway in the hinterland of the suburban line in the study area and its effect on the land usage type were investigated with the EU and Turkey Noise Regulation and the land cover data of the European Environment Agency

1. Introduction

In today's conditions, where the amount of mobility is increasing and industrialization is developing day by day, some negative effects of transportation systems on the environment. Noise pollution is one of these effects, and its negative effects on people in terms of physical, physiological, psychological, and performance (such as concentration impairment, and decreased work efficiency) have been revealed in this study. [1, 2, 3, 4, 5, 6, 7, 8]. Although the World Health Organization does not want to exceed the noise limit value of 55 dB (A) during the day and 40 dB (A) at night, according to studies, 20% of the European Union countries have 65 dB (A) and 40% 55 dB (A) noise pollution. [1, 9, 10]. This exposure has caused dissatisfaction among people and an inefficient workforce in densely populated areas [11-13]. For this reason, national and international studies have been carried out about the solution to environmental noise have continued since the 1960s [6, 9, 10]. With the effect of developing technologies and the development of railway systems, it has become highly necessary to investigate the damage of noise pollution and vibration caused by rail systems [14]. Maps of the regional noise have started to be prepared in order to better analyze the environmental noise and in order to make appropriate action plans. Noise pollution maps are generally prepared by using GIS (Geographical Information Systems) based programs. European Union countries, the USA, Japan, China, and Turkey also use CadnaA and Sound plan which are noise simulation software [15, 16]. Noise measurement type, and duration; A noise pollution map was created by using appropriate parameters such as the building information of the region, its height, and distance. Interpolation methods such as inverse distance weighted (IDW), Kriging, and Radial Basis Function

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are used to generate noise maps [17]. While the noise pollution maps provide information about the current environmental noise in the region, they may be insufficient to make a comment on the future. Although there are many parameters of noise pollution, knowing the land usage of the region can be used to detect noise sources [18]. Thanks to the land cover data of the European Environment Agency (EEA), it can be observed in which trend the land usage of the regional structure differed until the 1990s. This data allowed us to analyze how housing, schools, and industrial areas around the railway lines changed. In line with this information, the effect of the noise pollution originating from the railway on the İzmir İZBAN line, which was selected as a sample line, was studied in order to determine the regional effect. For the sample region selected for this purpose, the effect of noise pollution and vibration is one of the noise pollution regulations; By using the Environmental Noise Assessment and Management Regulation (ENAMR) in Turkey and the Environmental Noise Directive (END) accepted by the European Union countries. The noise measurement results made by Republic of Türkiye State Railways (TCDD) in the 4750 m area on the IZBAN line were analyzed [19-21]. After the noise pollution analysis, noise pollution maps of the study area were prepared with the IDW method with the ArcGIS 10.7 program. Afterwards, using the CORINE Land Cover CLC (Coordination of Information on the Environment) datasets, the changes in the land cover of the region between 2000 and2018 were compared, and the effect and change of the railway on the region, as well as how the region was affected by noise pollution and vibration, were investigated [22].

2. Material and Method

In this section, each related work is detailed in the subsequent subsections.

2.1. Workspace and Dataset

In addition to being Turkey's third largest city and having a dense population, İzmir was chosen as a study area due to its development in terms of industry, agriculture, logistics, and trade. The population of the city is 4,367,251 according to 2019 (Turkish Statistical Institute -TURKSTAT) data, and the population density of the city is increasing every year [23, 24] (Figure 1)

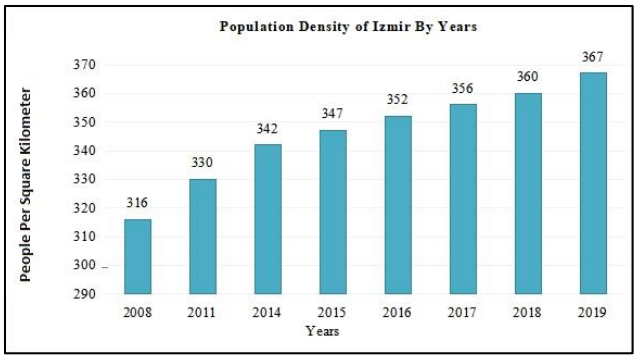

Figure 1. Izmir population density [24]

In the city of Izmir, as a rail system for urban transportation, there are suburban trains operated by IZBAN company on the north-south axis, İzmir metro operated by İzmir Metropolitan Municipality on the east-west axis and TramİzmirTramİzmir operated by İzmir Metro, which was put into service in Konak and Karşıyaka districts in 2017. In addition, main line passenger trains, regional trains and freight trains, which are under the responsibility of TCDD, also operate on the line where IZBAN suburban trains are located. In this study, noise pollution was analyzed within the framework of regulations in line with the measurements obtained in the 4750-meter section of the IZBAN line (Figure 2)

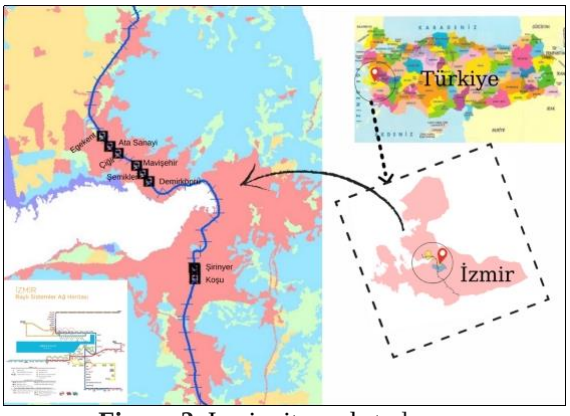

Figure 2. Izmir city and study area

Noise Measurements were made by TCDD in 2017-2018 and are given in able 1 [19] (Table 1). Materials used chart 2 shown with (Figure 2)

Table 1. Long-term noise measurement results* [19]

Location	Date/time	Lday(dBA) 07:00 to 19:00	Levening(dBA) 19.00-23.00	Lnight(dBA) 23.00-07.00
Mavişehir-Demirköprü	2017	69.5	70.7	64.6
Şirinyer-Koşu	2017	62	60.1	54.6
Cigli-Atasanayi	2018	67.5	68.7	61.7
Atasanayi-Egekent	2018	64	61.8	57.1

*Lday: It is the average of the measurements made during the daytime (07.00-17.00) of the year in long-term measurements. Levening: It is the average of the measurements made in the evening (17.00-23.00) of the year in long-term measurements. Lnight: It is the average of the measurements made at night (23.00-07.00) of the year in long-term measurements.

Table 2. Data type and sources used in the study

Data Type	Data	Source of Data
Report	Sound Screen Projects Noise Measurement	TCDD- Republic of Turkey State Railways
Regulation	Evaluation and management of environmental noise	Official Gazette No.27601
EU Directive	2002/49/EC Environmental Noise Directive	Official journal of the european communities
Software	Arcmap 10.7	Software- Esri
Land usage	Maps of the Corine Land usage	EEA (European Environment Agency)

In order to analyze the noise measurements made in this study, the Environmental Noise Directive-Environmental Noise Directive (END) 2002/49/EC, which was accepted by the European Union countries in 2002, was used [21]. In Türkiye, the 'Rail System Environmental Noise Criteria' contained in the Environmental Noise Assessment and Management Regulation (EMR) have been used [20]. CORINE Land Cover datasets prepared by EU (European Union) countries were used to observe the land usage change in the hinterland of the railway line [22].

2.2. Method

The study was prepared by using the point noise measurement results made at 8 different stops, namely Koşu, Şirinyer, Demirköprü, Şemikler, Mavişehir, Çiğli, Atasanayi, Egekent passing through the districts of Buca, Karşıyaka and Çiğli passing through the IZBAN line. Spot measurement results were analyzed using the inverse distance weighted (IDW) method using the ArcGIS 10.7 program. To function in the program of the IDW method, at least three different points should be entered into the system this by the position located Koşu- Şirinyer stops between Şirinyer selected as close as a third point reference point stop is in the made mapping. Since the stops between Demirköprü and Egekent in Karşıyaka-Çiğli region were uninterrupted, the noise measurement results were sufficient for mapping.

The noise pollution maps created afterwards were compared in terms of noise pollution and vibration regulations. The IZBAN line in the region where the noise measurement was made was put into operation in 2010, and the 10 years before the region was put into operation and 8 years after the operation were compared using the CORINE land cover data.

In this study, the noise pollution problem created by the railway line, the effect of the railway line on regional construction, the relationship between railway construction and the change in regional land use were investigated.

3. Results

3.1. The Evaluation of Noise Pollution and Vibration in Terms of Regulations

As a result of the measurement results of 2017 and 2018 obtained on the IZBAN line, it was determined that the noise pollution in the region where the measurements were made is above the threshold value. According to the ENAMR, the limit values must not exceed the limit values Lday 65 dB(A), Levening: 60 dB(A), and Lnight: 55 dB(A). Although similar figures are valid according to END data, these values differ between +5 and -5 depending on the building use of the region (housing, hospital, industrial area). According to the long-term measurement results in Table 3, the exceeded limit values are presented as percentages. As can be seen from the table, it has been revealed that the limit values on the Mavişehir-Demirköprü route are exceeded by almost 17%. The adverse effects of increased noise exposure, especially in the evening and at night, on the surrounding people were determined, and the results of the survey conducted in the literature also showed the negative effects of noise pollution exposure on people

Table 3. % dBA amount exceeded according to long-term measurement results

Location	Limit dBA exceeded in %		
	Ldaytime 07.00-19.00	Levening 19.00-23.00	Lnight 23.00-07.00
Mavişehir-Demirköprü	6.92	17.83	17.45
Şirinyer - Koşu	-	0.17	-
Cigli- Atasanayi	3.85	14.50	12.18
Atasanayi-Egekent	-	3.00	3.82

.2. The Evaluation of Noise Pollution Maps Made by IDW Method

The measurement results were analyzed with the IDW method via ArcGIS. This method was used because the long-term measurement results were point-based. As a result of the analysis, as seen in figure 3, measurements were made between Şirinyer and Koşu in the Buca region. As a result of measurements made in 2017 Lday 62 dBA, where appropriate Lday 60.1 dBA, and Lnight 54.6 dBA were detected and mapped. Since the analysis did not work without at least 3 points, the reference point close to Şirinyer stop was added as an assumption.

According to the analysis, the measurement results between Şirinyer and Koşu do not exceed the limit values specified in the regulation and do not pose a serious problem for the region in its current state

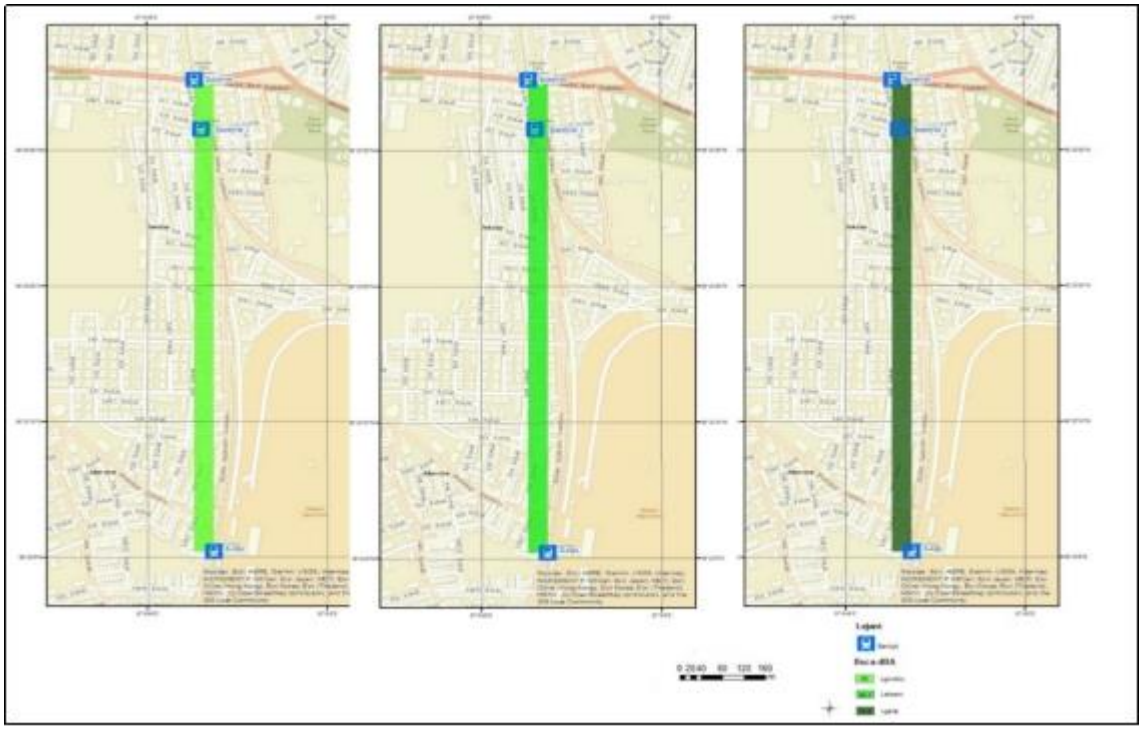

Figure 3. Map of the Buca noise pollution

Demirköprü, Şemikler, Mavişehir, Çiğli, which pass through Karşıyaka and Çiğli districts.

The measurement results at Atasanayi and Egekent stations were analyzed in Figure 4-5-6. As a result of the analysis, it was determined that the daytime limit value of 65 dBA was exceeded in Mavişehir, Şemikler and Demirköprü regions.

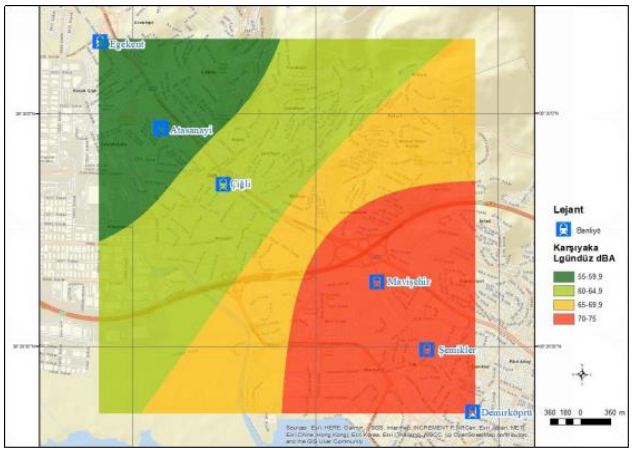

Figure 4. Map of the Karsiyaka daytime noise pollution

Evening noise in the Egekent-Atasanayi region: although the evening noise remained at the limit values, the evening noise regulation limit values were exceeded at Çiğli, Mavişehir, Şemikler, and Demirköprü stops.

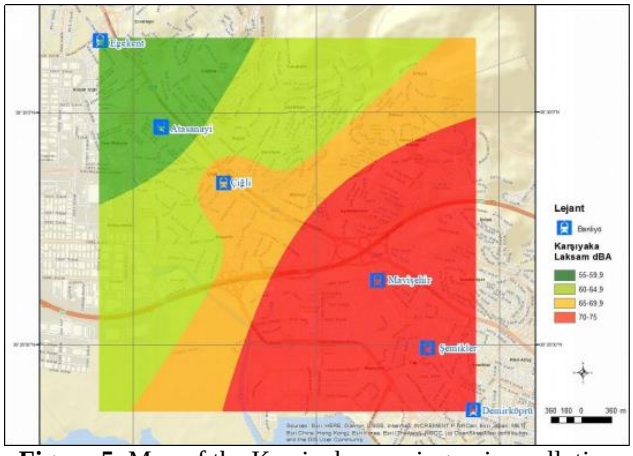

Figure 5. Map of the Karsiyaka evening noise pollution

Railway noise should be at night 55 dB(A) but Demirköprü-Egekent between 55 dB(A) seems to overcome. The limit value of approximately 15 dB (A) has been exceeded between Mavişehir and Demirköprü.

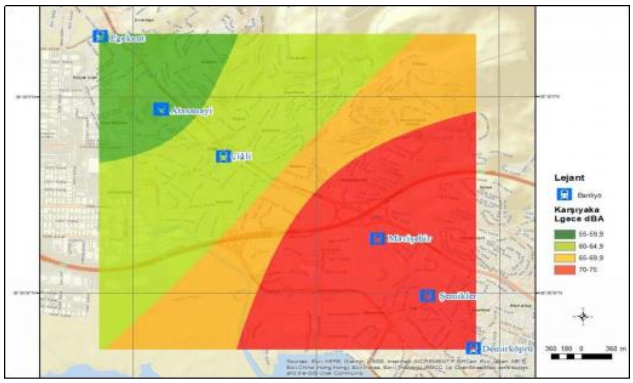

Figure 6. Map of the Karsiyaka night noise pollution

3.3. The Evaluation of Noise Pollution and Vibration in Terms of Land Usage

In the study, the effect of the IZBAN line on the land cover was examined. IZBAN line located in Buca and Karşıyaka districts was put into operation on 30 August 2010. In order to analyze the period before the opening of the IZBAN line, land use maps were selected pre-2010 land use maps, and in order to interpret the change in land use after the railway line was put into operation, the land use maps of 2000-2018 were selected. Considering the area occupied by the IZBAN line; Land usage type and changes from Corine land cover data of CLC2000, CLC2006, CLC2012, and CLC2018 were determined by basic spatial analysis processes made from the ArcMap program (Figure 7, 8,9,10).

The land use types on the maps are numbered as follows;

- 111 Continuous urban fabric
- 112 Discontinuous urban fabric
- 121 Industrial or commercial units
- 122 Road and rail networks and associated land
- 324 Transitional woodland-shrub
- 323 Sclerophyll plants
- 321 Natural grassland
- 313 Mixed forest
- 312 Coniferous forest
- 243 Land principally occupied by agriculture, with significant areas of natural vegetation
- 223 Olive groves
- 211 Non-irrigated arable land
- 133 Construction sites
- 131 Mineral extraction sites
- 333 Sparsely vegetated areas
- 242 Complex cultivation patterns
- 142 Sports and leisure facilities
- 141 Green urban areas

As a result of spatial analysis: it has been determined that the rail systems contribute to the development of the region and increase the housing in the hinterland of the railway line, as they provide convenience in journeys such as home, work, and school. In the 2000s, lands used as agricultural or green areas were converted into housing, industry, and connecting roads to meet demand. This change poses a risk in the long run, especially for the people of the region where housing has increased, in terms of catching diseases related to transportation noise.

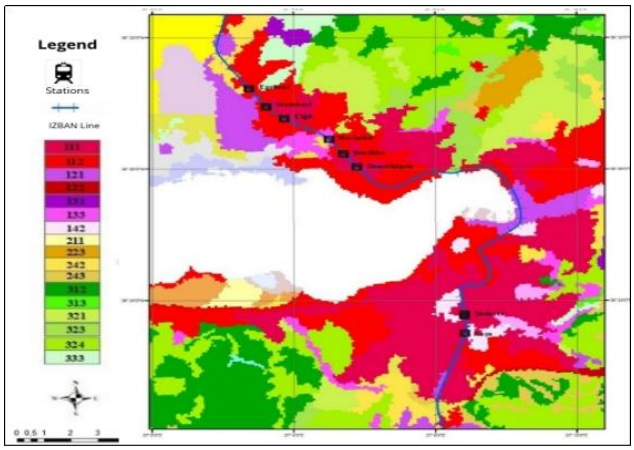

Figure 7. Map of the 2000 land usage

The land cover map of 2000 was prepared with Arcmap at a scale of 1/100,000. As can be seen in Map 5, the land use of the area in the hinterland of the study area is as follows.

There are a continuous urban texture, and sports and recreation areas between Şirinyer and Koşu. When we examine the land in the hinterland of Egekent-Demirköprü stops; continuous-discontinuous urban texture, construction areas, mixed agricultural areas, natural meadows and urban texture with industrial, and commercial units are observed.

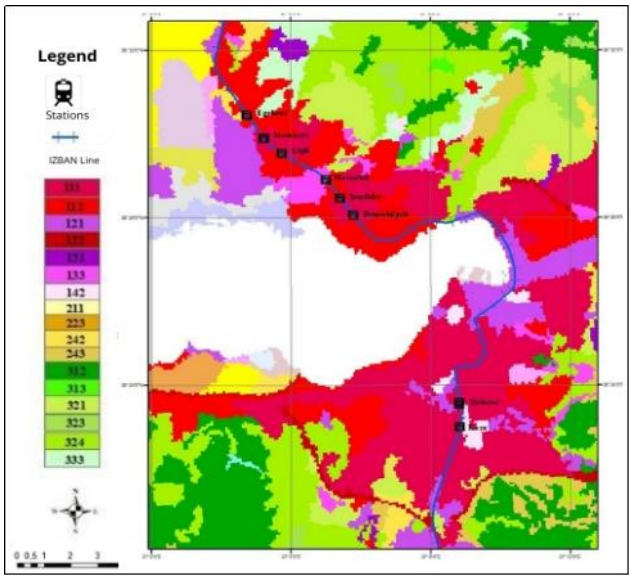

Figure 8. Map of the 2006 land usage

The land cover map of 2006 was prepared by Arcmap at a scale of 1/100,000. As can be seen in Map 6, it was observed that the hinterland of the study area changed from 2000 to 2006 as follows. Some of the sports and recreational areas located between Şirinyer and Koşu have been converted into industrial and commercial units. In the Egekent-Demirköprü hinterland, the mixed agricultural areas in the Mavişehir region have been transformed into construction areas, and the continuous urban texture on the Atasanayi-Çiğli line has increased

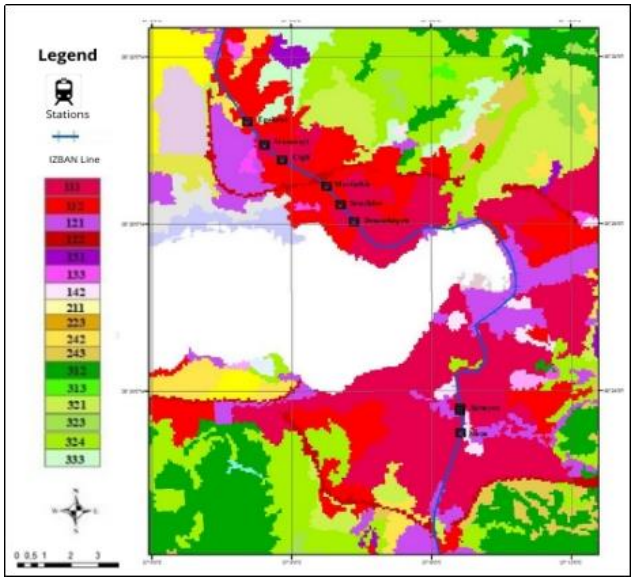

Figure 9. Map of the 2012 land usage

The land cover map of 2012 was prepared by Arcmap on a scale of 1/100,000. As can be seen in Map 7, it was observed that the hinterland of the study area changed from 2006 to 2012 as follows. It is observed that some of the sports and recreational areas in the running hinterland have turned into industrial and commercial units. It is observed that the construction areas in the Mavişehir region turn into a discontinuous urban texture, and the highway line that cuts the suburban line at 90 degrees has been put into operation. This is also one of the points that causes the noise level to be exceeded in the noise pollution maps of the region. It has been observed that some industrial areas in the Atasanayi region have been transformed into reconstructed areas

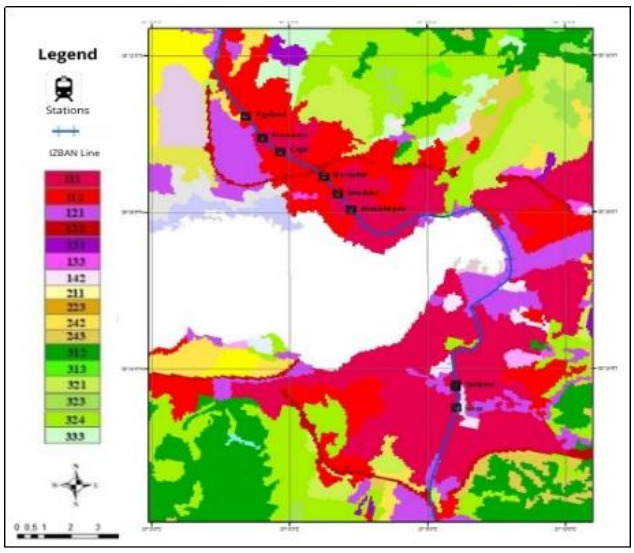

Figure 10. Map of the 2018 land usage

The land cover map of 2018 was prepared with Arcmap on a scale of 1/100,000. As can be seen in Map 8, it has been observed that the hinterland of the study area has changed from 2012 to 2018 as follows. No change was observed in the land use pattern between Şirinyer-Koşu. In the Atasanayi hinterland, the constructions in the industrial and commercial units have been completed and the land texture of the region has not changed much compared to the previous period. Considering that the İZBAN line was put into operation in 2010, we can observe that the land texture of the region does not allow for new changes about 8 years after the line was opened.

4. Discussion

Noise pollution is a serious environmental problem that causes environmental problems throughout the world. Noise pollution caused by railways is also a sub-branch of environmental problems arising from

transportation. Negative effects on humans in terms of physical, psychological, physiological, and labor performance are known, and in order to reduce these negative effects, the railway-induced change in the region's land usage was examined in the period between 2000 and2018, ten years before the opening of the line and eight years after. As a result of the examination, it has been investigated to what extent the noise pollution caused by the rail systems complies with the limit values specified in the EU regulations END and the ENAMR used by Turkey.A noise pollution map of the study area was created with the IDW method. Although it is done in a very limited area, it has been observed that the excess caused by noise pollution is at a level of 17% in places. While this value is above the values prescribed by WHO, it has also been determined that it is not at the appropriate level by the ENAMR and END regulations.

In addition, when the change in land use is examined in the research, the construction areas have increased with the construction of the railway line and the development of the region. When it comes to 2012-2018, changes in land use are now almost never seen. The reason for this is that railway investments do not allow the type of land usage to change after the development of the region reaches a certain saturation point and can servesociety in general. In this context, as can be understood from the findings of the study, the land use type of very limited areas in the region has changed after 2012.

In this study, noise pollution and vibration caused by rail systems were investigated, and the inability to measure vibrations in the region constituted the limitation of my study. It is known that vibration can cause structural damage as well as negative effects on human health. In other studies to be carried out, besides noise pollution and land usage, vibration measurements can be made and the damage to the structures in the region can be clearly determined. In addition, making the measurements at 8 stops enabled us to map with the IDW method. More precise measurements at more points will allow for more precise mapping of noise pollution to be created in ways that no other facility will.
Briefly;

- As a result of the evaluated field measurements, the noise limit value specified in the ENAMR and END regulations has been exceeded at a rate of 1 dB(A) and 10,7 dB(A) in the study area.
- In the type of land use, it was determined that the green areas in general changed from the construction areas to the continuous and discontinuous urban texture between the years 2000 and2012. It is thought that the effect of the Izmir IZBAN suburban line, which was put into operation in 2010, is among the reasons causing these changes.

- It is known that vibration causes structural damage, although vibration measurements could not be reached in this study; its compliance with the legislation should be checked and necessary precautions should be taken.

5. Conclusion

The study is an example for metropolitan cities since it was carried out in the metropolis and the port city of Izmir. In addition, each city can adapt the study to its own region, taking into account its socio-cultural and economic structure. Because noise pollution is environmental pollution that has been found to have negative effects on society in general. Therefore, if the cities are designed by taking into account the effects of noise pollution and vibration before making railway planning and considering the limit values of the regulation, both noise pollution and vibration problems around the rail systems will be prevented; efficient use of the land will be ensured. In addition, the high initial investment cost of the railway and the fact that the project changes are very difficult after the construction phase revealed the necessity of taking into account noise pollution and vibration in every project sensitively.

As a result, noise pollution, which is one of the leading environmental problems in the world, should not be ignored while designing the railway systems' project-construction-operation processes. The use of land usage types in the railway hinterland in accordance with the limit values in the noise pollution regulations is necessary for the sustainability of the cities.

Acknowledgments

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