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REFLECTION OF NOISE EFFECTS ON THE FORM OF URBAN SETTLEMENT IN AIRPORT CASE

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ABSTRACT

Noise, one of the main environmental pollutions today, is an important issue created by unplanned urbanization and side effects of technological developments. It is true that it reflects into ecosystem degradation with its negative impact on living creatures.

Nature destruction occurs with the degradation of ecosystem, which cannot be renewed artificially. Since this problem would deteriorate ecological balance caused by noise, it creates negative impact on living creatures. When examined according to urbanization feature in the relationship of city and nature, this interaction reflects into two features of urban settlement form that are;

1. Unplanned negative interaction of urban spaces and development trends due to excessive noise,

2. A physical threshold caused by excessive noise source and that cannot be overcome in urban development.

Thus, one of the biggest sources of environmental noise is surely airports. Besides the increase in the number of airports and airplanes with the technological innovations and developments, population growth causes settlements to shift of settlements to the airport areas. Therefore, the significance of the source of this noise has considerably increased. The location of different kinds of airplane and airports causes noise at different levels.

This study aimed to examine the noise in Batman airport to provide suggestions for determination of the reflection of interaction among living creatures into the form of urban settlement. Thus, day and evening limit values correspond to the noise level of 55 dBA around the settlements located around the airport, yet the night value remains at the limit. This may become an important problem with the construction and transfer of the airport capacity to large airports category.

Key Words: Noise, noise map, airport, Batman.

AIM AND SCOPE OF THE STUDY

The noise control also has entered our lives with the increasing population and construction day by day. As in all other cities, airport noise mapping and assessment become essential for the area around Batman province of Turkey, which currently hosts an immense settlement and is expected to become larger in the future.

As such, the scope of the study comprised rapid development of the area around the airport, serving the neighboring cities of Batman, which has a population of 620,278 according to 2020 data; and the effects of the noise on living creatures around the airport were investigated. Further sections of the study touch on noise assessment of the airport area, where construction is rapidly increasing using the sample of Batman airport noise maps obtained from the noise mapping study of the airports of the Ministry of Environment and Urbanization.

1. INTRODUCTION

The noise, one of the factors creating environmental problems, has been a fact affecting living life since the existence of humanity. This interaction causes formations degrading the ecological balance since it creates the problem of reproduction and abandonment of the living environment in animals and creates health problem in humans. Noise is generally defined as artificially generated disturbing sounds or super position of anarchic sound waves (Sabuncu, 1988). The noise problem in this definition forms as a side effect of innovations in technological developments and the result of unplanned developments caused by rapid industrialization in developing countries and dense population in cities besides infrastructure deficiencies.

Uncontrolled urbanization and technological developments are known to be the cause of environmental problems today. The noise which affects all creatures directly or indirectly has negative impacts

1- On human health in line with its amount,
2- Behaviors of animal species in the influence area,
3- Damage to plants due to the nature of its source.

This negative interaction realizes with the escape and extinction system according to sensitivity factor in the degradation of the ecological balance. Humans first try to take precautions when adversely affected by the intensity of the noise, then to move away from the noise source, thus affects the form of urban settlement in the area. Animal species are affected according to the sound sensitivity order and this accelerates the decline of species. This interaction in animal species deteriorates the balance;

a) Between animal species according to sensitivity feature,
b) Between plant species due to the decrease in animals feeding with plants.

Therefore, ecological balance of the nature degrades. This phenomenon causes nature destruction and is a sign of a future than cannot be renewed artificially. Since noise is generally made up disturbing sounds created artificially, the main source is technological developments and urbanization. As it is known, ecosystems peculiar to cities adversely affect plant life in cities and vegetation cannot adequately perform functions such as ecological-balancing, aesthetic-regulating, production service, etc. as expected (Aslanboğa, 1988).

Noise maps are formed to detect such problems emerged with the noise problem, to control noise and to determine the environmental disturbance. Noise mapping is done to determine the noise disturbance level of the population living in a certain region and to evaluate the environmental noise that the population is exposed to. For this, noise maps are prepared to show the noise produced by different sources (highway, airline, railway, industry, etc.). Data such as the annual noise values of the region, to what extent of dBA how much of the population is exposed to noise are obtained from the prepared noise maps. Thus, noise can be controlled in the region, which acts as a guide in strategic planning and the rate of noise change in the region over the years can be followed.

2. THE RELATIONSHIP OF NOISE SOURCES AND IMMEDIATE ENVIRONMENT

Noise is defined as disturbing sounds. According to their formation, sounds arising in the air or in solid environments turn into noise pollution in cities with their propagation from point, linear or planar sources (Türkiye'nin Çevre Sorunları, 1989) and their disturbing feature. However, environmental noise that turns into environmental pollution has negative impacts on people that are;

1. Indoor noise,
2. Outdoor noise.

While indoor noise has impact on people only, outdoor noise has more common impact on all creatures and is at higher levels. Because of this feature, the necessity for an examination of the nature and city is more important as it brings strategic and political decisions, starting from the planning scale to bring solutions (Kurra, 1988). Considering their impact on the urban form, noise types in open spaces outside the building are divided into five main groups according to their characteristics;

a) Transportation noise (highway, railway and air transportation),

b) Industrial noise (industrial tools and machinery as well as workplace noise),

c) Construction (worksite) noise (noise from roads and construction works),

d) Recreation noise (playgrounds, sports fields, shooting areas),

e) Commercial noise (open air cinemas, places of entertainment, increased advertising and music broadcasts, noisy vendors).

As indicated above, while outdoor noise sources are effective in all types of formation in the urban settlement area, transportation and recreation noises are effective in the region and country in the nature dimension. Considering the noise sources in urban areas;

- ✓ Construction (worksite) noise becomes disturbing depending on its level and time since it creates temporary noise source.
- ✓ However, industrial and commercial noises affect the macro form at a certain level in the development of the city since they form in the working areas of the city.
- ✓ Recreation and transportation noises reflect into the integrity of urban area with nature and make a limiting threshold for the development in the macro form of the city.

With this definition, noise sources have an impact on keeping away from noise sources on people and animals in the immediate environment relationship of noise sources and create buffer zones between plant species and the noise source.

3. EFFECTS OF AIRPORT NOISE ON LIVING CREATURES

With the technological innovations and developments, the number of airports and airplanes has begun to increase and the settlements to shift towards their airports. Thus, the importance of airport the source of noise significantly increases in both developing and developed countries. The location of different kinds of airplane and airports causes noise at different levels (Havaalanı Planlama Kılavuzu, 1987).

Airport noise, interaction of the noise source and its immediate environment generally bring along negativities for living creatures. Besides the impact of noise on health and comfort, considering its destructive effect for the ecosystem balance, it has a significant impact on all creatures, particularly people. 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. When sound pressure level increases, physiological effects occur around the size of 90-140 dBA. Finally, ear injury effects of 140 dBA and above come up (Figure 1). In brief, while the noise level starts from the limit above 30 dBA for human health, it is acceptable to be above 90 dBA as the limit value in terms of the occurrence of otological (ear-related) disorders in humans (Sabuncu, 1988).

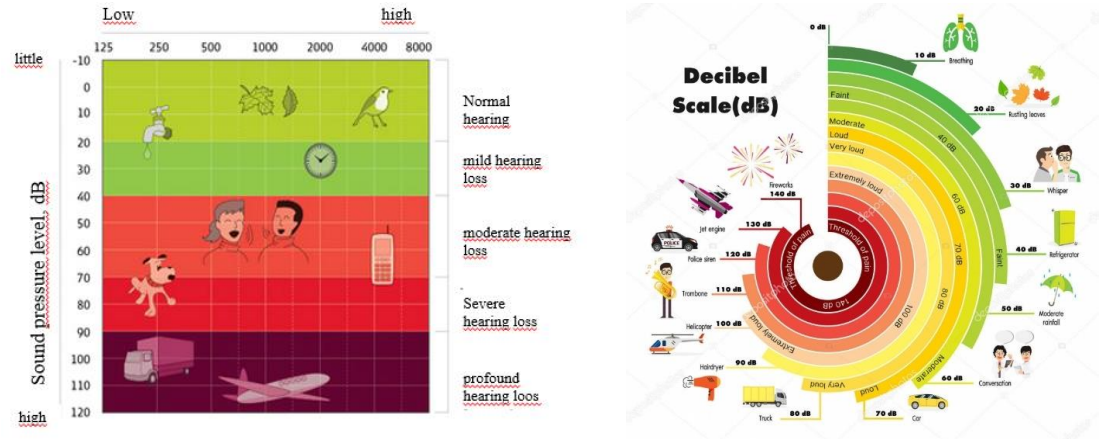


Figure 1. Hearing loss graph and decibel scale (https://tr.depositphotos.com/166752590/stock-illustration-the-decibel-scale.html)

The acceptable sound intensity for airports is 70 dBA among the noise sources specified in the noise regulation (Türk Çevre Mevzuatı, 1988). However, the sound pressure level created by the jet engine which reaches 140 dBA (Yılmaz, 1988) creates serious danger.

It is natural that the noise has similar effects on animals to those of people. As known, since animals have no ability to think, they have more sensitivity to sound. This phenomenon detracts the animal species from the area where the noise source is located. Also, airborne and terrestrial species are affected differently based on the source of noise. While moving away from the noise source on land, airborne bird species are in the danger of collision with the airplane in noisy areas like airports.

The noise has indirect impact on plants. Due to the type of noise source (e.g. airplane), as known, excessive dust and gas due to movement and vibration affects the leaves that are considered as lungs of plants, thus negatively affects their growth.

4. REFLECTION OF NOISE FACTOR ON THE FORM OF URBAN SETTLEMENT

Since noise forms disturbing sounds, it creates a limit in moving away with its source based on the sound pressure level in the urban settlement. As it is known, this limit forms buffer zones with tree species to lower the noise intensity. However, as some noise sources make insuperable thresholds at macro form in the development of the city (intercity highways, railways, large industrial areas and especially airports) they bring along the following problems;

1- Unplanned developments,

2- Disconnection between function areas of the city in future,

3- Difficulties in infrastructure.

These problems occur on land which is a natural source. As it is known, the solution for the problem of nutrition and settlement, which is affected by the population increase in the world, is the unreproducible land (Ergen, 1989). While creating urban settlements on the land, all functions and the problems that may occur should be predetermined in planning and the balance of city and nature should be protected.

For example, in urban development, NEF 30 limit for settlements in international standards and NEF 30 to 40 provided that special sound insulation measures are taken are projected in the airport area with a high level of noise problem. Settlement is prohibited in areas of NEF 40.

Yılmaz (1979) made his calculations on NEF that was a measurement parameter of that time. At first, he determined the class of the airport (3rd class) and then drew the contours in and around the airport according to the NEF 30 and NEF 40 values obtained. Then, he determined an A receiver point based on the usage aim of the built environment and calculated Leq (24), which indicates the equivalent noise level for 24 hours. The calculations provided the value of 63 dBA. Being 63 dBA > 55 dBA, he determined that the receiver point was not suitable for the settlement area. He found the value of 55 dBA with calculations made selecting a B receiver point. This showed that point could be used as an area of settlement. However, it was impossible to calculate the 3rd dimension limits with that method, so Yılmaz (1979) carried out his study using calculation method (Yılmaz, 1979).

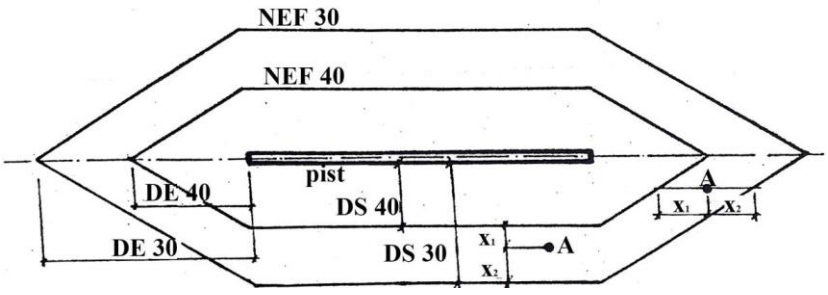


Figure 2. Illustration of NEF-30 NEF-40 contours according to Drawing Guides method (Yılmaz, 1979)

While noise reflects on the city with these features, it causes irreparable damage in the natural environment and degrades the ecological balance.

There are a number of policies and regulations regarding noise in different countries. One of them, In the USA, the HUD (Housing and Urban Development Department) accepts the noise level of Ldn = 65 dBA

outdoors or up to 65 dBA in residences. It points that at least 20 dBA noise abatement is necessary for standard buildings. Thus, the lower limit of the indoor Ldn value is 45 dBA. The abatement requirements in the regulations are determined based on this limitation. HUD's assumptions as a guide for land uses are given in Chart 1 (Demirkale, 2007; Aktaş, 2016).

Chart 1. American Guidelines for Land Users in Housing and Urban Planning (Demirkale, 2007; Aktaş, 2016)

Land use category	Fully acceptable	Can be regarded as normal	Cannot be considered normal	Totally unacceptable
Residences, classrooms, churches, libraries, hospitals, infirmaries, sports areas (inside and outside)	**< 60**	**60 - 65**	**65 - 75**	**> 75**
Short-term used rooms	**< 65**	**65 - 70**	**70 - 80**	**> 80**
Auditoriums, concert halls	**< 50**	**50 - 60**	**60 - 70**	**> 70**
Playgrounds, parks	**< 55**	**55 - 65**	**65 - 75**	**> 75**
Golf courses, riding areas, water recreation areas, cemeteries	**< 60**	**60 - 70**	**70 - 80**	**> 80**
Office buildings, recreation, theaters, restaurants	**< 65**	**65 - 75**	**75 - 80**	**> 80**
Wholesale, industrial, manufacturing, public service	**< 70**	**70 - 80**	**80 - 85**	**> 85**
Manufactories, communications	**< 55**	**55 - 70**	**70 - 80**	**> 80**
Farming	**< 60**	**60 - 75**	**75 - 80**	**> 80**
Wide area natural recreation areas	**< 60**	**60 - 75**	**75 - 85**	**> 85**

Outdoor noise limits for Portugal are shown in Chart 2. According to Portuguese legislation, limit values of sensitive areas are 55 dBA between 07.00-22.00 and 45 dBA between 22.00-07.00. Sensitive areas include such places as residences, schools and hospitals. However, limit values in mixed areas providing trade and services are determined as 65 dBA between 07.00-22.00 and 55 dBA between 22.00-07.00 (Coelho, 2003).

Chart 2. Outdoor noise limits (dBA) according to the Portuguese 3rd Noise Law (Rocha, 2007)

Area Usage	All day (Lden)	Night (Ln)
Mixed Areas	Lden = 65 dBA	Ln = 55 dBA
Sensitive Areas	Lden = 55 dBA	Ln = 45 dBA
Sensitive Areas (Near an existing highway)	Lden = 65 dBA	Ln = 55 dBA
Sensitive Areas (Near a planned main road)	Lden = 60 dBA	Ln = 50 dBA
Sensitive Areas (Near a planned airport)	Lden = 65 dBA	Ln = 55 dBA
Unclassified Areas	Lden = 63 dBA	Ln = 53 dBA

5. NOISE FACTOR AND ABATEMENT PRECAUTIONS IN AIRPORTS

The noise of airplanes, used in airline transportation and the fastest and most comfortable mode of transportation today, threatens the health of airport employees, residents and workplaces around the airport. The noise sources at airports consist of air traffic density, types of airplanes landing on the airport, types of engines used in airplanes, road vehicles arriving at and departing from the airport and providing ground services at the airport. In particular, the air traffic, motor power used and size of the airplane are sources that affect noise significantly (Lambert et al, 2015; Dursun et al, 2017).

The factors causing noise in the framework program about noise at airports should be identified. The noise should be minimized taking into account the demands and requests of airline companies and residents of the settlements around the airport. Thus, being a social responsibility, social duties against the environment and airport users will be fulfilled (Dursun et al, 2017; Korul, 2003).

There are many procedures applied to reduce the intensity of the noise caused by the airport activities, to eliminate the reaction of the society, to ensure that people are less affected by airplane noise and to operate in a quieter way (Dursun et al, 2017; Horonjeff et al, 2010).Those procedures are:

- ✓ The use of several methods to reduce noise
- ✓ Limitation of night flights
- ✓ Controlling and inspecting airplane noise levels
- ✓ The use of appropriate lands
- ✓ The use of appropriate runways
- ✓ Measuring the noise with audiometers.

Figure 3 shows the programs applied and relationship between them to reduce noise at the airports.

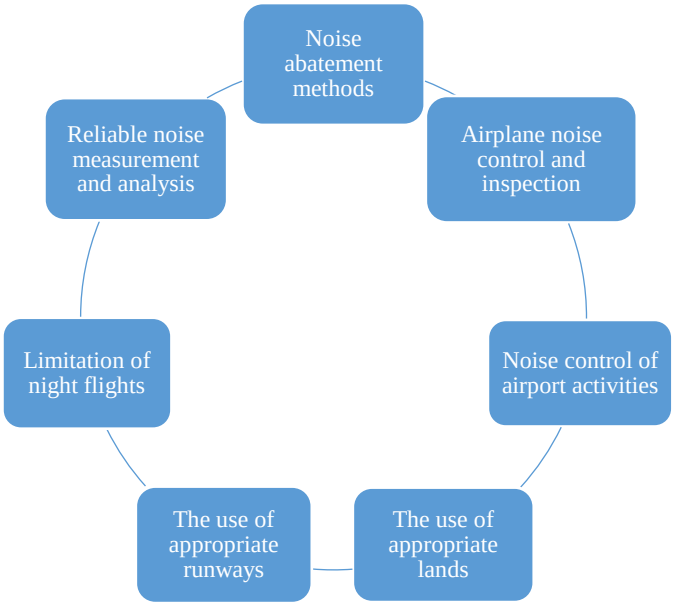


Figure 3. The programs used to reduce noise at the airports (Horonjeff et al, 2010)

The noise limitations entail the use of operation procedures to reduce noise levels in the near areas. For the selection of specific approach and take-off routes and specific stages of operation, adjustment of engine thrust settings consist the airplane noise abatement procedures that are currently applied. Furthermore, airplane engine and auxiliary power units (APU) operating on the ground can be controlled by the movement of airplane on the ground and noise from certain airport construction activities.

Reducing the effects of noise can be ensured by;

a. Land use planning
b. Acoustic barriers (Şahin, 2007).

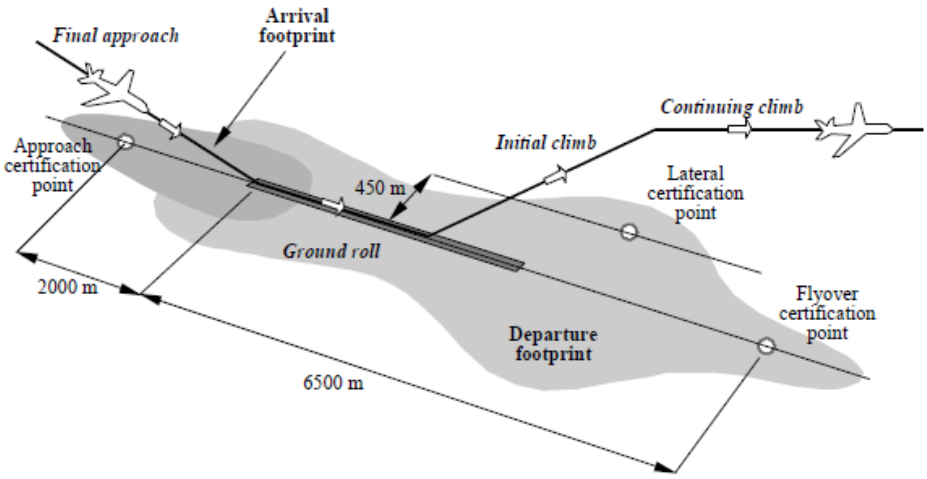


Figure 4. Expression of certification reference points (ECAC.CEAC Doc 29, 2016)

The noise certification tests have been adopted by ICAO and all airplane manufacturing states. The single case noise levels are determined in three reference points:

- ✓ Approaching below the landing road 2000 m before the landing threshold,
- ✓ Lateral (or sideline) at the noisiest point on a line 450 m from the edge of the first climb after the take-off,
- ✓ Overpass of 6500 m. under the take-off and climb road.

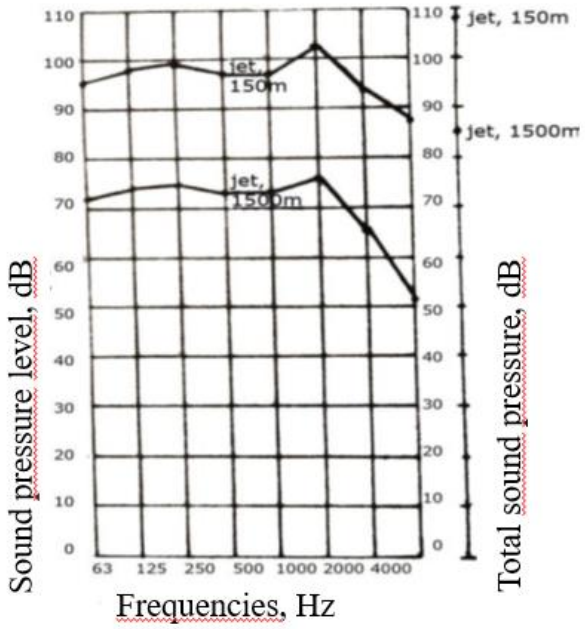


Figure 5. The noise spectrum of the airplane at an altitude of 150 m and 1500 m (Yılmaz, 2007; Keskin, 2014)

Figure 5 shows the noise spectrum of a four-engine commercial jet airplane at 150 m and 1500 m altitude just above the measuring device.

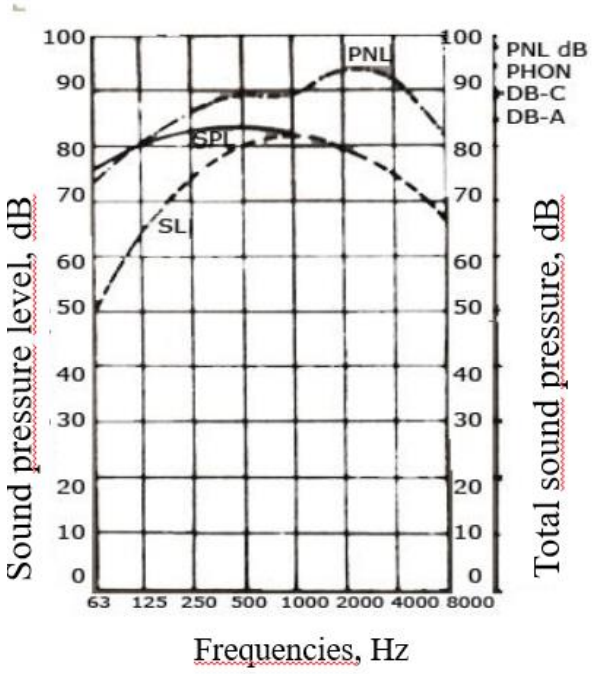


Figure 6. Jet noise spectrums expressed by A-weighted sound levels and perceived noise levels (PNdB) (Yılmaz, 2007; Keskin, 2014)

Figure 6 shows the spectrums of another jet aircraft measured with an electro-acoustic system separately in the form of sound pressure levels and perceived noise levels (PNdB). As it can be seen, the total sound pressure level is 89 dB. The dashed curve is the measured sound spectrum of the same noise when brought to scale A. Therefore, the sound level is 85 dBA. However, the curve in the form of dot-dash is the sound spectrum of the same noise measured by bringing the sound level scale to scale N. The perceived sound pressure level is 98 PNdB (Yılmaz, 2007; Keskin, 2014).

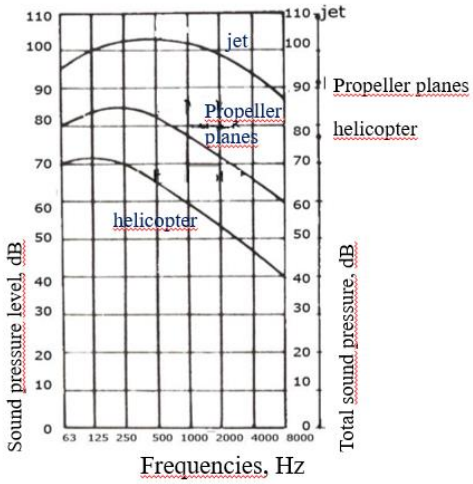


Figure 7: The noise spectrum measured at a distance of 150 m (Yılmaz, 2007; Keskin, 2014)

Figure 7 shows the noise spectrums of a big jet plane, a medium scale of 30,000 lbs fully laden propeller airplane like DC-3 and a piston powered helicopter weighing less than 10,000 lbs (Yılmaz, 2007; Keskin, 2014).

5.1. Directing Features

Yılmaz (1979) showed that the sound emitted from a point source spread in circles. Thus, the sound level is identical at every point on a circle. However, the sound levels at equal distances from the source are not the same in airplanes. As shown in Figure 8, the sound level of an airplane in the center of a circle is highest at the 135th and 225th degrees. This feature is called the directing patterns of airplanes. Directing patterns of airplanes depend on the number of jet engines, the final approach, the number of mufflers, type and nozzle diameter.

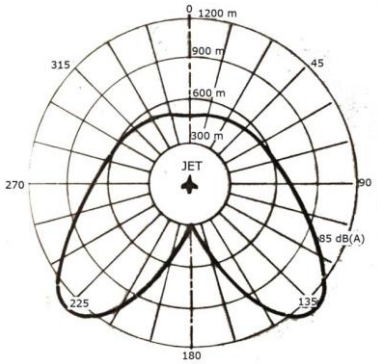


Figure 8. Directing pattern of a jet airplane (Yılmaz, 2007; Keskin, 2014)

Figure 9 shows the area affected by an airport at vertical angles. The straight lines indicate the approximate contour of 100 PNdB of a passenger jet on the ground. The take-off and landing points show the center of the circle (Yılmaz, 2007; Keskin, 2014).

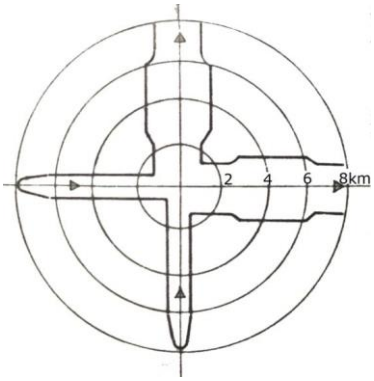


Figure 9. The area where airplane noise is affected (Yılmaz, 2007; Keskin, 2014)

Pietrzko and Hoffman (1987) stated that directional features of airplane noise propagation are based on simultaneous records of acoustic and geometric information. Acoustic measurements are done at different ground positions and are synchronized with tracking radar data. When processing the data, the global propagation, atmospheric absorption and delay times between the source and receiver are considered. The result states a simple analytical explanation of the directing pattern of the aircraft in-flight as a group of coefficients assigned for each airplane. The coefficients are obtained as curves based on the acoustic and geometric data. These take place as a series of polynomials that provide valid results as distances and emission angles over a wide range. For subsonic airplane in-flight, A-weighted sound level can be predicted accurately. Also, the duration of overhead flight noise history can be simulated for any observation point according to the flight path. As shown in Figure 10, the inclined distance is measured by the closest approach point (A) between an observer (M) on the ground and a flight path.

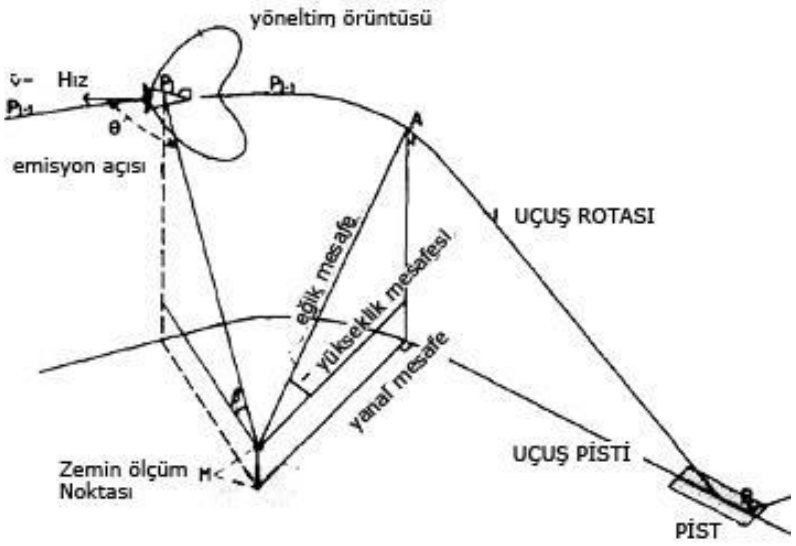


Figure 10. Geometric model for airplane noise estimation (Keskin, 2014; Pietrzko et al, 1987)

5.2. Noise Mapping

The 2002/49/EC Directive of the European Parliament and Council dated June 25, 2002 on the assessment and management of environmental noise requires the member states and their competent authorities to draw up a noise map with its related data. This directive applies to noise to which people are exposed in certain areas, public parks or other quiet areas with settlements, quiet areas on open lands, schools, hospitals and other sound-sensitive buildings and areas. Environmental noise is known as harmful or unwanted external noise formed by human activities (Çevre ve Orman Bakanlığı, 2007).

The concept of harmful effects should be known as adverse effects on human health. Strategic noise map means a map designed for global assessment of noise exposure within given areas due to various noise sources and for general precautions in those areas (Çevre ve Orman Bakanlığı, 2007).

The member states have to authorize the institutions and organizations with appropriate authorization for the enforcement of this directive. Responsibilities of the competent authority:

(a) to make and approve noise maps to appropriate areas and to prepare action plans for residential areas, major highways, railways and airports,

(b) to gather noise maps and action plans.

As indicated in Annex-2 (1) of the Regulation on Assessment and Management of Environmental Noise, L_{den} and L_{night} values are determined by calculation or assessment (L_{den} = day - evening - night). Day (112 hours: 7.00 – 9.00), evening (4 hours: 19.00 – 23.00), night (8 hours: 23.00 – 7.00).

$$L_{gag} = \frac{1}{24}\left[12x10^{\frac{L_{gündüz}}{10}} + 4x10^{\frac{L_{akşam+5}}{10}} + 8x10^{\frac{L_{gece+10}}{10}}\right]$$

In the formulation:

- ✓ Lday, ISO 1996-2: As determined in 1987, it is a long-term volume weighted average level and is evaluated in daytime periods throughout a year.
- ✓ Levening, ISO 1996-2: As determined in 1987, it is a long-term volume weighted average level and is evaluated in evening periods throughout a year.
- ✓ Lnight, ISO 1996-2: As determined in 1987, it is a long-term volume weighted average level and is evaluated in night periods throughout a year.

6. EXAMINATION OF AIRPORT NOISE IN BATMAN CASE

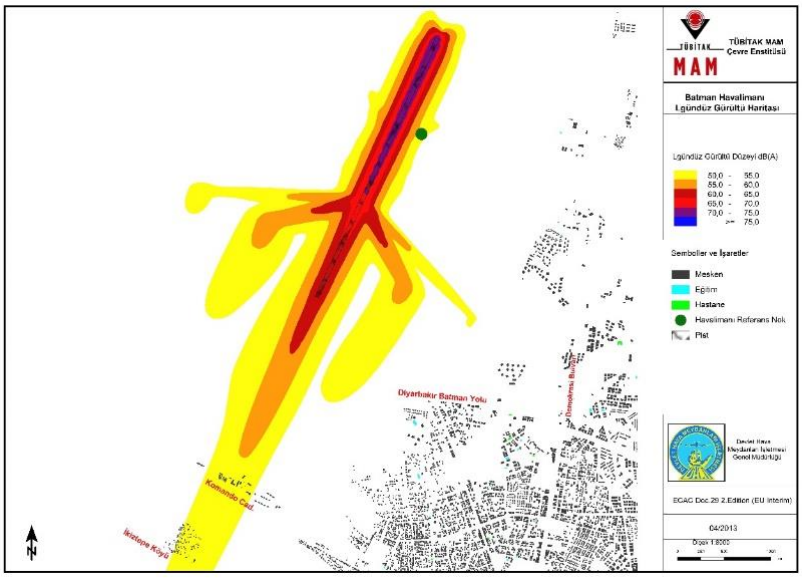
Chart 3 shows the acceptable environmental noise limits around the airport according to the Regulation on Assessment and Management of Environmental Noise.

Chart 3. Environmental noise limit values for the airport

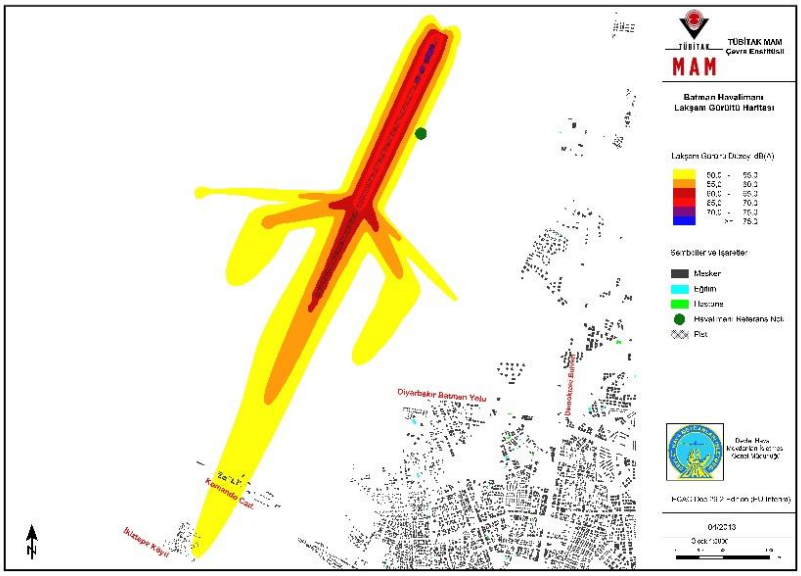
Fields	**Small airports (airports with less than fifty thousand landings / takeoffs per year)**			**Large airports (Airports with fifty thousand or more landings / takeoffs per year)**		
	L_{day} (dBA)	**$L_{evening}$ (dBA)**	**L_{night} (dBA)**	**L_{day} (dBA)**	**$L_{evening}$ (dBA)**	**L_{night} (dBA)**
Areas in which there are mainly education, culture and health areas besides summer resorts and camping among the noise-sensitive usages	63	58	53	65	60	55
Areas in which there are commercial buildings and noise-sensitive usages along with dense residences	65	60	55	68	63	58
Areas in which there are commercial buildings and noise-sensitive usages along with dense workplaces	67	62	57	72	67	62
Industrial areas	70	65	60	75	70	65

Photo 1. Batman airport drawings [Ergen, Y.B. archive (1-2-3-4),23 (5-6-7)]

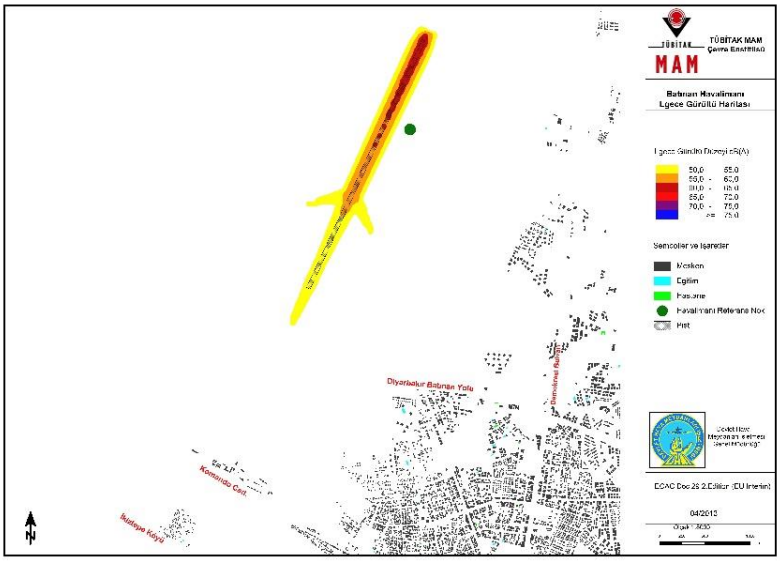
Day, evening, night and Lgag noise maps of Batman airport are provided below.



Map 1. Batman daytime noise map (Provincial Directorate for Environment and Urbanization)



Map 2. Batman evening noise map (Provincial Directorate for Environment and Urbanization)



Map 3. Batman night noise map (Provincial Directorate for Environment and Urbanization)

Yellow regions have noise levels of 50-55 dBA, orange regions have 55-60 dBA, dark red regions have 60-65 dBA, red regions have 65-70 dBA, purple regions have 70-75 dBA and dark blue regions have 75 dBA. This situation of the airport environment and the lack of settlement in its immediate environment provide positive results in terms of impact on people, while the levels are high for other living creatures.

The information provided by the noise maps shows that day and evening limit values are met with the noise level of 55 dBA around İkiz Tepe village, yet the night value remains at the limit. This may become an important problem with the construction and transfer of the airport capacity to large airports category.

7. RESULTS AND SUGGESTIONS

The day and evening limit values are met with the noise level of 55 dBA in the settlement area around the airport (İkiz Tepe village), yet the night value remains at the limit. However, there is no forestation around the airport.

Reflection of the noise effects on living creatures in the form of urban settlement is land use and urban settlement. Therefore, to resolve negativities that may stem from the noise and prevent it;

1. The noise source and the harmful circle in its immediate environment should be determined and deemed as a "protected area",
2. In planning phase, sound muting and absorbing arrangements should be made between the source of noise and the housing units,
3. While the problem is solved in terms of land use around the airport, the airplane noise which is non-similar to other noise sources should be designed in such a way that the air corridor of the plane taking off never comes over the urban settlement area,
4. When choosing a place for the source of noise, the criteria for the degradation of the natural balance are examined and the areas in a suitable location are preferred,

and as a result, maximum benefit can be achieved. As a result, by applying the proposed method, the damages that cannot be repaired artificially in the form of urban settlement and in the natural environment of the noise generated in line with the precautions may have been prevented.

The city structure that develops with the structuring will also reflect into airport area. Important measures include imposing restrictions and not violating these restrictions considering the airport area of this structuring.

Furthermore, the current noise measurements can be done and the noise level can be controlled as much as possible with the noise maps planned to be revised at certain intervals (every 5 years).

Considering that day and evening noise levels affect the airport area in the light of the information on the maps, attentive regulations of flight times can also reduce the noise effect.

Since Batman airport area is a land open to new settlements, the noise predictions should be considered in land use planning and the regulations should never allow construction in the areas that are detected to exceed the noise limits for day, evening and night.

Building height around the airport should be rearranged considering the noise studies.

Preventing the buildings close to the airport from noise effects is believed to be successful through artificial or natural soil grading of barrier applications like barriers around the airport. Paying attention to floor heights can be effective. Also, facade noise studies can be carried out to determine the required storey heights in buildings.

Local governments should increase sensitivity on noise and carry out solution-oriented studies.

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