AN IN-DEPTH EVALUATION OF NOISE MANAGEMENT AND SOUNDSCAPE POLICIES: A PROPOSAL ON INTEGRATING INDOOR SOUNDSCAPING TO DESIGN AND APPLICATION PROCESS

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AN IN-DEPTH EVALUATION OF NOISE MANAGEMENT AND SOUNDSCAPE POLICIES: A PROPOSAL ON INTEGRATING INDOOR SOUNDSCAPING TO DESIGN AND APPLICATION PROCESS

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ABSTRACT

AN IN-DEPTH EVALUATION OF NOISE MANAGEMENT AND SOUNDSCAPE POLICIES: A PROPOSAL ON INTEGRATING INDOOR SOUNDSCAPING TO DESIGN AND APPLICATION PROCESS

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Improvement of the importance of acoustic environment quality has revealed a discussion about sufficiency of noise interventions to fulfill the requirements of people on acoustic environment. Developing soundscape studies and policies states that soundscape approach, which considers noise interventions as well, should replace noise management. However, the considerable amount of soundscape studies, regarding urban scaled soundscape, deals with acoustic quality of open public spaces. In addition, a crucial gap has found in the field of indoor soundscaping, as a result of critical literature review and literature matrix that is prepared in this study. This thesis aims to investigate indoor soundscaping principles and factors and the possibility of integration of the indoor soundscaping to architectural design process and application. Since the most convenient attempt for this integration can be possible with the governmental enforcements, a regulatory approach regarding indoor soundscaping is considered in this study. To propose a model for integration process, and to find out the relevancies between noise management and soundscape approach, current governmental documents (regulations, standards and guidelines) that have been used in noise management applications in Turkey and Europe are evaluated and compared within the scope of this study. As a result of the analysis five stages are observed that can be used in indoor soundscape integration process; (1) establishment of a topic specific institution or working group on indoor soundscaping; (2) preparation of a standard including definitions, indoor soundscape factors and methods; (3) preparation of indoor soundscape directive; (4) preparation of indoor soundscape guideline; (5) providing maintenance and supervision by experts and authorities.

Keywords: Soundscape standardization, Soundscape Application, Noise management, Indoor soundscaping

ÖZ

GÜRÜLTÜ YÖNETİMİ VE İŞİTSEL PEYZAJ POLİTİKALARININ DETAYLI DEĞERLENDİRİLMESİ: İÇ MEKAN İŞİTSEL PEYZAJ İLKELERİNİN TASARIM VE UYGULAMA SÜRECİNE DAHİL EDİLMESİ HAKKINDA ÖNERİ

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İşitsel ortam kalitesinin öneminin artmasıyla birlikte, insanların işitsel ortamdaki gereksinimlerini yerine getirmek için gürültü müdahalelerinin yeterliliği konusunda bir tartışma ortaya çıkmıştır. İlerleyen işitsel peyzaj çalışmaları ve politikaları, gürültü müdahalelerini de göz önünde bulunduran işitsel peyzaj yaklaşımının gürültü yönetiminin yerini alması gerektiği fikrini ortaya çıkarmıştır. Bununla birlikte, kayda değer miktarda işitsel peyzaj çalışması açık kamusal alanlardaki işitsel ortamın kalitesini ele alan, kentsel ölçekli işitsel peyzajla ilgilidir ve bu çalışmada yapılan eleştirel literatür taraması ve hazırlanan literatür matrisi sonucunda iç mekan işitsel peyzaj alanında önemli bir boşluk bulunmuştur. Bu tez, iç mekan işitsel peyzaj ilkelerini, etkenlerini ve mimari uygulama ve tasarım sürecine entegrasyon olasılığını incelemeyi amaçlamaktadır. Bu entegrasyon için en uygun girişim hükümet tarafından yürütülecek yaptırımlarla mümkün olabileceğinden, bu çalışmada iç mekan işitsel peyzaja ilişkin yönetmelik hazırlanmasına yönelik bir yaklaşım ele alınmıştır. Entegrasyon süreci için bir model önermek ve gürültü yönetimi ile işitsel peyzaj yaklaşımı arasındaki ilişkiyi bulmak için, gürültü yönetimi uygulamalarında kullanılan mevcut resmi belgeler (yönetmelikler, standartlar ve kılavuzlar) bu çalışmada, Türkiye ve Avrupa kapsamında karşılaştırılarak değerlendirilmiştir. Bu analizler sonucunda, iç mekan işitsel peyzaj entegrasyonu sürecinde kullanılabilecek beş aşama gözlenmiştir; (1) konuyla ilgili bir kurum veya çalışma grubunun kurulması; (2) konuyla ilgili tanımlar, iç mekan işitsel peyzaj faktörlerini ve yöntemlerini içeren bir standardın hazırlanması; (3) iç mekan işitsel peyzaj yönetmeliğinin hazırlanması; (4) iç mekan işitsel peyzaj kılavuzunun hazırlanması; (5) uzmanlar ve yetkililer tarafından devamlılık ve denetimin sağlanması.

Anahtar Kelimeler: İşitsel peyzaj standardizasyonu, İşitsel Peyzaj Uygulamaları, Gürültü Yönetimi, İç Mekan İşitsel Peyzajı

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LIST OF ABBREVIATIONS

ISO	International Organization for Standardization
COST	European Cooperation in Science and Technology
SSID	Soundscape Indices
EC	European Commission
ERC	European Research Council
EU	European Union
EEA	European Environment Agency
SPL, L_P	Sound Pressure Level
L_{eq}	Equivalent Continuous Sound Level
L_W	Sound Power Level
RT	Reverberation Time
EDT	Early Decay Time
SII	Speech Intelligibility Index
STI	Speech Transmission Index
Pa	Pascals
W	Watts

dB	Decibel
IEC	International Electro Technical Commission
SI	Speech Intelligibility
WHO	World Health Organization
IHD	Ischemic Heart Diseases
DALY	Disability-Adjusted Life Year
YLL	Years of Life Lost
YLD	Years Lost Due to Disability
STC	Sound Transmission Class
HVAC	Heating Ventilating and Air Conditioning
IN	Issue Number of Official Journal
TSE	Turkish Standard Institution
TS	Turkish Standard

CHAPTER I

INTRODUCTION

With the rapidly improving urbanization, the environment that we live in is losing its livability. These conditions affect both the psychological and physiological health of the people. One of the foremost research fields to enhance the environment is "soundscape" that concentrates on ecological, urban and indoor sound environments, which focuses on improving the quality and pleasantness of sound environment. Soundscape is multi-factorial study field in comparison with noise management. Additional to acoustical measurements, urban and ecological soundscape deals with human perceptual assessments of an acoustic environment. Besides, indoor soundscape field considers architectural characteristics of an enclosure as well, unlike urban and ecological soundscape. Most of the studies in the literature about noise assert the negative effect of disturbing sound environments which is mostly occurred by the artificial or manmade sounds. However, soundscape concerns both management of positive sounds and masking of negative sounds (Brown, 2012). This approach shows that noise management is insufficient by itself and reveals the necessity of soundscape assessment should be considered as part of the design process and managed by people to create a healthy sound environment. Otherwise the sounds that are heard may be perceived as disturbing or meaningless even if all unwanted sounds that are considered as noise has been masked. As Schafer (1977) asks: "Is the soundscape of the world an indeterminate composition over which we have no control, or are we its composers and performers, responsible for giving it form and beauty?" (p.5).

Ability of designing sustainable soundscapes and the necessity of it, have led to a new discussion on standardization of soundscapes. In 2008, International Organization for

Standardization (ISO) established a new working group which was entitled "perceptual assessment of soundscape quality" (ISO/TC 43/SCI/WG 54) and published the first part of the standardization "ISO 12913-1 Acoustics-Soundscape-Definition and conceptual framework" in 2014. Second part of the standardization "ISO/TS 12913-2:2018 Acoustics-Soundscape- Part 2: Data collection and reporting requirements" was published in 2018. Working group; not only focuses on the management of annoying sounds but also incorporates with the positive effects of the whole sound environment that is perceived by people (Brown, Kang & Gjestland, 2011). This focal point of the working group also represents the difference of soundscape from noise management and demonstrates that noise management is included in the broader soundscape research field. After that, between the years 2009 and 2013, European Cooperation in Science and Technology (COST) had been conducted a project named "Soundscape of European Cities and Landscapes" which aimed the improvement of soundscape in an international and interdisciplinary scope. Besides, as an ongoing study, in March 2018, a project under the title "Soundscape Indices" (SSID), has been organized and funded by European Commissions (EC)'s European Research Council (ERC) in order to begin a process on characterizing soundscapes, analyzing soundscape factors and integration of soundscape to architectural design.

ISO working group, COST action on soundscape and SSID study has been studying soundscape integration, quality, methods and parameters of open public spaces in an urban scale. However, indoor soundscape quality, which is a more recent research topic, is as important as the urban soundscape and directly involves the users. Therefore, its standardization and implementation in the architectural design and application process is very crucial in order to improve indoor acoustic environments.

In addition, understanding and evaluation of the governmental policies on noise management have an importance to discuss the possible future soundscape implementation enforcements and to find out the deficiencies and the interrelation between the noise management and soundscaping. As for that, the governmental documents on noise management which are regulations/directives, standards and guidelines should be assessed. In this study, European and Turkish region have been selected for the evaluation of noise management policies in a comparative manner.

1.1. Gap in the Literature

When the present policies on noise management and soundscape are assessed in both Turkey and Europe, it is seen that there has been a concurrent process in terms of noise management. However, it is observed that the soundscape policies in Turkey has not been enhanced as much as in Europe. Although, European Union (EU) has an improving and progressing process on urban soundscape integration on application process, governmental enforcements or documents have not been revealed yet, except the ISO standard 12913-1 (ISO, 2014) and European Environment Agency's (EEA) guideline on quite areas (EEA, 2014). Besides, both in Turkey and Europe there are not any existing governmental policies related to the integration of indoor soundscaping to architectural design and application process, which is a more recent field in comparison to the urban soundscaping.

1.2. Aim and Scope

The essential aim of this study is, to examine the possibility of indoor soundscape integration to application and design process through the review of the current literature in detail and analyzing the present policies related with noise management and soundscape in Turkey and Europe. Also, this study aims to find out whether the present regulations, standards and guidelines on noise management and soundscape are sufficient to lead a possible future indoor soundscape governmental enforcements in order to improve the pleasantness and livability of indoor acoustic environments. In addition, identification and categorization of soundscape factors are presented in order to propose an integration model of indoor soundscaping, with the architectural design and application process.

1.3. Structure of the Thesis

The thesis consists of six main chapters, starting with the introduction that includes general information about the subject, gap in the literature, aim and scope, and structure of the thesis.

Design of the study is explained in chapter two under the title of methodology. This chapter consists of research questions, objectives of the thesis, hypothesis and methods that used in the study.

Third chapter reviews the literature related with soundscape concept starting with definitions of acoustic environment and soundscape and categorization of sound sources. This chapter continues with the identification of indoor soundscape factors in three main parts as acoustical, contextual and architectural factors, and data gathering methods of these factors. Soundscape mapping, and soundscape policies of Turkey and EU is also included in third chapter.

The fourth chapter of the thesis is related with the noise management which includes definitions of noise and noise sources, statement of health effects of noise and management to define the interventions of noise. Besides, comparative analysis between Turkey and Europe, regarding present noise management regulations, acoustical standards and noise guidelines, are included in fourth chapter.

Chapter five discusses how to integrate indoor soundscape to architectural design and application process, depending on the literature review of thesis and noise management policies in Turkey and Europe, and presents a proposal model on integration process. The thesis concludes with the sixth chapter which is followed by the references and appendix.

CHAPTER II

METHODOLOGY

2.1. Research Questions

Under the scope of the thesis, four main research questions are aimed to study. These research questions respectively are;

- What are the effecting factors of soundscaping that are identified in the current related literature?

- What are the current policies on urban and indoor soundscape in Turkey and Europe?

- What are the current noise management policies in Turkey and Europe?

- How the indoor soundscaping can be integrated into architectural design and application process?

2.2.Objectives

The main four objectives of the thesis aim to fulfill the research questions. The objectives of the study respectively are;

- To identify the indoor soundscape factors and methods and to propose merged models;

- To assess the current policies on urban and indoor soundscape in Turkey and Europe and identify the gaps or deficiencies if they have;

- To evaluate present policies on noise management in a comparative attitude between Turkey and Europe;

- To investigate the possibility of integration of indoor soundscape to architectural process and to propose an integration model.

2.3. Hypothesis

The essential hypothesis of this study is the gap in the governmental enforcements on the application process of indoor soundscaping both in Turkey and Europe. As a result of this gap the enhanced and pleasant indoor spaces cannot be provided.

Second hypothesis is the current noise policies' inability to create a required and qualified soundscape. Hence, it is more beneficial to execute noise policies under the scope of soundscape approach.

The third hypothesis is there is a deficiency of standardization and/or identification of indoor soundscape factors under the scope of the governmental institutions.

The last hypothesis of this study is that, European soundscape policies and actions are more improved in comparison to Turkey.

2.4. Methods

In the thesis, to fulfill the objectives, three methods are used;

- Systematic literature matrix preparation in order to find the gaps in the literature and governmental enforcements;

- Critical literature review to identify soundscape factors and create a merged model;

- Structured and topic specific comparison in selected regions as Turkey and Europe, regarding the noise management and soundscape policies.

2.4.1. Systematic Literature Matrix

A systematic literature matrix is prepared in chronologically and listed based on the literature review of the thesis (see Table 1), in order to identify the gap in the literature regarding noise management and soundscape studies. In table 1, it can be seen that the most importance has been given to noise management approach in the general frame. Regarding soundscape studies in the literature, studies in urban scale are seen more often in comparison to indoor soundscape studies. From the regulatory point of view, no documents related with urban and/or indoor soundscape except the ISO 12913-1 (ISO, 2014) and EEA's guideline (EEA, 2014) on urban soundscape. When the established working groups are evaluated, promising projects can be seen in terms of urban soundscape, but unfortunately it cannot be seen for indoor soundscape approach. In conclusion, it is observed from the prepared matrix that there is a critical gap both in the literature and governmental policies regarding principles and application of indoor soundscaping.

Table 1 A systematic matrix on sources in the literature, regarding noise management and soundscape approach.

Scope / Sources	Environmental Noise	Indoor Noise	Health Effects of Noise	Urban Soundscape	Urban Sound Sources	Urban Soundscape Factors and/or Methods	Application of Urban Soundscape	Indoor Soundscape	Indoor Sound Sources	Indoor Soundscape Factors and/or Methods	Application of on Indoor Soundscape
Studies/Researches in Literature											
Mathers, Smith & Concha, 2000	X		X								
Gage et al., 2004				X	X						
Jarup et al., 2008	X		X								
Herranz-Pascual, Aspuru & García, 2010				X		X					
Hygge & Kjellberg, 2010	X		X								

Brown, Kang & Gjestland, 2011	X			X	X						
Brown, 2012	X			X		X	X				
Özçevik & Yüksel, 2012				X		X					
Davies et.al., 2013				X		X					
Bruce and Davies, 2014				X		X					
Aletta & Kang, 2015	X				X		X				
Hygge & Kjellberg, 2010; Stansfeld & Clark, 2015	X		X								
Stansfeld & Clark, 2015	X		X								
Aletta, Kang & Axelson, 2016				X		X					
Brown, Gjestland & Dubois., 2016				X							
Dökmeci & Kang, 2016								X		X	
Kang et.al., 2016	X				X		X				
Lindborg, 2016								X	X		
Brown & van Kamp, 2017	X		X								
Eurofound, 2017	X		X								
Guski, Schreckenberg & Schuemer, 2017	X		X								
Nieuwenhuijsen, Ristovska & Dadvand, 2017	X		X								
Śliwińska-Kowalska & Zaborowski, 2017	X		X								
Aburawis and Dökmeci, 2018								X	X	X	
Basner & McGuire, 2018	X		X								
Clark & Paunovic, 2018b	X		X								
Clark and Paunovic, 2018a	X		X								
van Kempen et al., 2018	X		X								
Directives											
2000/14/AT, 2000	X										
70/157/AT, 2000	X										
Council directive 2000/14/EC, 2000	X										

Council directive 2002/49/EC,2002	X										
Council directive 2003/10/EC, 2003		X									
Council directive 2007/46/EC, 2007	X										
2002/49/EC, 2010	X										
Çalışanların gürültü ile,2013		X									
Council directive 598/2014, 2014	X										
Binaların gürültüye karşı, 2017		X									
Guidelines											
WHO, 1999	X		X								
Good practice, 2007	X										
Gürültü haritalandırma, 2008	X										
WHO, 2009	X		X								
EEA, 2010	X		X								
Çevresel gürültü, 2011	X		X								
WHO, 2011	X		X								
EEA, 2014	X				X		X				
Gürültü azaltım, 2015	X										
WHO, 2018a	X		X								
WHO, 2018b	X		X								
WHO, 2018c	X		X								
WHO, 2018d	X										
Standards											
ISO, 2014				X	X	X					
ISO, 2018				X	X	X					
Working Groups/Projects funded by Governments											
COST Action				X		X	X				
ISO/TC 43/SCI/WG 54				X		X					
SSID				X		X	X				

CHAPTER III

CONCEPT OF SOUNDSCAPE

3.1. Acoustic Environment and Soundscape

“Acoustic environment” and “soundscape” has different meanings or different contextual contents in terminology, as the related working group of ISO (ISO/TC 43/SCI/WG 54) clarified. Acoustic environment is defined as “sound at the receiver from all sound sources as modified by the environment” and soundscape is defined as “acoustic environment as perceived or experienced and/or understood by a person or people, in context” (ISO, 2014, p.1). In other words, acoustic, sound or sonic environment of a place is all sounds that can be heard by an individual (Brown, Gjestland & Dubois, 2016), but soundscape is involved with how acoustic environment is perceived by a person.

The term “soundscape” was emerged as a part of the World Soundscape Project in 1978 and advanced by the pioneers, Shaffer and Traux. The most essential notion that distinguishes soundscape from acoustic environment is perception. “Most authors (Porteous and Mastin 1985; Truax 1999; Finegold and Hiramatsu 2003; Gage et al. 2004; Brown and Muhar 2004; Yang and Kang 2005; Dubois et al. 2006; Kang 2006) suggest the soundscape of a place is a person’s perceptual construct of the acoustic environment of that place” (Brown et al., 2016, p.5). Indoor soundscaping is an integrative research field that correlates acoustic environments, architectural characteristics, and human perception (Dökmeci & Kang, 2016). Since soundscape can be defined as the communication between individuals and their environment through sound (Acun, 2015), the function of the environment is very important. Sound is perceived and assessed within a context through the functions of a space. These mentioned perceptual and spatial determinants of soundscape field give an initial idea about why noise regulations can be inadequate and are needed to be extended. Noise is basically uncomfortable or unhealthful sound levels, and “reducing the sound levels from certain sound sources may not necessarily result in an acoustic environment of high quality” (Aletta, Kang & Axelson, 2016, p.66). On the other hand, soundscape framework is involved with both negative and positive sounds to build human wellbeing, and allows to organize more preferred, healthy and extensive acoustic environments with its many different factors.

Another difference should be underlined that is between noise management and soundscape in order to understand soundscape approach. Basically, these two approaches have different attitudes towards sound, and different interests on outcomes. Environmental noise management deals with only unwanted sounds, but soundscape approach conceives sound as a resource. As a result, noise management is interested in negative effects of sound on people, but in soundscape study field the focus point is on “sounds of preference” (Brown, 2012) (see Table 2).

Table 2 “The different foci of environmental noise and soundscape approaches” (Brown, 2012, p.75).

Environmental Noise Management Approach	**Soundscape Approach**
Sound managed as a waste	Sound perceived as a resource
Focus is on sounds of discomfort	Focus is on sounds of preference

Soundscape and noise management differ in regards of management and measurements as well. Environmental noise management mostly concerns with physical measurements of sound. However, these measurements are not useful for determining the preference of people on soundscape (Raimbault & Dubois, 2005). Though, especially indoor soundscape approach has many dimensions in the process of management and measurement, Brown’s (2012) model, about the management differences between urban soundscape and environmental noise, helps to discriminate noise and soundscape clearly (see Table 3).

Table 3 "Differences with respect to level, measurement, and management" (Brown, 2012, p.76).

Environmental Noise Management Approach	Soundscape Approach
Human response related to level of sound	Preference often unrelated to level-quite not the objective
Measures by integrating across all sound sources	Requires differentiation between sound sources: wanted sound from unwanted sound
Manages by reducing level	Manages by wanted sounds, masking unwanted sounds

Another matter is differences between noise annoyance measurement and soundscape preference measurement that strengthen the comprehension of soundscape study field (see Table 4). In table 4, it can be seen that the fields of two notions are separated with each other. While noise has the annoyance only as an outcome, but soundscape has various preference outcomes, even included opposite ones like pleasantness. Soundscape has wide variety regarding places, activities and temporality, and contrary to noise annoyance, deals with all sound sources and all sound levels that people can perceive.

Table 4 "Situational differences between annoyance measurement and soundscape preference measurement" (Brown, Kang & Gjestland 2011, p. 391).

Annoyance measurement	Soundscape preference measurement
Single outcome (annoyance)	Many outcomes
Indoor (sometimes outdoor) at home Home activities disturbed by external noise	Many different places Many different activities
Live in that location	May be temporarily in that location
Assumes respondents aggregate their annoyance over an extended period	Unspecified assumptions regarding aggregation of perception
Usually high level of sound	Range of levels of sound
Sounds usually (though not exclusively) from transport sources	Many different sound sources

These reviews on urban soundscape and noise management basically show that why soundscape study field should be needed to enhance and why noise management is not sufficient to compose a livable and preferable sound environment.

3.2.Categorization of Sound Sources

Sound sources are defined by ISO working group basically as “sounds generated by nature or human activity” (ISO, 2014, p.1). Previously in the literature, Gage et al. (2004) presented a categorization for all sound sources in three parts as, (1) biophony, (2) geophony, and (3) anthrophony (see Figure 1). All biological organisms, except human beings, are the source of biophonic sounds; such as the sounds of animals and insects. In this proposal biophonic sounds are divided into two sub-group as intentional and incidental signals. Geophonic sounds are generated by the physical environment and natural events of earth; such as water flow, wind, earthquake, and thunder. Anthrophonic sounds are the signals, which are originated from human activities and anything human-made, as it can be seen from the sub-groups; mechanistic and oral.

However, this classification has been used in non-urban areas and is inadequate for the urban studies. Therefore, a classification has been needed in which human activities are dealt with in detail, as urban scale soundscape research mostly gets in contact with anthrophonic sounds (Brown et al., 2016).

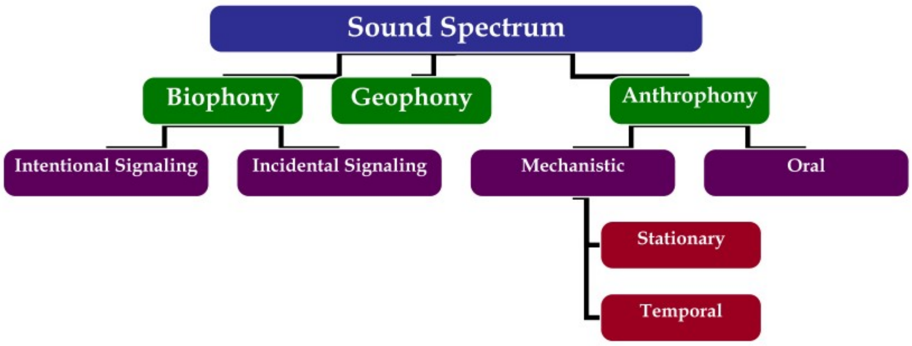

Figure 1 “Taxonomy of Acoustics” (Gage et al., 2004, n.p.)

Brown, Kang and Gjestland (2011) suggested a taxonometric system, which can be used as a "common framework or a checklist" to create a classification for all the sound sources. In their classification system (see Figure 2), the acoustic environment is divided into two main categories; "indoor acoustic environment" and "outdoor acoustic environment". "Outdoor acoustic environment" is divided into four sub-categories; "urban acoustic environment", "rural acoustic environment", "wilderness acoustic environment" and "underwater acoustic environment". In this classification, only urban acoustic environment was studied in detail. This classification chart is emerged for standardizing the sound sources for soundscape study field.

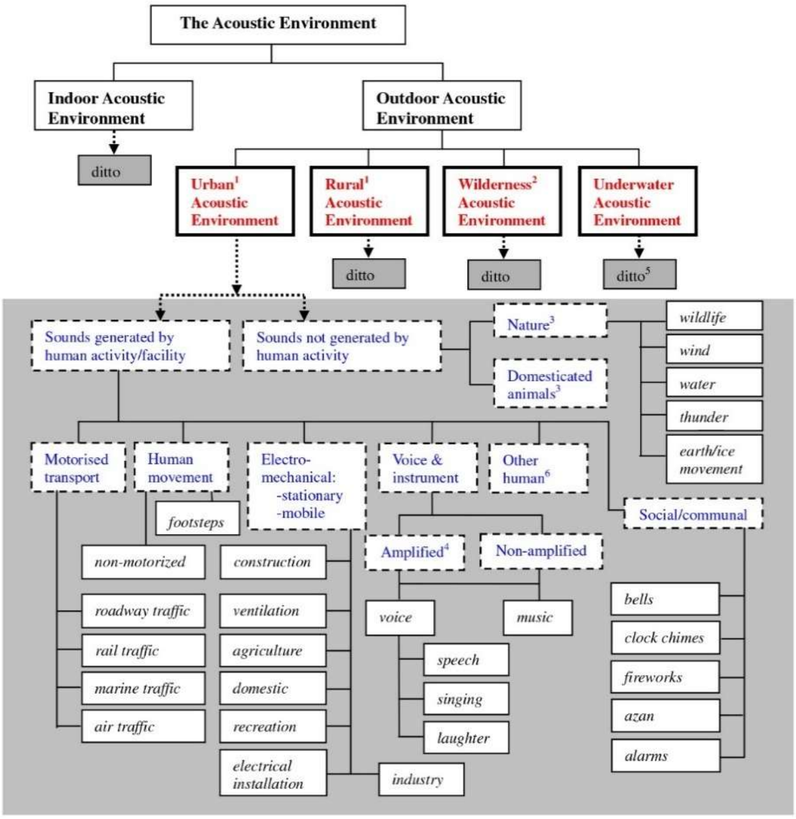

Figure 2 "A taxonomy of the acoustic environment for soundscape studies" (Brown, Kang & Gjestland 2011, p. 390).

To introduce indoor soundscape, this taxonomic approach is useful but may not be sufficient in some cases. This taxonomy of sound sources can be used as a starting point, but sound sources differ greatly in different enclosed spaces that are varied in function. Even the classification method would need some adaptations according to the topic of the indoor soundscaping study.

Since these taxonomies are inadequate, a search for a more detailed classification for indoor soundscape has been needed. Lindborg (2016) suggested a taxonomy for sound sources in restaurants (SSR) (see Figure 3). This study investigates how people experience sound in a specific context and has developed a 4-level taxonomy that can be used for restaurants (Lindborg, 2016).

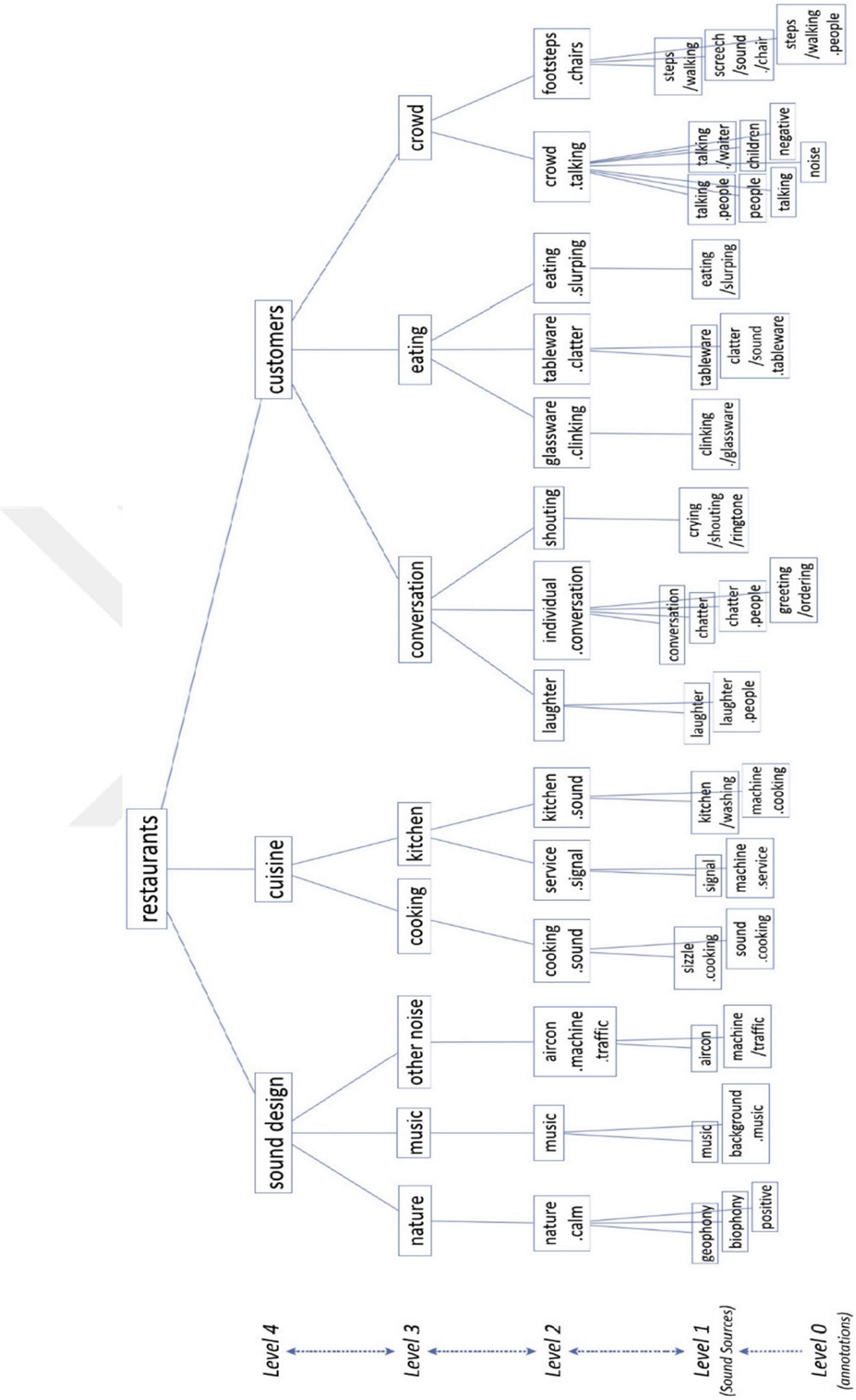

Figure 3 "Overview of the taxonomy of sound sources in restaurants (SSR)" (Lindborg, 2016, p.308).

Since the function or usage of a place has an influence on how people perceive the sounds in that environment, each place may need its own sound classification based on the function of it. For example, a loud music in a bar is acceptable and perceived as favorable, but it would be distracting and inacceptable in an office (Acun, 2015).

3.3.Soundscape Factors

Soundscape study field contact many factors additional to acoustical sound measurements. Understanding the factors of soundscape have an essential importance in order to assess the existing regulations, standards, and deficiencies of them if they have, and to propose the possible future standards and applications. Since most of these factors are more individual oriented and related with the environmental and architectural properties, the data obtained, may need to be assessed in itself for each case. For the classification of these factors there are some different proposals in the literature. In the publication of ISO about soundscape, a process diagram is suggested about the factors of urban soundscaping (see Figure 4). Seven factors are mentioned that include context, sound sources, acoustic environment, auditory sensation, interpretation of auditory sensation, responses, and outcomes (ISO, 2014). That process aims to follow interrelation between the auditory sensations and the perception on acoustic environment. However, architectural characteristics need to be inserted to "indoor soundscape" factors, because of its direct relation with sound and user. Also, architectural features have a remarkable influence on formation of sound (Dökmeci and Kang 2016).

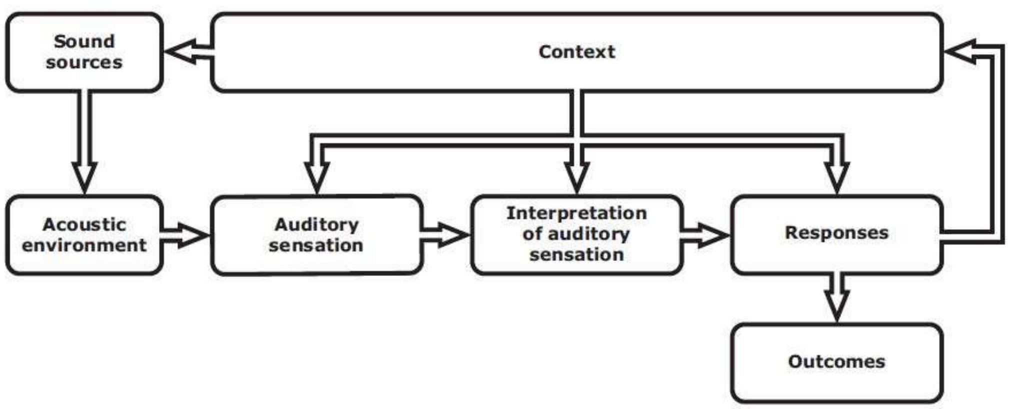

Figure 4 “Elements in the perceptual construct of soundscape” (ISO, 2014, p.2).

Dökmeci and Kang (2016), made a classification about the factors that are related with the indoor soundscape studies and proposed three main groups relied on the literature about indoor soundscape factors; sound environment, contextual experience, and built entity (see Figure 5). In that classification, under the "sound environment" title, acoustical properties (to attain objective data of sound) and psychoacoustical factors (to have subjective evaluations) are highlighted. User/audience-based data are classified as "contextual experience" which reflects the perception of user, and "built entity" factors are inserted with the subtitles; functional, spatial and environmental.

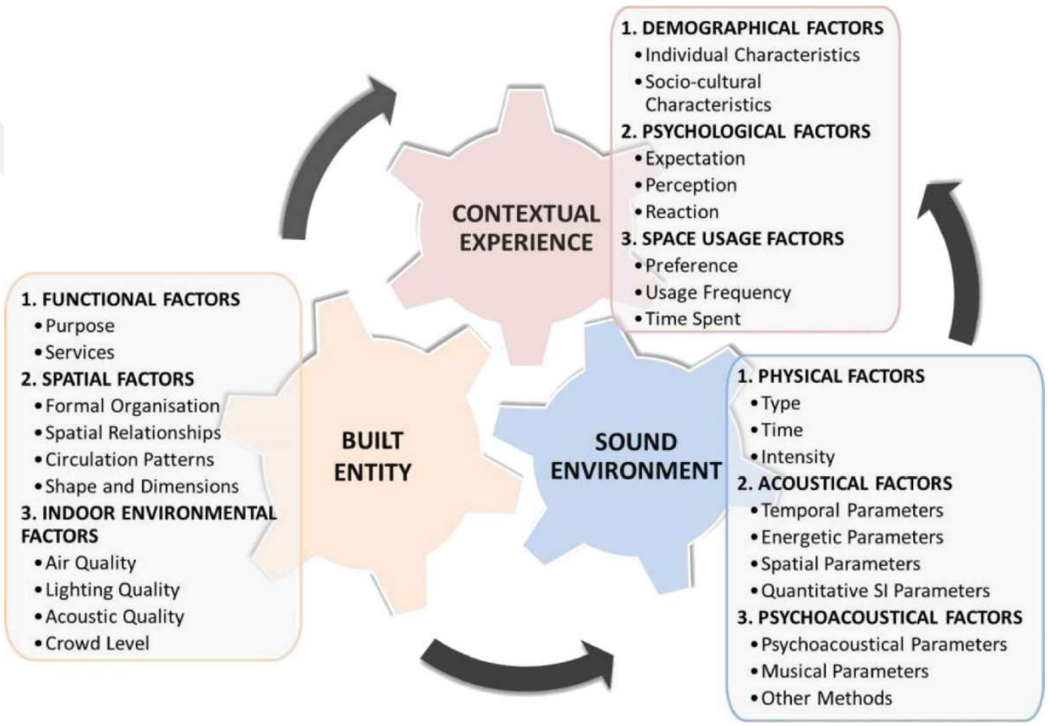

Figure 5 "Collaborative system wheel of indoor soundscaping framework with the three main variables and nine related factors" (Dökmeci and Kang, 2016, p.204).

Another integrated model of Herranz-Pascual, Aspuru and García (2010) about urban soundscape that presents the interactions between the dimensions of soundscape can be instructive for indoor soundscaping as well (see Figure 6). This model has three essential components (person, activity and place) which reveal "environmental experience", and also includes the relation between person-place interactions.

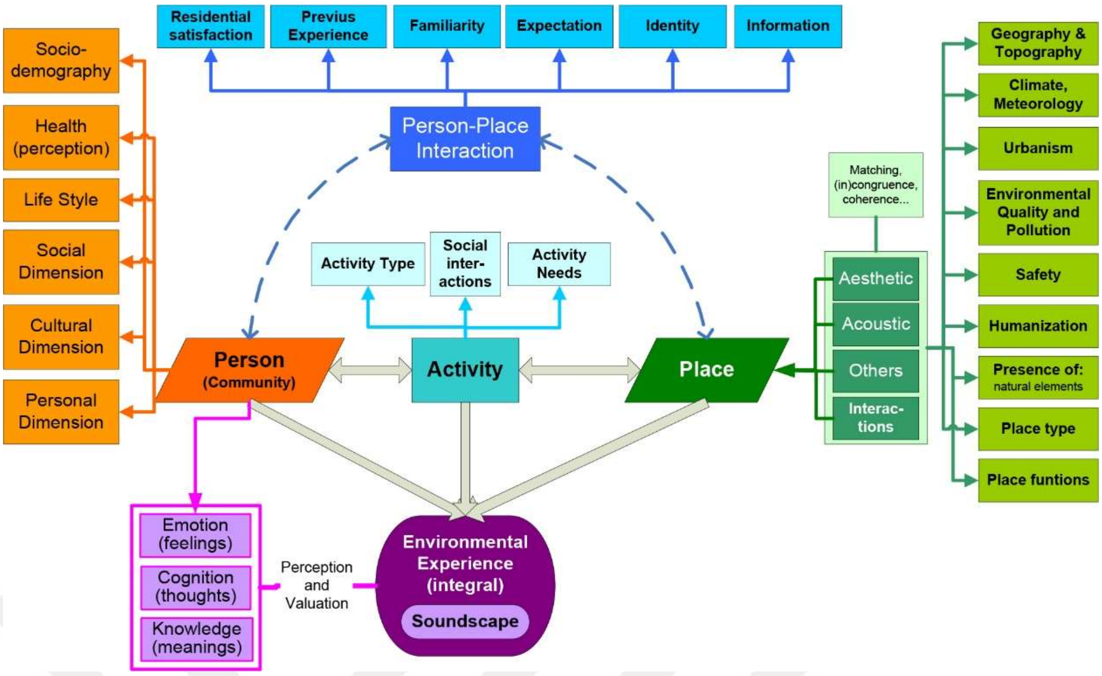

Figure 6 "Proposal of Conceptual Model about Environmental Experience to study the Soundscape" (Herranz-Pascual, Aspuru & García, 2010, p.6).

The most distinctive factor of soundscape study field for both indoor and urban soundscaping is contextual dimensions that is related with environmental experience and perception of user/audience. Basically, within the scope of contextual factors, answers the questions such as; 'how people experience and perceive their built and acoustic environment', 'what type of sensations they have', 'how they evaluate them' and 'which behavioral responses are obtained'. Herranz-Pascual, Aspuru and García (2010)'s model presents a model of environmental experience which demonstrates that environmental perception, cognition (thoughts), and meaning (emotional cohesions arising from past experiences) of people leads to evaluate their environment. As a result of environmental valuation, behavioral outcomes are obtained (see Figure 7).

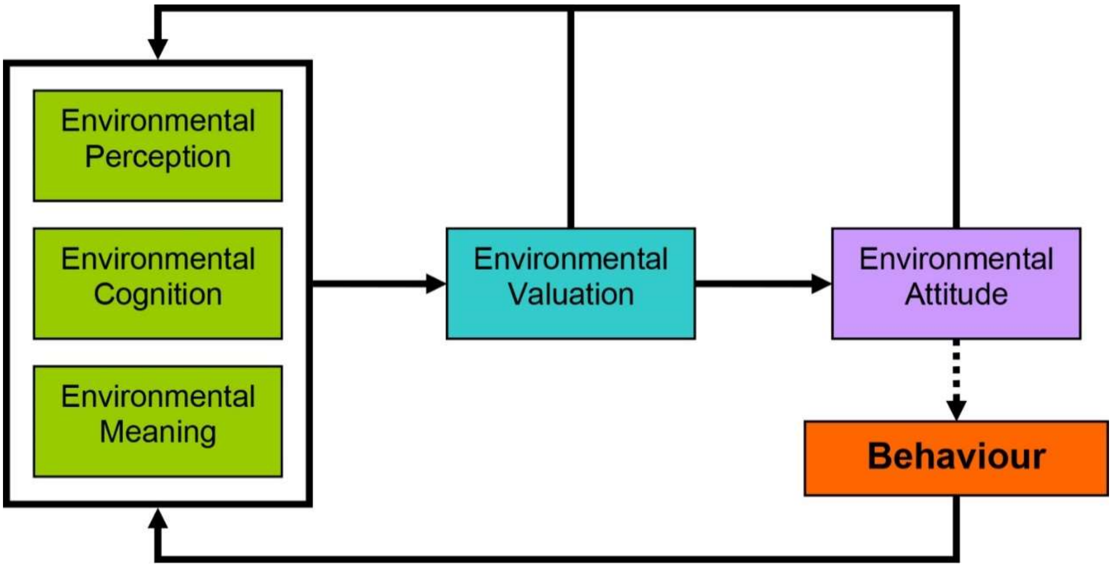

Figure 7 "Psychosocial process of environmental experience" (Herranz-Pascual, Aspuru & García, 2010, p.2)

Aburawis and Dökmeci (2018), presented two merged model about soundscape factors, based on the literature. First one is for soundscape perception factors consisted with six main items and detailed relevancies on each of them (see Figure 8) and second one presents the factors of space experience that is identified with five main items and their contents (see figure 9).

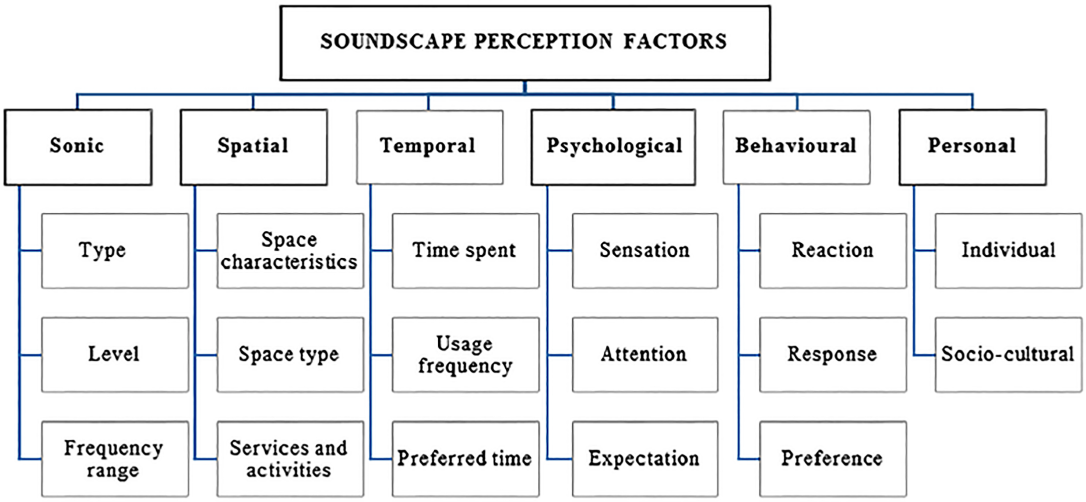

Figure 8 "Merged and detailed factors of soundscape perception to be tested by acoustical post- occupancy evaluation" (Aburawis and Dökmeci, 2018, p.8).

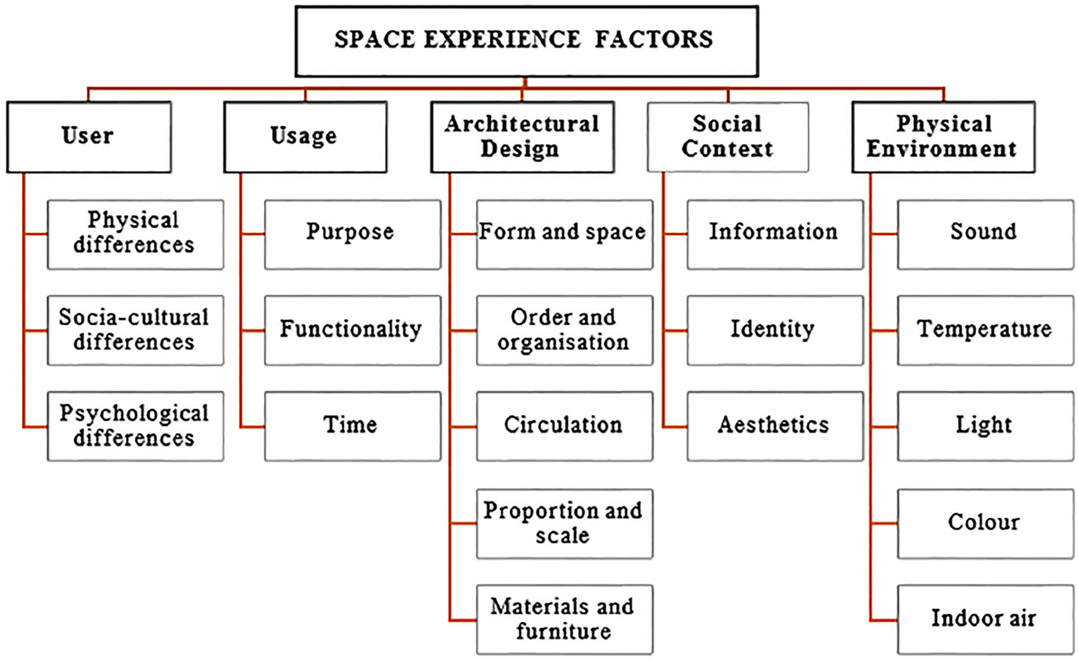

Figure 9 "Merged and detailed factors of the space experience to be tested by acoustical post-occupancy evaluation" (Aburawis and Dökmeci, 2018, p.11).

According to the suggested classifications for the factors of soundscape in the literature, indoor soundscaping factors can be classified in three main groups; acoustical variables, contextual factors, and architectural factors. Acoustical variables are needed, in order to comprehend the physical characteristics of sound and to have an objective data to ascertain which kind of sounds are dealt with. Since soundscape is a user-based concept, it has been needed contextual factors, which directly investigate the human perception and experiences on sound and environment around them. Besides, the architectural characteristics of a space have important roles because of their effects on the perception of users and reaction of sound. Therefore, contextual and architectural factors of indoor soundscaping is needed for finding out how sound is perceived by users, yet acoustical variables deal with the physical properties of sound. Although the sound levels and measurable variables affect the decision of users about sound perception, acoustical variables are primarily used to attain an objective or quantitative data.

Since the study field of indoor soundscape has many variables, standardization for application process may be seen complicated. Nevertheless, architectural factors are needed to be analyzed more in detail in order to arrange a possible regulation or standard. The detailed classification of built entity factors of Dökmeci and Kang's study in 2016, guides to categorization of architectural factors (see figure 9).

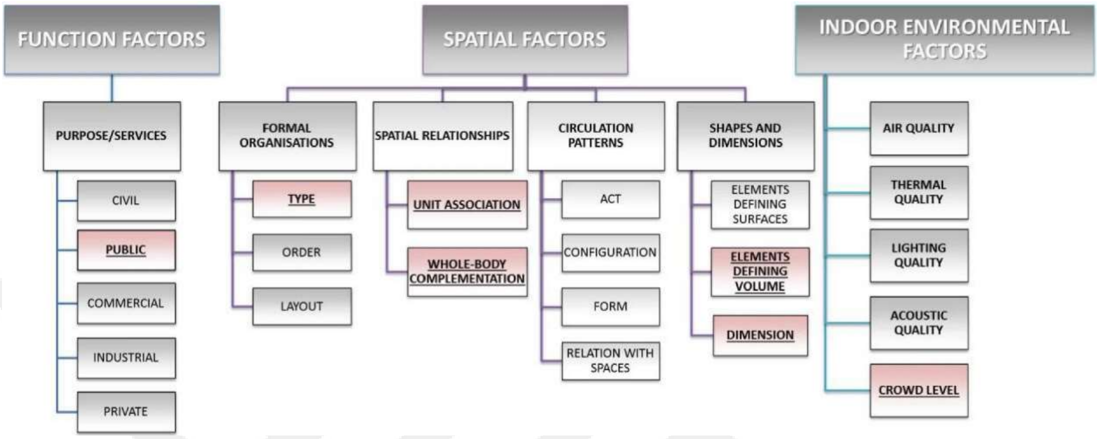

Figure 10 "Factors among the built entity variable" (highlighted titles are used for their studies) (Dökmeci and Kang, 2016, p.205).

When this classification is analyzed, it can be seen that functional factors become more important for "indoor soundscaping" in the aspect of design and application process. The expected sound environment alters based on the function of a place. For instance, public, industrial, commercial or residential enclosures needs different soundscapes. However, the public and commercial fields of functional factors include many different services in terms of soundscape needs. For example, libraries, hospitals and educational buildings may all have considered as public spaces, concert halls and shopping malls may both be considered as commercial places. Each one has different sound environment and requires different approaches in design process. At this point contextual factors and functionality of an enclosure may collaborate. Basically, user expectation and preference from acoustic environments in different functions may enlighten about preferable sound environment.

Besides, circulation areas, formal characteristics, and voids of mechanical equipment (elevator shafts, engine rooms, ventilation shafts etc.) should be focused on. Planning of circulation areas especially which have frequent utilization, have an importance on designing indoor soundscape. Dimensional features and formal organization of an interior have an influence on reaction of sound. Since the mechanical voids are remarkable noise sources, the organization of that kind of volumes become substantial as well.

Based on the guidance of these proposals in literature (ISO, 2014; Dökmeci and Kang 2016; Herranz-Pascual, Aspuru and García, 2010; Aburawis and Dökmeci, 2018), a new merged classification model for indoor soundscaping factors has been prepared to analyze the soundscape factors in this study (see Figure 11). This model presents the factors that influences on soundscape planning divided into three main group as acoustical variables, architectural factors and contextual factors.

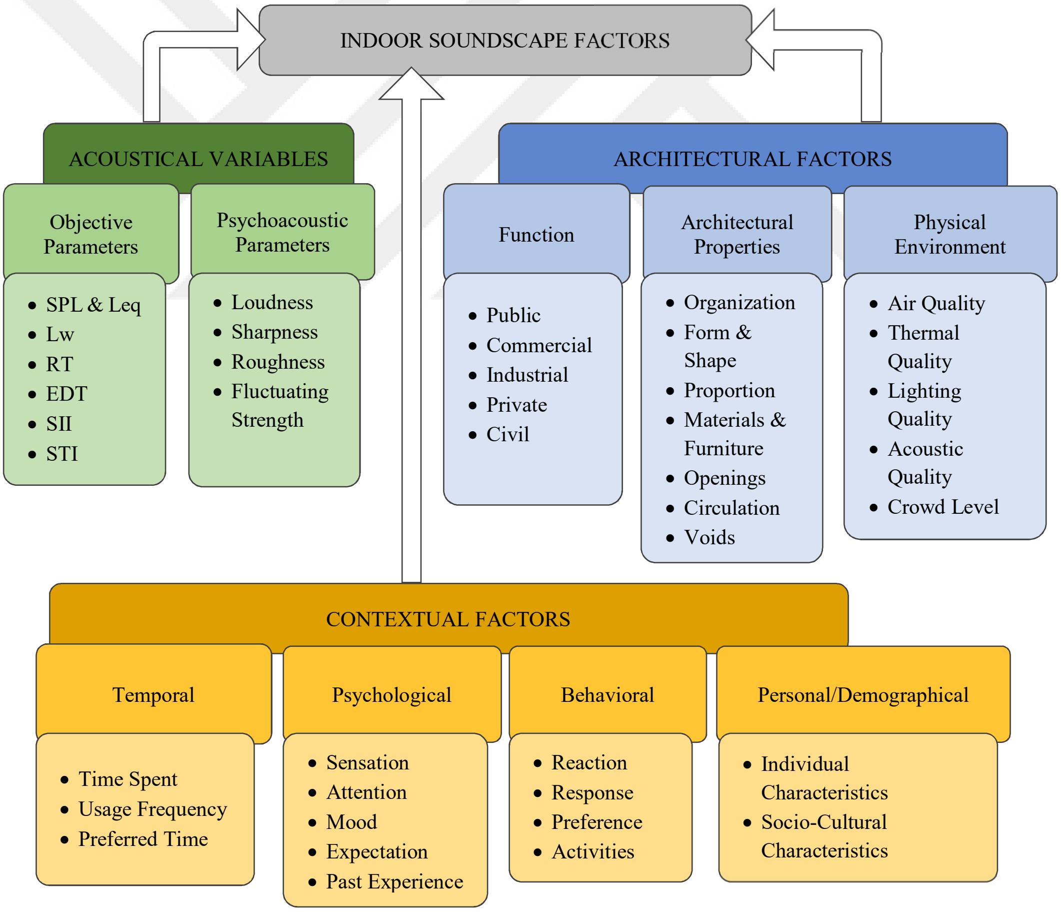

Figure 11 A merged model for factors that influence indoor soundscape.

3.3.1. Acoustical Factors

Acoustical factors have been needed to identify the physical characteristics of sound with the objective parameters, and the subjective evaluations of sound regarding audience perception with the psychoacoustic parameters. Objective parameters are used in both soundscape studies and noise management approach including governmental and institutional documents (regulations, guidelines and standards). However, because of the perceptual data outcomes, psychoacoustic parameters are commonly used in soundscape studies.

3.3.1.1. Objective Parameters

The most frequently parameters that are used in regulations, standards and research, about noise and soundscape, should be defined in the objective parameters section of soundscape in order to analyze and comprehend the regulations in detail. The most common objective parameters that are included in noise and soundscape studies are;

- Sound Pressure Level (SPL, L_p), Equivalent Continuous Sound Level (L_{eq})
- Sound Power Level (L_W)
- Reverberation Time (RT)
- Early Decay Time (EDT)
- Speech Intelligibility Index (SII)
- Speech Transmission Index (STI)

Sound pressure and sound power have a wide range in their units Pascals (Pa) and Watts (W) that causes difficulties in practical use. To facilitate that, sound levels has been revealed in unit of bels, which is "the logarithm of a number divided by a reference quantity" (Long, 2006, p.60) and decibel (dB) is one tenth of a bel.

The definition of sound pressure level in International Electrotechnical Commission is "logarithm of the ratio of a given sound pressure to the reference sound pressure. Sound pressure level in decibels is 20 times the logarithm to the base ten of the ratio" (IEC 801-22-07).

$$\text{Sound pressure level} = L_p = 10 \log \left[\frac{p(t)}{p\,ref}\right]^2 = 20 \log \frac{p(t)}{p\,ref} = \text{dB}$$

(Vér and Beranek, 1992).

where p = root-mean-square sound pressure (Pa)

p_{ref} = reference pressure, 2×10^{-5} Pa (Long, 2006).

IEC describes sound power level as "it is logarithm of the ratio of a given sound power to the reference sound power. Such power level in decibels is ten times the logarithm to the base ten of the ratio" (IEC 801-22-05).

$$\text{Sound power level} = L_w = 10 \log \frac{W}{W_o} = \text{dB}$$

where W = Sound Power, W (watts)

Wo = reference sound power, 10^{-12} W (Vér and Beranek, 1992).

Sound pressure level, that has a direct relation with user perception of loudness, is the most seen parameter of acoustic wave strength (Long, 2006). SPL is used often in noise regulations and acoustics standards to specify noise levels and loudness of sound. Sound level meters are used to measure sound levels with the weighting filters A, C and Z that correlates with the human hearing responses. A and C weightings are the most common ones in regulations and standards, because they have nearest response with human ear to the frequencies. A and C weightings are both cover the whole human frequency threshold (20 Hz to 20 kHz) but A-weighting is generally used for lower sound levels, C-weighted is for higher sound levels. If it is not specifically indicated, it means that A-weighted filter has been used. Also, time averaging schemes has been advanced in order to account the variances between sound level and time, because duration of a sound may affect the noisiness perception, and the most usual system is "Equivalent Continuous Sound Level (L_{eq})" (Long, 2006). The examples of L_{eq} usage, that are used in regulations from both UK and Turkish to matchup languages of same indicators and to explain most common time periods in regulations, can be seen in Table 5.

Table 5 Examples of L_{eq}, from UK and Turkish regulations.

UK REGULATION	REGULATIONS IN TURKEY	EXPLANATIONS
$L_{day\ [dB(A)]}$	$L_{gündüz\ (dBA)}$	A-Weighted L_{eq} during 12-hour day period (07.00-19.00).
$L_{evening\ [dB(A)]}$	$L_{akşam\ (dBA)}$	A-Weighted L_{eq} during 4-hour evening period (19.00-23.00).
$L_{night\ [dB(A)]}$	$L_{gece\ (dBA)}$	A-Weighted L_{eq} during 8-hour evening period (23.00-07.00).
$L_{den\ [dB(A)]}$	$L_{gag\ (dBA)}$	A-Weighted L_{eq} that covers day, night and evening period (23.00-07.00).
$LA_{eq,T\ [dB(A)]}$	$LA_{eq,T\ (dBA)}$	A-Weighted L_{eq} that indicates a specific given time period. E.g. $LA_{eq,3m,}$ $LA_{eq,16h}$
$LC_{eq,T\ [dB(C)]}$	$LC_{eq,T\ (dBC)}$	C-Weighted L_{eq} that indicates a specific given time period. E.g. $LC_{eq,3m,}$ $LC_{eq,16h}$

Another variable which is related with room acoustic and has an influence on soundscape comfort in terms of speech intelligibility is "Reverberation Time". In 1895, Wallace Clement Sabine presented that "the persistence of a reflected sound energy" is related with the room size, furnishing and users. This persistence which Sabine denominated "residual sound of duration of audibility" is used as "reverberation time" today. (Egan, 2007). Reverberation time is the time required for the sound level to decay 60 dB and shown as "RT60" or "T60". Sabine's formula in metric units for RT60 is;

$$T60 = 0.161\frac{V}{A}$$

where V = volume of the room (cbm)

A = total area of absorption in the room (sabins)

$= S1\ \alpha 1 + S2\ \alpha 2 + S3\ \alpha 3 + \cdot\cdot\cdot + Sn\ \alpha n$ (Long, 2006).

However, in some cases, measurement of T60 is not enough for determining that if a space has a proper reverberation time. For example, same volume and same reverberation time in two different places have generally different acoustics reactions (Maekawa et al., 2011). Therefore, "Early Decay Time" (EDT) has been suggested to attain more detailed data. EDT (T10) is the elapsed time for initial 10dB sound decay, which is multiplied by 6, and it provides a comparison with reverberation time (Long, 2006). With the same principle T20 multiplied by 3 and T30 multiplied by 2 are also used for reverberation measurements (Ermann, 2015).

Speech intelligibility (SI) is another considerable factor for room acoustics and indoor soundscaping in order to assess the acoustic environment. SI, in general, is about "how well the listener receives and comprehends the speech signal" (Gelfand, 2018, p.368). The essential principle of SI study is to ask an audience listen to the stimuli presented like syllables, words, phrases, etc. and to define what he/she heard (Gelfand, 2018). "Speech Transmission Index" (STI) and "Speech Intelligibility Index" (SII) are both objective measurement techniques for analyzing speech intelligibility and their rating results are between 0.0-1.0. A rating of STI and its relation between speech intelligibility, which Maekawa et al. (2011) prepared based on Danish Standard DS/EN 60268-16:2003 to show the direct proportion between STI and SI, can be seen in Table 6. STI and SII has been used to extrapolate the speech intelligibility within the existing noise and/or reverberation (Payton & Shrestha, 2013). Zu et al. (2014) found that STI and SII do not have major differences between them except their calculation techniques. Since, measurement process of SII is more complicated, using STI have more benefits in architectural acoustics measurements (Zu et al., 2014). Nevertheless, both methods are being used to measure speech intelligibility.

Table 6 "Relation between STI and speech intelligibility" (Maekawa et al., 2011, p.91).

STI	Speech intelligibility
0.00–0.30	Bad
0.30–0.45	Poor
0.45–0.60	Fair
0.60–0.75	Good
0.75–1.00	Excellent

3.3.1.2.Psychoacoustic Parameters

Psychoacoustic parameters are subjective evaluation of objective sound data to understand how audiences perceive the sounds. The most common parameters that are used frequently in soundscape studies are loudness (N), sharpness (S), fluctuation strength, and roughness (R).

Loudness is the value of audience perception on sound intensity (Segura et.al., 2013). The measurement principle of Loudness depends on "how much louder or softer a sound is heard relative to a standard sound" (Fastl & Zwicker, 2007, p.205). The proposed standard sound is the level of 40dB of 1 kHz tone for 1 sense of loudness with the unit of "sone" (Fastl & Zwicker, 2007).

Sharpness is a critical parameter because of its close relation in meaning with unpleasantness sense regarding a sound (Segura et.al., 2013; Fastl & Zwicker, 2007). Similar with Loudness, Sharpness is needed a reference point to be given a quantitative value. "Acum" unit is used for Sharpness and "reference sound producing 1 acum is a narrow-band noise one critical-band wide at a center frequency of 1 kHz having a level of 60 dB" (Fastl & Zwicker, 2007, p.239).

Roughness is a fluctuation sensation value that is used in the subjective evaluation of sound. "With a higher roughness, noise emissions are perceived to be more perceptible and usually more aggressive and annoying, even if for example, the loudness or sound pressure level with A-filter remains unchanged" (Segura et.al., 2013, p. 16). Unit of Roughness is "Asper". To define the roughness of 1 asper the 60-dB, 1-kHz tone that is 100% modulated in amplitude at a modulation frequency of 70 Hz is chosen (Fastl & Zwicker, 2007).

Fluctuation strength is "signal variations with very low modulation frequencies" (Segura et.al., 2013, p. 17). "Vacil" unit is used for Fluctuation Strength. 1 Vacil unit is defined by the same tone with Roughness but differently, the modulation frequency is 4 Hz (Segura et.al., 2013, p. 16).

3.3.2. Contextual Factors

Contextual factors of soundscape are directly based on the individual's cognition and the parameters that influence their cognition. Mainly, it can be assessed in four categories as temporal, psychological, behavioral and demographical characteristics. Temporal parameters rely on the relation between person/audience and time within a space. The three temporal dimensions; time spent, frequency and time preference are determinant and distinctive for indoor soundscaping and specifies the frame of the study. Psychological factors (attention and mood while listening, past experiences and expectations) have an influence on the perception of soundscape and the behavioral outcomes (reactions and responses of user to acoustic environment, and preference on a soundscape of a place). Besides, personal and demographical information has an importance on soundscape study field to characterize the users of a place or the participants of a soundscape study. Different user profile may reflect different soundscape perception. Personal and demographical information, that can be seen also on model of Herranz-Pascual et. al. (2010) (see Figure 6), like age, gender, cultural and social differences, personal characteristics, health conditions, and lifestyle have an influence on soundscape expectation and preference. Hence, the entities under the contextual factors have an impact on soundscape perception of people and works in an interaction with each other (see Figure 12).

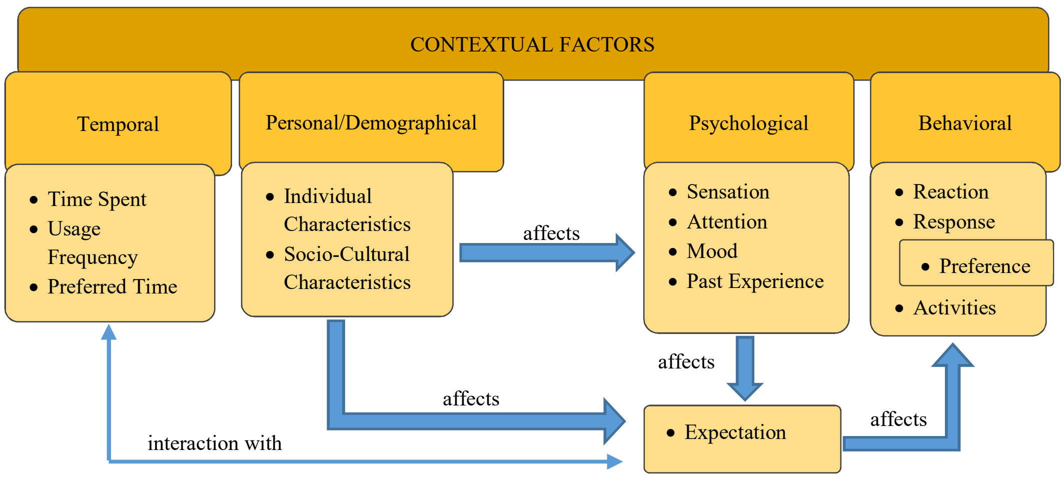

Figure 12 Interaction between the entities of contextual factors (Bruce & Davies, 2014; Brown, 2012; Herranz-Pascual et. al., 2010).

As it can be seen in Figure 12; soundscape expectation has an effect on behavioral outcomes. However, soundscape preference may be thought separate from other outcomes, because expected soundscape is not always match up with the preferred soundscape of a place. Since expectation and preference are the most significant dimensions that influence soundscape perception, they are needed to be assessed in more detail.

Soundscape expectation of a place is mostly composed by the past experiences of users. Therefore, while people identify the soundscape expectation, they decide by their information background about similar places that they have experienced before. Bruce and Davies's (2014) study indicates that soundscape expectation does not rely only on the expectation of sound sources, but also deals with "expected places", "expected control", "expected behavior", "expected activity" and "expected information". More in detail, expected places refers the overall place expectation of a user. "Expected control" is related with the expected rules that are gained before from the similar environment and if soundscape is not providing the expected environment, participant's "ability to control their activity within the soundscape" is questioned; "can they remove themselves or particular sounds from the current soundscape space or have the ability to control their interaction with the space?" (Bruce and Davies, 2014, p.7). Besides, expected behavior and activity represents the user's expectation from other users' behavior and activities. Finally, Bruce and Davies (2014) explained "expected information" as "a combination of activity and source expectation relates to an expectation of obtaining information" (p.8) and exemplified it as hearing ability of conversation, announcements or phone ringing. When these six dimensions (expected sound, expected places, expected control, expected behavior, expected activity, expected information) meet the users' expectation, the perception of user may not notice as negative, although the annoying sounds exist as well (Bruce and Davies, 2014). As a consequence, expectation effects people's perception and evaluation on soundscape and the decision about whether soundscape is pleasant or unpleasant.

Soundscape preference outcome of people differs in different places and different activities or functions. For example, while reason of preference is "peaceful" or “tranquil” for a soundscape, another soundscape may be preferred because of its “lively” or “excited” property (Brown, 2012). Table 7 presents wider sample list of preference outcomes for different soundscape. Regarding indoor soundscape approach, user preference is one of the most considerable factor to understand the soundscape needs of an enclosure, and to form a pleasant and acceptable soundscape.

Table 7 “Different outcomes which might determine preference for the soundscape in different places and contexts” (Brown, 2012, p. 389).

acceptability	identification of place	relaxation
appropriateness	importance	safety
clarity	information	satisfaction
comfort	liveliness	sense of control
communication	naturalness	solitude
enjoyment	nature appreciation	tranquility
excitement	nostalgic attachment	uniqueness
happiness	peacefulness	variety
harmony	place attachment	well-being

Besides, depending on the preference, masking tool has been discussed as a promising key of soundscape studies. Masking tool can be used to design soundscapes considering the preference factor through the identification of the wanted sounds and unwanted sounds, so the masker sounds can be promoted. In other words, preferred sounds should not be masked by unwanted sounds, or wanted sounds should mask unwanted sounds (Brown, 2012).

In conclusion, soundscape approach is rather subjective field because of its direct relation with user perception. Therefore, consideration of contextual factors that ascertain user perception in design process of soundscape is crucial.

3.3.3. Architectural Factors

Architectural factors which are distinctive field of indoor soundscaping should be evaluated into soundscape design process to characterize the enclosure, and relation with the acoustic environment. Architectural factors can be evaluated under three main subjects as function, architectural properties and physical environment (see Figure 13).

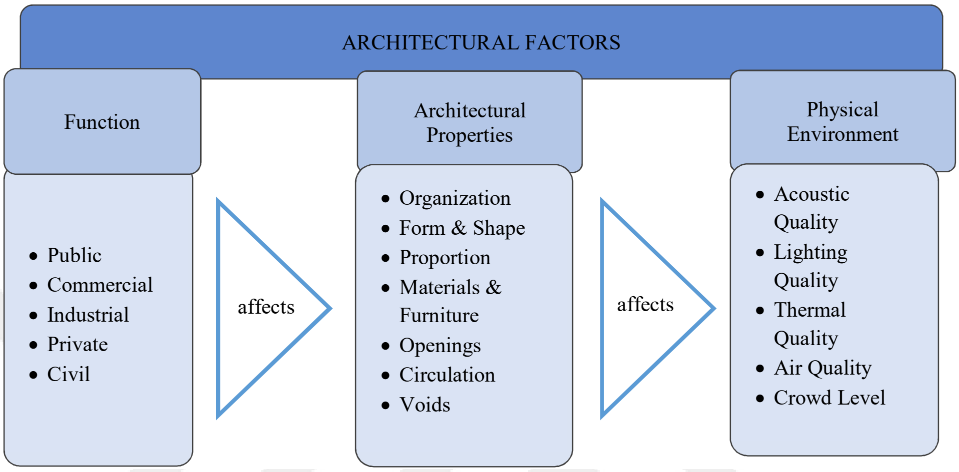

Figure 13 Architectural factors of indoor soundscape and their influence areas (Dökmeci and Kang, 2016; Aburawis and Dökmeci, 2018; Yılmazer & Acun, 2018).

Information on function of a space is important for design process of soundscape as it can help to collect possible future predictions on preference of users. Expectation on a soundscape that depends on usually the past experiences of users, differs in different functions. Hence, regarding architectural design process, at first, type of the building/space and what purpose that the space is used for should be considered to address the needs of soundscape, specific to each case.

Architectural properties of an indoor space affect user's perception of soundscape through its influence on sound and can be analyzed with the properties of two-dimensional organization, volumetric shape and proportion, materials and furniture used, openings, circulation patterns, and mechanical and installation voids. Before volumetric properties, two-dimensional organization of an enclosure should be evaluated. Layout plan of an indoor space give information about general overview of that place and space interactions, which form the base for any indoor soundscape study. Since volumetric form and shape, and proportion of an interior have remarkable influence on physical properties and formation of sound, they are needed to be analyzed in detail to control and sustain acoustic comfort. Similarly, construction and finishing materials, and furnishing are determinant on sound formation and can be used as affective applications to control the acoustic formations and overall acoustic quality.

Openings in buildings are other architectural elements that should be considered for the reason of their direct connection with outdoor environment. Openings affect the audial, visual, thermal and lighting characteristics of the indoor spaces. Even if there are materials which have high Sound Transmission Class (STC) rating for window openings, usually transmission of outdoor sound to indoor is provided by openings. Likewise, regarding thermal control, air quality, usage of natural lighting, window openings should be the initial consideration to provide indoor environmental quality before the indoor applications like Heating Ventilating and Air Conditioning (HVAC) systems, or artificial lighting design. In other words, building openings are the basic elements to design and control outdoor sound transmission, thermal and air quality, and natural light. Besides, physical environmental factors including crowding level of an enclosure, affect psychological situations and soundscape perception of users and as a result, overall space experience can form differently.

The other two architectural properties that should be underlined regarding indoor soundscape studies and application process are circulation patterns of an enclosure/building and voids constructed for mechanical and installation purposes. Circulation areas are the frequently used transition areas that provide integration between other spaces and they have the possibility of owning greater part of crowd level. For this reason, it should not be ignored the possible influence on soundscape and needed to be well designed. Finally, the voids in buildings like elevator shafts and engine rooms etc. are source of noise generation and other voids for ventilation, plumbing and electricity installation provide a path for sound transmission between spaces. Hence, regarding indoor soundscape design, it is needed to be given importance on management and design of these kind of voids to avoid causing an unwanted soundscape.

In order to integrate the indoor soundscape approach to the design process, architectural factors are the primary subject to regard. Functional information that forms the contextual factors, architectural features that are used for managing sound, and the condition of physical environment compose the essential framework of an enclosure which is dealt with in a study or design.

3.4.Data Gathering Methods of Soundscape Factors

Integration of soundscaping to the architectural design process especially in the early stages is crucial (Aburawis and Dökmeci, 2018). Standardization and clarification of methods and data types, which have been used for obtaining related factors, should be the subsequent step after factor identification, in order to integrate soundscape as a part of architectural design.

Several urban soundscape studies related with the data types and methods in the literature demonstrated methods as; in situ and laboratory (Aletta, Kang & Axelson, 2016; Özçevik & Yüksel, 2012), and presents it depends on audience experience with interdisciplinary approach. (Davies et.al., 2013). Aletta, Kang and Axelson's (2016) study presents a diagram which demonstrates the relationship between audiences' listening mode (in situ, in laboratory, or depending the memory) data collection methods and tools (see Figure 14). Similarly, Özçevik and Yüksel's (2012) study divided soundscape analysis methods as in-situ and laboratory experiments but demonstrated together with the urban soundscape factors (see Figure 15).

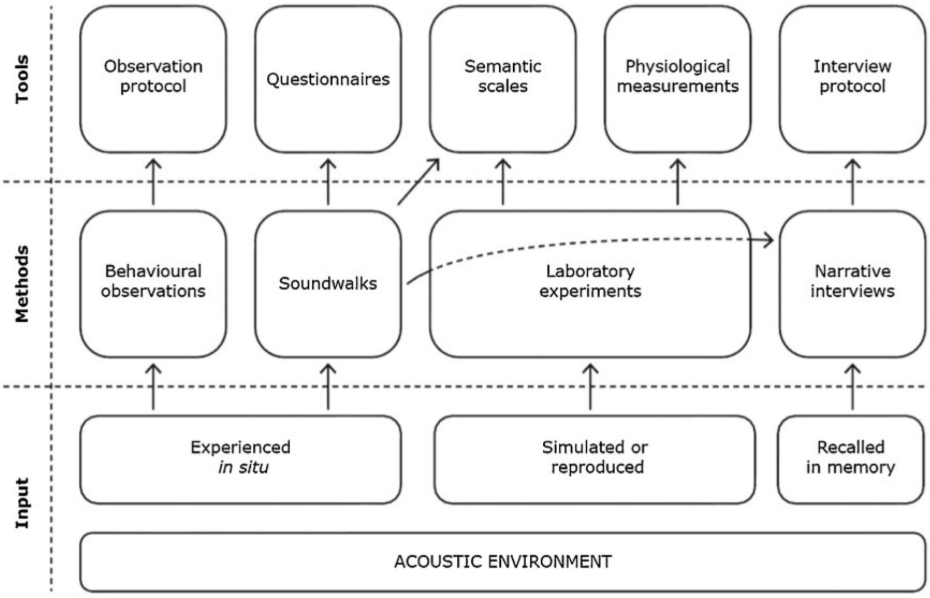

Figure 14 "Schematic illustration of the relationships between data collection methods and tools used in soundscape studies" (Aletta, Kang & Axelson, 2016, p.71).

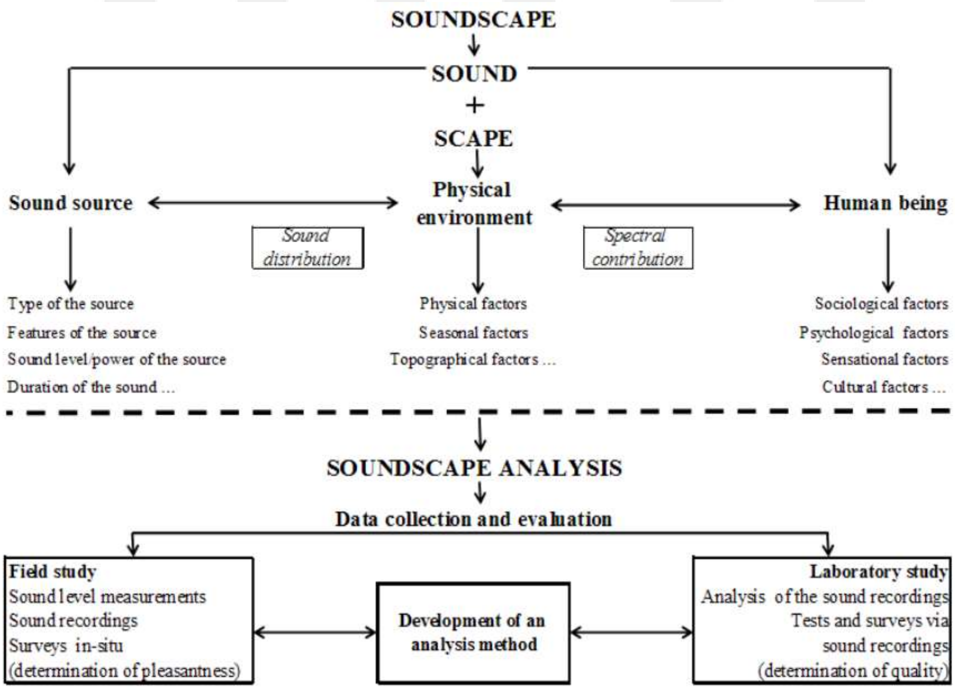

Figure 15 "The complex interaction among sound source, physical environment and human being, at the soundscape researches" (Özçevik & Yüksel, 2012, p.558)

Davies et. al. (2013), indicated the urban soundscape methods, which they had been used in their study, for audience experiences from the perspectives of different disciplines and listed according to parts of their project (see Table 8). Even if Table 8 has been prepared specific to a study, it is beneficial for evaluating data types and obtained outcomes, in general.

Table 8 "The parts of the Positive Soundscape Project" (Davies et.al., 2013, p.225).

Part	**Method**	**Main output**
Soundwalks and interviews	Qualitative: semi-structured interviews	Cognitive soundscape components
Focus groups	Qualitative	Cognitive soundscape features
Listening tests	Quantitative: semantic differential scales	Perceptual dimensions: calmness and vibrancy
Neuroscience	Quantitative: fMRI scans	Validation of perceptual dimensions; brain images
Physiological	Quantitative: heart rate, galvanic skin response	Relationship of basic physiology to perception
Speech intelligibility	Quantitative: signal processing and listening tests	Draft modification to speech intelligibility index
Soundscape simulator	Artistic and quantitative	Simulation device/method and webpage
Favorite sound	Artistic: field survey and recording	Favorite sounds database and CD
Exploration of positive soundscapes	Artistic: multiple original commissions	Art exhibition
Conceptual framework	Qualitative: deskwork	Sound-scape perception model
Soundscape planning and assessment	Qualitative: deskwork	Methods for planning and assessment
Soundscape expectation	Qualitative: interviews and observed simulator use	Model of expectation, context and competence

In addition to these studies (Aletta, Kang & Axelson, 2016; Özçevik & Yüksel, 2012, Davies et.al., 2013), ISO 12913-2 standard also specifies the data collection methods of urban soundscape. In this standard, five methods are indicated as (1) soundwalk, (2) questionnaire, (3) guided interview, (4) sound source taxonomy, and (5) binaural measurements (ISO, 2018).

Another study on indoor soundscape classifies methods, data types and related soundscape factors for acoustical post-occupancy evaluation in three stages as "indicative" and "investigative" as the identification phase of soundscape and "diagnostic" as the evaluative phase of soundscape (see Table 9) (Aburawis and Dökmeci, 2018).

Table 9 "Proposed study design to test merged factors of soundscape perception and space experience" (Aburawis and Dökmeci, 2018, p.13).

Phase	Poe stage	Method	Type of data	Evaluated soundscape perception factor	Evaluated space experience factor
1	Indicative	Observation Measurement	Qualitative Quantitative	Spatial Behavioral Sonic	Usage Physical environment
Collected data to be used in structuring the second phase					
2	Investigative	Interview Architectural survey	Qualitative Quantitative	Psychological Temporal Spatial	User Social context Architectural design
Collected data to be used in structuring the third phase					
3	Diagnostic	Soundwalk Questionnaire	Qualitative Quantitative	All soundscape perception and space experience factors are integrated for further statistical analysis	

Under the scope of standardization and integration indoor soundscaping to design process, it can also be useful to classify methods, based on the factors of indoor soundscape in order to evaluate factors and methods together. Classification of indoor soundscape methods that can be seen in Figure 16 is prepared based on the factors proposed in Figure 11. In Figure 16, three main concepts of indoor soundscape factors and their methods for gathering data, types of data and finally the expected outcomes that are planned to be obtained through those methods are presented.

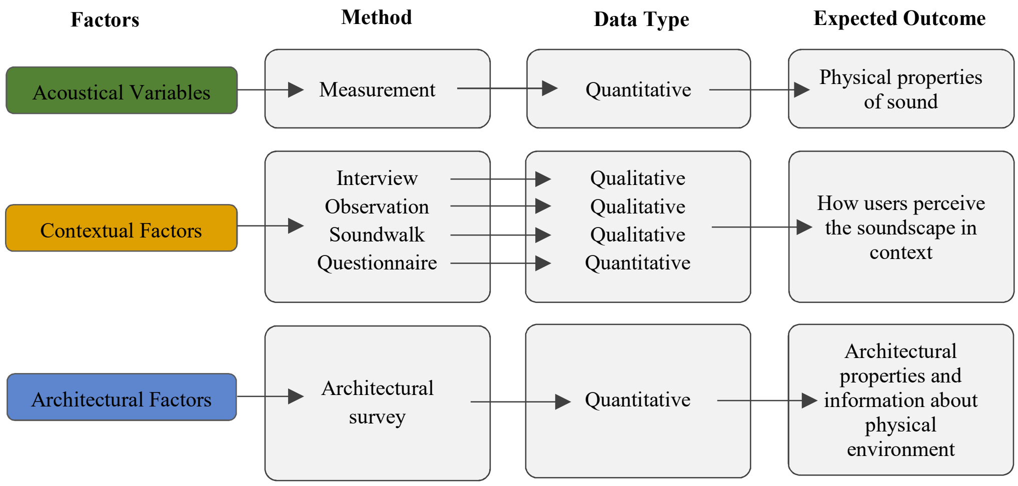

Figure 16 A proposal model on indoor soundscaping methods based on related factors.

The models on indoor soundscape factors (see Figure 11) and methods (see Figure 16) which interact with each other are proposed as a sample to standardization of the indicators of indoor soundscaping that should be used in architectural design process. Through further studies, they can be extended and/or evolved.

3.5.Soundscape Mapping

Noise mapping is an operational tool for planning process of noise management applications that are led by environmental noise management directives. However, noise maps include only noise sources and not related with the perception of people on sound environment (Kang et.al., 2016). This limitation of noise mapping has led to necessity of sound mapping and relevant studies (Kang et.al., 2016; Aletta & Kang, 2015). Sound mapping tool aims to provide sound-level distribution with more sound source types including both positive and negative sounds. Kang et.al. practiced soundscape mapping in their study "based on human perception of sound sources; soundscape mapping developed using artificial neural networks (ANNs), which show people's perception; psychoacoustic mapping and mind mapping; and mapping of noticed sounds" (Kang et.al., 2016, p. 162).

Other study on soundscape mapping aims to integrate soundscape approach into noise mapping operation (Aletta & Kang, 2015). Aletta and Kang (2015), presents three types of maps regarding selected field; noise maps considering traffic noise, sound maps on water features and birdsong, and soundscape maps to identify overall soundscape quality. This methodology used in Aletta and Kang's (2015) study, is found effective to obtain information about open public sound environments.

3.6.Soundscape Policies in Turkey and Europe

In Europe, urban soundscape policies and actions have been developed in recent years, but unfortunately, it is not given the deserved importance on soundscape approach in Turkey. When the Policies in EU are investigated three publications related to soundscape stands out. First one is the ISO 12913-1 standard (ISO,2014) that was published by ISO working group ISO/TC 43/SCI/WG 54 in 2014. This standard is including the related definitions, and the factors interacted and influenced each other in context, which can be seen in Figure 4. ISO 12913-1 shows that factors of soundscape can be possible to standardize. Second publication is ISO 12913-2 standard (ISO, 2018) which was published in 2018 as second part of ISO 12913 series. This standard aims to specify "requirements and supporting information on data collection and reporting for soundscape studies, investigations and applications" (ISO, 2018, p.1). However, these two standards are published for urban soundscape principles, thereby there is not found a published standard on indoor soundscape approach yet.

The third publication, "Good Practice Guideline on Quite Areas" is published by EEA in 2014, on open public quite areas which suggests combining different methodologies identified as "(1) noise mapping by modelling and calculations, (2) actual measurements of sound-pressure levels in situ, (3) evaluation of user/visitor experiences (i.e. the soundscape approach), and (4) expert assessments" (EEA, 2014, p.22) in order to maintain and manage the areas which have good environmental noise quality (Aletta & Kang, 2015). This guideline states that current noise measurement techniques do not have an ability to measuring acoustic quality of an area and this arises the necessity of new approaches as soundscape framework (EEA, 2014).

Besides these publications, the other operations regarding the improvement of soundscape are; "Soundscape of European Cities and Landscapes" project as a COST Action which had been progressed between 2009 and 2013, and SSID project, which is started on March 2018 which has been funded through the ERC of the European Commission. The EU COST Action on Soundscape of European Cities and Landscapes had been purposed to provide a practical guidance through organizing an international network consisted of 23 COST countries and 10 participants from non-EU countries including Turkey (Kang et.al., 2013). The essential aim of this Action to supply underpinning science of soundscape and improve the soundscape framework to more advanced position from the present condition, through coordinated international and interdisciplinary approach. COST Action had been aimed to advance soundscape into present policies and practice to enhance and/or preserve the sound environment (Kang et.al., 2013). The other objectives which are stated in Kang et.al. (2013) as the secondary objectives are as follows;

> (1) Understanding and exchanging:
> • Fostering interdisciplinary exchanges;
> • Exchanging technical know-how on an international/interdisciplinary basis; and
> • Examining cultural differences.
> (2) Collecting and documenting:
> • Gathering soundscape data to be reanalyzed from inter-disciplinary perspectives.
> (3) Harmonizing:
> • Reviewing and harmonizing current methodology;
> • Developing a standard protocol; and
> • Laying the foundations for future European/international standards.
> (4) Creating and designing:
> • Providing practical guidance and tools for the design of soundscapes; and
> • Providing guidelines for preserving architectural heritage sites.
> (5) Outreaching and training:
> • Creating awareness among general public, stakeholders, and policy makers; and
> • Providing training for early-stage researchers (Brown, 2012, p.75).

After the finalization of COST Action plan, another related project has been started. Soundscape Indices (SSID) project states that noise level reduction is not sufficient to enhance the quality of life and consideration of acoustic environment as it perceived is necessary (EC CORDIS Web site). The objectives of SSID are;

(1) To characterize soundscapes, by capturing soundscapes and establishing a comprehensive database, which will be a cornerstone for the proposed analysis, and an invaluable resource for scientists for years to come.
(2) To determine key factors and their influence on soundscape quality based on the database, by conducting laboratory psychological evaluation, physical/psychoacoustic factors analysis, and more importantly, to research at a physiological/biological level, including the use of functional magnetic resonance imaging.
(3) To develop, test and validate the soundscape indices, through analyzing the influences by various factors, using a number of inter- & trans-disciplinary approaches.
(4) To demonstrate the applicability of the soundscape indices in practice, by establishing frameworks for soundscape prediction, design, and standardization (EC CORDIS Web site).

However, since COST Action and SSID project have been started in order to develop urban scaled sound environment, it has not been included indoor soundscape approach yet.

CHAPTER IV

NOISE MANAGEMENT

Noise and its adverse health effects are important to consider in related research fields. Soundscape approach concerns with managing unwanted sounds as well, in order to improve the quality of acoustic environment. In addition, to investigate the integration of soundscape principles to architectural design and application process, the evaluation of present noise management policies is needed.

4.1. Definition of Noise and Noise Sources

Noise is basically the sounds that are unwanted or unpleasant (WHO, 1999) and "harmful acoustic air vibrations perceived by the ear or other parts of human body" (Śliwińska-Kowalska & Zaborowski 2017, p.2). According to World Health Organization (WHO)'s guideline for environmental noise, the sources of noise can be divided into two as environmental noise and indoor noise. Environmental noise can be defined with transport noise (road, rail and air traffic), industrial noise (construction and public work) and neighborhood. Indoor noise sources simply consist of ventilation systems, office machines, home appliances and neighbors (WHO, 1999).

4.2. Health Effects of Noise

Noise exposure has a considerable place in literature with its critical health effects. Exposure to noise causes both auditory and nonauditory diseases/disorders. Besides the auditory defects like hearing loss and tinnitus (ringing in the ears), noise can cause, after long term exposures, psychological and physiological diseases, and facilitates the disease process because it affects the organism's ability to protect its own metabolism (Basner et al., 2014).

In 2011, WHO published a report that quantified the loss of healthy years of life in western European countries through the environmental noise. The results of this report show that "at least one million healthy years of life are lost every year from traffic-related environmental noise in western Europe" (WHO, 2018b, p.2). Therefore, noise pollution is the second highest indicator after air pollution that causes diseases (WHO, 2018b). European Environment Agency (EEA) also estimated that "eight million people in the EU suffer sleep disturbances because of environmental noise, which further contributes to 10,000 premature deaths, 900,000 cases of hypertension and 43,000 hospitalizations each year" (Eurofound, 2017, p.62). Since the most dominant noise source is accepted as road traffic (Eurofound, 2017), many of the researches are based on transport noise to disclose the health outcomes of noise. To enhance the WHO's environmental noise guideline, systematic reviews on health effects of noise exposure were studied and rated evidences qualities to encourage further studies related currently insufficient field. A study on transport noise, which is one of the reviews of WHO's environmental noise guideline, bases three transport type (road traffic, railway and aircraft) and it reveals the health outcomes and noise interventions (Brown & van Kamp, 2017). Health outcomes are mentioned as;

- Adverse birth outcomes
- Annoyance
- Cardiovascular and Metabolic outcomes
- Cognitive impairment
- Effects on sleep
- Hearing impairment and tinnitus
- Quality of life, mental health and well-being

These outcomes were selected to assess the literature in detail and to find the sufficiency of the evidences regarding the relation with noise exposure. As a result of reviews on numerously study, the evidences on the relation between noise and specified health outcomes are not concluded with high relevance for each one. Nevertheless, these diseases are suggested to be kept within the scope of possible risks and continue to be investigated, because not opposite high-quality evidences were found as well to prove the exact irrelevance between noise and them (Brown & van Kamp, 2017).

Considering adverse birth outcome, which is involved preterm delivery, low birth weight and congenital anomalies, has low quality evidences in terms of the relation with environmental noise and it is needed to be more qualified studies to be proved strongly but still stands as a risk (Nieuwenhuijsen, Ristovska & Dadvand, 2017).

On the other hand, annoyance caused by environmental noise has high quality evidences (Guski, Schreckenberg & Schuemer, 2017) and after sleep disturbance it is assessed as the second major health outcome of environmental noise (WHO, 2011). Annoyance surveys, which participants responded with the regard of their past experiences about a noise source, revealed three main responses;

> (1) an often-repeated disturbance due to noise (repeated disturbance of intended activities, e.g., communicating with other persons, listening to music or watching TV, reading, working, sleeping), and often combined with behavioral responses in order to minimize disturbances;
>
> (2) an emotional/attitudinal response (anger about the exposure and negative evaluation of the noise source); and
>
> (3) a cognitive response (e.g., the distressful insight that one cannot do much against this unwanted situation). (Guski, Schreckenberg & Schuemer 2017, p.2).

A review on cardiovascular diseases (involved hypertension, ischemic heart diseases and stroke) and metabolic diseases (involved obesity and diabetes), which caused by environmental noise, indicates various evidence qualities. The evidences on noise influences on hypertension, stroke and metabolic diseases are found very low quality or insufficient. However, it is also found high quality evidences on environmental noise that causes ischemic heart diseases (IHD) (van Kempen et al., 2018). WHO guideline (1999) also indicates that, long term noise exposure during $LA_{eq,\,24hr}$ with 65-

70 dB causes to cardiovascular impacts, where the exposure should be 55 dB or lower to be protected from cardiovascular diseases (WHO, 2009).

Cognitive impairment which is included learning ability, reading and oral comprehension, memory and attention deficiency is one of the expectative health effects of noise exposure in literature. Evidences of noise exposure on especially children's learning ability has increased in the last decade (Hygge & Kjellberg, 2010; Stansfeld & Clark, 2015). That is estimated that 45.000 DALYs (Disability-Adjusted Life Year) were lost each year with the cognitive impairment in children (WHO, 2011). One DALY can be described as one lost year of healthy life and is calculated as;

$$DALY = YLL + YLD$$

where YLL (years of life lost) regarding premature mortality in the population

YLD (Years Lost due to Disability) regarding the people who has the health condition or its results. (WHO, Health statistics and information systems).

Clark and Paunovic's (2018a) systematic review on relation between environmental noise and cognition shows that, there is no substantial evidences that prove the noise is innocent over children's cognition impairment. Yet, there is convincing evidences on noise effects over children's attention (Clark and Paunovic, 2018a).

Sleep disturbance, as indicated before, is accepted as the major health problem caused by environmental noise because many experimental studies asserted that sleep disorders causes many diseases like obesity, diabetes, high blood pressure, and dementia (Basner & McGuire, 2018). Hence, if it is agreed that noise exposure causes sleep disturbance, it may also lead to metabolic diseases (which have low quality evidences on noise relation). Epidemiologic studies also presented strong relevancies that long-term night noise exposures have stronger health effects than daytime exposures (Jarup et al., 2008). Addition to long-term effects, since sleep disorders has instant results like increased sleepiness and affected cognitive performance, which allows errors and accidents, sleep health should be protected from noise (Basner & McGuire, 2018).

Auditory health outcomes are another highlighted issue under the frame of adverse health effect of noise exposure. WHO's hearing loss statistics in the year 2000 indicates that approximately 5% (360 million people) of world population deals with hearing disorders, and one of the effectual causes of hearing impairments is noise exposure. In the aspect of loss of healthy years, adult-onset hearing loss is second major reason of YLDs at global level and formed 4.6% of total global YLDs in 2000 (Mathers, Smith & Concha, 2000). Noise exposure leads the sensory cells of inner ear and outer hair cells damage causes tinnitus (ringing in ear), permanent hearing threshold shift and attenuation of speech intelligibility (Śliwińska-Kowalska & Zaborowski, 2017).

General overview of noise exposure results is expected to affect wellbeing and mental health of people as well. Many studies that related with the life quality of both children and adults revealed the potential outcomes as; depression and anxiety, medication use and childhood emotional problems (Clark & Paunovic, 2018b). According to WHO (1999), acute noise exposure causes an increase in physiological arousal that may be concluded with increase in stress as well. Also, as a result of the chronic exposure on this arousal, depression and anxiety may occur (Stansfeld & Clark, 2015). The systematic review of Clark and Paunovic (2018b) shows that there are moderate quality evidences in the literature about the effects of noise on wellbeing and mental health. It is also mentioned that the "moderate quality evidences" should not be understood as noise has weak effects on wellbeing of people. Contrarily, it is needed to be studied more influentially (Clark & Paunovic, 2018b).

The systematic reviews on noise health effect that are prepared for WHO's Environmental Noise Guideline clearly shows that noise need to be intervened and managed even if all foreseen health outcomes' relationship with noise exposure has not been proved strongly.

4.3.Noise Management and Applications

Potential and proved health effects of noise exposure leads to enhance the preparation of related researches, guidelines, and regulations. Guideline development group of WHO reviewed the interventions to manage noise. Brown and van Kamp (2017) presented the noise interventions into five main categories based on the literature and their experiences on noise management (see Table 10).

Table 10 "Categorization of Noise Interventions" (Brown & van Kamp, 2017, p.3).

Type	Intervention Category	Intervention Sub-Category	Examples
A	Source interventions	change in emission levels of sources	motor vehicle emission regulation, rail grinding, road surface change, change in traffic flow, change in number of aircraft flights
		time restrictions on source operations	airport curfew, heavy vehicle curfew
B	Path interventions	change in the path between source and receiver	noise barrier
		path control through insulation of receiver's dwelling	insulation of building envelope
C	New/closed infrastructure	opening of a new infrastructure noise source, or closure of an existing one	new flight path; new railway line; new road bypass; or closure of any of these
		planning controls between (new) receivers and sources	urban planning control; 'buffer' requirements
D	Other Physical interventions	change in other physical dimensions of dwelling/neighborhood	availability of a quiet side; appearance of the neighborhood; availability of green space
E	Education/communication interventions	change in behavior to reduce exposures; avoidance or duration of exposure	Educating people on how to change their exposure
		community education, communication	Informing people to influence their perceptions regarding sources, or explaining reason for noise changes

These interventions that are indicated in Table 10 are implemented by governments through the environmental noise management directives and guidelines. The most common operational tool is noise mapping that is used for implication of environmental noise directive and provides a visual demonstration of yearly average noise levels of a particular field (Aletta & Kang, 2015).

To discuss the possible future soundscape application process and documental preparation of indoor soundscape as regulations/directives, standards and guidelines, present noise management documents should be evaluated primarily since noise management is a part of overall soundscape approach. To evaluate the present governmental documents on noise management, Turkey and EU regions are selected in this study. As a result of the policies that have been implemented in Turkey and EU, related regulations/directives and guidelines regarding noise management were published based on ISO acoustics standards.

4.3.1. Noise Regulations in Turkey and Europe

When the present noise regulations/directives of EU and Turkey were assessed, it is revealed that there are six different essential regulations related to noise management. Table 11 presents a comparison of regulations in Turkey and EU, in terms of the scope and regulation numbers (official journal issue numbers are used for the ones which do not have a regulation number, and those ones are indicated as issue number [IN]). In table 11, it can be also seen that, four of the six regulations in Turkey have been prepared by reference from the equivalent directives in EU. These equivalent directives are about environmental noise management (2002/49/EC, 2010; Council directive 2002/49/EC, 2002), protection of the workers from risks of the noise exposure (Çalışanların gürültü ile,2013; Council directive 2003/10/EC, 2003), noise emission of outdoor equipment (2000/14/AT, 2000; Council directive 2000/14/EC, 2000), and sound levels of motor vehicles (70/157/AT, 2000; Council directive 2007/46/EC, 2007). Besides, in Turkey, there is a regulation on, "protection of buildings against noise" (Binaların gürültüye karşı, 2017) but an equivalent directive in EU does not exist. Furthermore, EU has a directive on noise-related operating restrictions at airports (Council directive 598/2014, 2014), which is not published in Turkey as an equivalent directive. More detailed information (full title, published year, issuing organization, RN or IN, content, scope) and comparison are presented in Tables 12, 13, 14, 15, 16. In these detailed tables, titles of Turkish regulations are translated into English. Regulations/Directives that are presented has been amended or added content several times over the years and probably will be proceed within the next years, but the latest ones that are published in full text are used and cited in this study, and shown in bold.

Table 11 Comparison of noise regulations in Turkey and Europe.

Scope of Regulation	Turkey	European Union
1.Environmental noise	**2002/49/EC**	**Directive 2002/49/EC**
2.Protection of buildings	**23616 (IN)**	-
3.Protection of Workers	**18647 (IN)** Reference: 2003/10/EC	**Directive 2003/10/EC**
4.Airports	-	**Directive (EU) 598/2014** Repealing 2002/30/EC
5.Outdoor equipment	**2000/14/AT** Reference: 2005/88/EC Reference: 2000/14/EC	**Directive 2005/88/EC** Amending 2000/14/EC
6.Motor vehicles	**70/157/AT**	Regulation (EU) 540/2014 **Amending 2007/46/EC** Repealing 70/150/EEC

Turkish regulations are all published and prepared by the related ministries and European regulations are published and prepared by European Parliament and the Council of the European Union. It is seen that most of the regulations have same content and scope, since most of the Turkish regulations have been prepared based on the regulations in Europe. The regulation on environmental noise in Turkey is one of the samples that has been prepared as an equivalent regulation to European directive and it has the same content and scope (see Table 12). In table 12, even though the publication date of Turkish regulation is indicated as 2010 (as it is stated before, latest full text directives are used as citation), the first publication year of environmental noise management directive is 2005. Environmental noise management regulations are prepared for the open public areas where people have been more exposed to environmental noise. As the same with others, content of environmental noise management regulation starts with the definitions of terminology that are used in the document. Then specifies the noise indicators and required sound levels or limits values for open public spaces. Environmental noise directives also include preparation of noise maps and action plans and informing to public regarding these contents of the directive. For the application and maintenance, implementation and responsibilities of the authorities are also included.

Table 12 Comparison of noise regulations on environmental noise in Turkey and Europe. Prepared based on the regulations in Turkey and Europe (2002/49/EC, 2010; Council directive 2002/49/EC, 2002).

ENVIRONMENTAL NOISE	**TURKEY**	**EUROPE**
Title-Year	Regulation on assessment and management of environmental noise, 2010	The assessment and management of environmental noise, 2002
Issuing Organization	Ministry of Environment and Urbanization	The European Parliament and the Council of the European Union
RN or IN	**2002/49/EC**	**Directive 2002/49/EC**
Content	Definitions Noise indicators Required sound levels Noise mapping Action plans Implementation and responsibilities Information to public Review and reporting	Definitions Noise indicators Required sound levels Noise mapping Action plans Information to public Implementation and responsibilities Review and reporting
Scope	"Directive shall apply to environmental noise to which humans are exposed in particular in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals and other noise sensitive buildings and areas" (Council directive 2002/49/EC, 2002).	

The regulation on protection of building against noise has been published in Turkey and its equivalent directive was not found in Europe (see Table 13). This regulation aims to regulate design, construction, usage, maintenance and management rules for minimizing the adverse effects of noise. To enhance people's welfare in an enclosure and control noise that arise during construction, management and usage, several classifications and rules are indicated depending on the functional properties of buildings and neighbor relations of the spaces by demonstrating construction materials and components, noise and insulation indicators, acoustical performance rates, usage of installation and service equipment. Besides, this regulation states on the supervision and licensing of management and construction project and license rules in order to maintenance control during the usage of a building, and finally obligations and responsibilities of authorities for maintenance. This regulation is promising to act as a backbone and starting point for the preparation of a possible future indoor soundscaping regulation or standard, as the rules have been prepared according to each building function and the neighboring relations of the spaces.

Table 13 Comparison of noise regulations on building protection against noise in Turkey and Europe. Prepared based on the regulation in Turkey (*Binaların gürültüye karşı*, 2017).

BUILDINGS	TURKEY	EUROPE
Title-Year	Regulation on the protection of buildings against noise, 2017	No equivalent directive
Issuing Organization	Ministry of Environment and Urbanization	-
RN or IN	**30082 (IN)**	-
Content	Definitions Construction project and license Construction materials and components Obligation and responsibilities Noise and insulation indicators Acoustical performance rates Installation and service equipment Supervision and licensing	-
Scope	Aim of this regulation is to determine the rules of design, construction, usage, maintenance and management in order to minimize the adverse effects of noise (originated from outside and inside of the building) to people's welfare, mental and physical health, and provide the adequate conditions for hearing and cognition, during the usage of each type of buildings' usage and management. (Binaların gürültüye karşı, 2017)	

Another regulation that concerns with indoor spaces as well which is also mentioned in the regulation about building protection, is about protection of workers from noise (see Table 14). The origin of this regulation is the EU and the Turkish equivalent has been prepared with reference to Directive 2003/10 / EC (Council Directive 2003/10 / EC). Hence, the content and scope of these regulations (Çalışanların gürültü ile,2013; Council directive 2003/10/EC, 2003) are the same. These regulations aim to provide minimum requirements for the protection of workers from adverse effects of noise exposure including hearing impairments demonstrating exposure limit values, reducing exposure and limitation of exposure. These regulations also aim to inform workers about personal protection and to raise awareness employers about their obligations.

Table 14 Comparison of noise regulations on protection of workers against noise in Turkey and Europe. Prepared based on the regulation in Turkey and Europe (*Çalışanların gürültü ile*,2013; Council directive 2003/10/EC, 2003).

WORKERS	TURKEY	EUROPE
Title-Year	Regulation on protection of workers from risks arising from noise, 2013	The minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), 2003
Issuing Organization	Ministry of Labor and Social Security	The European Parliament and the Council of the European Union
RN or IN	**28271 (IN)** Reference 2003/10/EC	**Directive 2003/10/EC**
Content	Definitions Exposure limit values and exposure action values Obligations of employers Avoiding or reducing exposure Personal protection Limitation of exposure	Definitions Exposure limit values and exposure action values Obligations of employers Avoiding or reducing exposure Personal protection Limitation of exposure
Scope	To provide “minimum requirements for the protection of workers from risks to their health and safety arising or likely to arise from exposure to noise and in particular the risk to hearing” (Council directive 2003/10/EC, 2003).	

Other directive that is specific to EU, that does not have an equivalent in Turkey, is about airports (see Table 15). This directive was published for determining the rules of noise-related operating restrictions in EU airports and protecting people from the adverse effect of aircraft noise (Council directive 598/2014, 2014). Directive 598/2014 includes the rules on aircraft noise management and assessment, noise performance information, exemption for aircraft operations of an exceptional nature and delegated acts of operation.

Table 15 Comparison of noise regulations on airports in Turkey and Europe. Prepared based on the regulation in Europe (Council directive 598/2014, 2014).

AIRPORTS	**TURKEY**	**EUROPE**
Title-Year	No equivalent directive	The establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach, 2014
Issuing Organization	-	The European Parliament and the Council of the European Union
RN or IN	-	**Directive (EU) 598/2014** Repealing 2002/30/EC
Content	-	Definitions General rules on aircraft noise management Rules on noise assessment Noise performance information Exemption for aircraft operations of an exceptional nature Delegated acts
Scope	"This Regulation lays down, where a noise problem has been identified, rules on the process to be followed for the introduction of noise-related operating restrictions in a consistent manner on an airport-by-airport basis, so as to help improve the noise climate and to limit or reduce the number of people significantly affected by potentially harmful effects of aircraft noise, in accordance with the Balanced Approach" (Council directive 598/2014, 2014).	

The last two regulations, which are about noise emission of outdoor equipment (2000/14/AT, 2000; Council directive 2000/14/EC, 2000) and noise emission of motor vehicles (70/157/AT, 2000; Council directive 2007/46/EC, 2007), are EU origin and was published in Turkey with the reference of European directives (see Table 16 and 17). Regulation on outdoor equipment (some e.g. of equipment mentioned in regulations; combined high pressure flusher and suction vehicle, compressor, concrete-breakers or mixer, water pump unit) aims to provide rules and standards on permitted sound power levels, noise marking and standards, conformity assessment procedures, placing on the market, market surveillance, non-compliance of equipment (Council directive 2000/14/EC, 2000).

Table 16 Comparison of noise regulations on outdoor equipment in Turkey and Europe. Prepared based on the regulation in Turkey and Europe (2000/14/AT, 2000; Council directive 2000/14/EC, 2000).

OUTDOOR EQUIPMENT	**TURKEY**	**EUROPE**
Title-Year	Regulation on noise emission in the environment generated by outdoor equipment, 2006	The approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, 2005
Issuing Organization	Ministry of Science, Industry and Technology	The European Parliament and the Council of the European Union
RN or IN	**2000/14/AT** Reference 2005/88/EC Reference 2000/14/EC	Directive 2005/88/EC **Amending 2000/14/EC**
Content	Definitions Permitted sound power levels, noise marking and standards Conformity assessment procedures Placing on the market Market surveillance Non-compliance of equipment	Definitions Equipment subject to noise limits Equipment subject to noise marking only Conformity assessment Collection of noise data Placing on the market Market surveillance EC Declaration of conformity Non-compliance of equipment Presumption of conformity
Scope	"This directive aims to provide noise emission standards, conformity assessment procedures, marking, technical documentation and collection of data concerning the noise emission in the environment of equipment for use outdoors. It will contribute to the smooth functioning of the internal market, while protecting human health and well-being" (Council directive 2000/14/EC, 2000).	

The detailed information as content and scope of the directives on motor vehicles' noise emissions and exhaust systems are not stated in Table 17, because the content of these directives is not relevant with the subject directly, except the noise emission standards. They have focused more on the exhaust systems of motor vehicles.

Table 17 Comparison of noise regulations on motor vehicles in Turkey and Europe. Prepared based on the regulation in Turkey and Europe (70/157/AT, 2000; Council directive 2007/46/EC, 2007).

MOTOR VEHICLES	TURKEY	EUROPE
Title-Year	Regulations for external noise emissions and exhaust systems of motor vehicles, 2000	The sound level of motor vehicles and of replacement silencing systems, 2014
Issuing Organization	Ministry of Science, Industry and Technology	The European Parliament and the Council of the European Union
RN or IN	**70/157/AT** Reference 70/150/EEC	Regulation (EU) 540/2014 **Amending 2007/46/EC** Repealing 70/150/EEC

All these regulations that are stated in this study, have been prepared and published to manage noise with applying sanction on rules and to integrate the relevant standards to application and maintenance process. Noise policies and regulatory approach in Turkey has been progressed in a consistency with EU.

4.3.2. Standards on Acoustics in Turkey and Europe

More than fifty standards in total are present in the literature, which are published under the name; "ISO/TC 43 Acoustics" by the technical committee and includes items such as, recommended sound levels, acoustical measurement protocols, evaluation and rating scales that are being used in noise directives and guidelines. Wide list of standards used in existing regulations and guidelines are presented in Appendix. Turkish Standard Institution (TSE) translated almost all of these standards into Turkish language. These translated Turkish standards (TS) have been used in the Turkish regulations and guidelines.

Regarding soundscape regulatory attitude, present standards on acoustics will be essential as well to use standardized sound levels, measurement techniques and data collection methods. The conspicuous standards which have been used in current directives and guidelines and presented in Appendix, can be also used or mentioned in possible future regulations and/or guidelines on indoor soundscape. The reason of necessity of noise related standards in soundscape design is the consideration of noise masking besides positive sounds (Brown, 2012). These standards are ISO 1996-1:9982 (TS equivalent: TS 9315 ISO 1996-1) (ISO, 1996) and ISO 1996-2:1987 (TS equivalent: TS ISO 1996-2) (ISO, 1987) which are related to environmental noise measurement, evaluations and sound levels. Additionally, several standards that are published by the Building Acoustics technical committee (ISO/TC43/SC 2) and standards of Noise technical committee (ISO/TC43/SC 1) may also need consideration for indoor soundscape regulatory approach. Since an enclosure is exposed to environmental noise besides indoor originated sounds, standards on environmental noise levels, management, and assessment are indicated in the Appendix as well. In addition, more detailed further study is needed on contents of acoustical standards to find out the relation between these standards and indoor soundscape factors, and to specify how these acoustical standards would contribute to architectural design and application process of indoor soundscape.

4.3.3. Noise Guidelines in Turkey and Europe

Other governmental documents that should be assessed after regulations in order to study on integration of soundscaping to application process are guidelines regarding noise management because of their corporation with the regulations. The essential aim of these noise guidelines is; "to provide recommendations for protecting human health from exposure to environmental noise" (WHO, 2018b) and to support implementation of environmental noise directive (*Gürültü azaltım*, 2015). In Europe, World Health Organization (WHO)'s Regional Office for Europe prepared a series of guidelines on environmental noise and harmful health effects of the noise exposure for European region. On the other hand, the guidelines in Turkey were prepared by the Ministry of Environment and Urbanization under the scope of the twinning project TR/2004/IB/EN/02 "Harmonization and Implementation of the EU Directive Related to Environmental Noise Management", which is promoted by European Commission (EC). Table 18 presents a list of these guidelines with full title regarding environmental noise both in Turkey and Europe.

Table 18 List of noise guidelines in Turkey and Europe

Turkey	Europe – WHO & EC
1.Guideline on environmental noise measurement and evaluation (Çevresel gürültü, 2011)	1.Environmental noise guidelines for the European Region (WHO, 2018b)
2.Guideline of noise reduction precautions (Gürültü azaltım, 2015)	2.Guidelines for community noise (WHO, 1999)
3.Noise mapping guideline (Gürültü haritalandırma, 2008)	3.Night noise guidelines for Europe (WHO, 2009)
	4.Methodology for systematic evidence reviews for the who noise guidelines for European region (WHO, 2018c)
	5.Biological mechanisms related to cardiovascular and metabolic effects by environmental noise (WHO, 2018a)
	6.Burden of disease from environmental noise (WHO, 2011)
	7.Results from the search for available systematic reviews and meta-analyses on environmental noise (WHO, 2018d)
	8. Good practice guide for strategic noise mapping and the production of associated data on noise exposure. (Good practice, 2007).
	9. Good practice guide on noise exposure and potential health effects. (EEA, 2010).

Guidelines in Turkey, which are about environmental noise measurement and evaluation (*Çevresel gürültü*, 2011), noise reduction precautions (*Gürültü azaltım*, 2015) and noise mapping (*Gürültü haritalandırma*, 2008), has not been prepared with the reference of WHO's guidelines, as it can be seen in the regulations. However, Turkish guideline on noise mapping has been prepared with the reference of EC's noise mapping guideline (*Good practice*, 2007) and Turkish guideline on environmental noise has been prepared with the reference of EEA's guideline (EEA, 2010) under the twinning project. Nevertheless, contents of Turkish guidelines are similar with WHO's guidelines as well, but the contents of WHO's guidelines are more comprehensive and current. When the European noise guidelines are evaluated, a developing process can be seen clearly. The prior environmental noise guidelines of WHO are; Guidelines for Community Noise (WHO, 1999) which is published in 1999, was more-expert base and included more detailed technical issues on sound measurements and sources, and Night Noise Guideline (WHO, 2009) which was published in 2009, is related with the night noise exposure, sleep disturbance and night noise levels. The subsequent enhanced environmental noise guidelines of WHO (WHO, 2011; WHO 2018a; WHO 2018b; WHO 2018c; WHO 2018d) were published including broader health outcomes of noise exposure, management of indoor noise levels and management of noise policies and regulatory standards (WHO, 2018b). During this developing process, WHO reveals the guidelines that are focused more on adverse health effects to inform public and to attract attention to negative effects of noise exposure.

When the European and Turkish guidelines are compared it can be seen that Turkish guidelines are more similar with prior WHO's guideline and the past publications of EC and EEA and they have deficiencies on health outcomes information. Since providing information to the public and related disciplines on health effects of noise exposure is crucial to provide awareness of noise hazard, guidelines on health effects of noise should be developed in Turkey as well.

CHAPTER V

PROPOSAL ON INTEGRATION PROCESS OF INDOOR SOUNDSCAPING

In comparison with noise management, soundscape is a multi-factorial approach that considers human experience and perception. Additionally, soundscape framework concerns whole acoustic environment, not only annoying sounds or noise but also positive sounds. Regarding this attitude, noise is not the only indicator that effects people in an acoustic environment, i.e. noise masking does not provide the required or pleasant soundscape by itself. Instead of relying solely on noise management, soundscape approach can be enhanced to a framework which contains noise interventions as well. In fact, noise management approach can be evaluated under the scope of the soundscape framework. The difficulty of researching in the soundscape field is to separately handle various factors as well as considering their interactions (Davies et.al. 2013), since it is a rather subjective concept (Aburawis & Dökmeci, 2018). Therefore, this difficulty arises the need of standardization on soundscape factors and methods. The first attempt of standardization on soundscape has been revealed by ISO working group ISO/TC 43/SCI/WG 54 with publishing urban soundscape standards. However, there is not an existing standard related to indoor soundscaping yet. The other attempts regarding enhancing soundscape and integration of soundscape to architectural process are "Soundscape of European Cities and Landscapes" project as a COST Action, and SSID project, which is funded through the ERC of the European Commission. Nevertheless, since COST Action and SSID project have been started because of the inability of EU environmental noise management directive 2002/49/EC on enhancing entire sound environment (Kang et.al., 2013; EC CORDIS Web site), it has not been included indoor soundscape approach yet. Besides COST Action and SSID project, EEA published a guideline in 2014 on open public quite areas which suggests combining different methodologies.

To develop the indoor soundscape approach, its integration to the architectural design process in early stages is crucial. However, the subjective attribution of indoor soundscape arouses the necessity of characterizing the factors and methods, which are needed to be used in the design process. Certainly, a possible regulation/directive will also promote the integration of indoor soundscape principles to the design process in order to implementation of the standards that would be published and existing ones. In that stage, evaluation of present policies on noise management has high importance on the process of developing a soundscape directive. Also, assessment of present documents (regulations/directives and guidelines) is important because of the noise relevance of soundscape, and possible future regulation may need to refer these regulations under the scope of noise interventions. In other words, since soundscape approach involves noise management, noise policies and the related published documents should be in interaction with soundscape regulatory attitude. When the present regulations/directives and guidelines published by the relevant institutions (e.g. ISO, TS) are assessed, it is clearly seen that they have been prepared based on the standards and rely on the implementation of them. Therefore, preparation of standards regarding indoor soundscape factors and methods, which will be in cooperation with other acoustics standards in a possible regulation, can be the first stage. Simultaneously, the support and consultation of experts such as architects, acousticians, interior architects, related governmental institutions or ministries or any other related discipline would be beneficial for the standardization process of indoor soundscaping.

Another important point on integration process is discrimination of indispensable function component of indoor soundscaping, since indoor soundscape expectation and preference differs regarding functional properties of a space and each case should be evaluated within itself. As it can be seen in the regulation on the Protection of Buildings Against Noise (*Binaların gürültüye karşı*, 2017), soundscape evaluations in a possible future directive can be organized depending on the functional properties of enclosures. Hence, characterizing and separating the preference and expectation of users according to function and types of buildings may be needed, while preparing a standard that will be used in a future indoor soundscape regulation/directive.

When the process of noise management policies is followed, last step of integration process might be the preparation of a guideline on indoor soundscaping, which will inform public and related professions about soundscape philosophy, factors, methods, effects and directive implementation.

In conclusion, integration of indoor soundscaping to the architectural design process can be possible with governmental enforcements to proceed in a formal procedure. Correspondingly, the establishment of relevant institution and working groups in it would be needed initially. When the present applications were evaluated, process has been started with the preparation of standard which should be considered in design phase, then continuing with regulation/directive that would become an enforcement for the application stage. Lastly, this integration process should be supported with guidelines in order to provide an information for the design process (see Figure 17). Certainly, during this process, necessity of support and consultation of experts and authorities are essential.

Besides, with in the comparisons of existing noise and soundscape policies in this study, it can be seen that noise management developments in Turkey have been proceeded in cooperation substantially with EU policies. However, same process could not be seen regarding soundscape approach except the participation of Turkey to COST Action. To improve a soundscape approach in Turkey, first the translation of ISO 12913-1:2014 (ISO, 2014) as an equivalent soundscape standard, and then starting to the developing process is necessary.

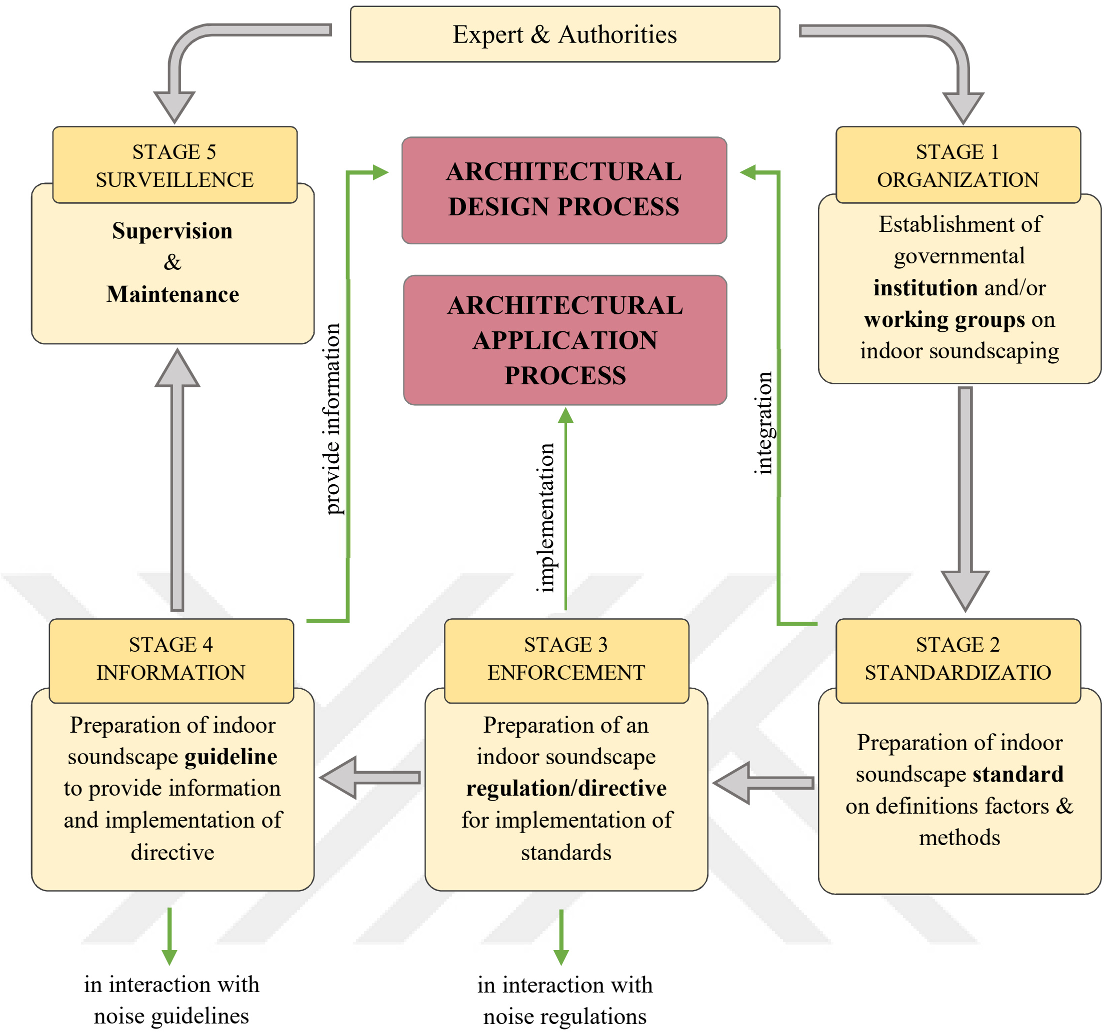

Figure 17 Integration process of indoor soundscape to architectural design and application process and interactions between the entities.

CHAPTER VI

CONCLUSION

Indoor acoustic environment quality is one of the foremost subjects to improve the welfare of people since people spend most of their time in indoor spaces. Certainly, managing noise has great importance, but noise interventions have been assumed insufficient in recent years. It is even argued that soundscape approach should replace the noise management. Therefore, soundscape approach that includes noise management as well, is a better attitude to manage the whole acoustic environment, as it has extensive multi-factorial scope i.e. not limited with acoustical measurements but considers the human perception and context.

In this study, the essential aim is to investigate the process of integration of soundscape to the architectural design process. Initial stage of this investigation is evaluation of extensive factors and methods of indoor soundscaping to understand the philosophy of soundscape approach and advantages that is not involved in noise management approach. After that stage, the present and ongoing policies on soundscape and noise management were evaluated. Turkey and European Union (where the soundscape policies have been advanced in comparison with Turkey) were selected in order to actualize the evaluation of policies in a comparative attitude. The governmental and institutional documents on noise management as directives, guidelines and standards were compared and it is seen that Turkish directives has been prepared as an equivalent to European directives except the regulation on protection of buildings against noise. Similarly, acoustical standards of TSE which have been using in the regulations/directives have been translated from ISO standards and Turkish noise guidelines have been prepared under the scope of EU twinning project. Hence, it was seen that the noise management policies of EU and Turkey have been proceed compatible. However, this compatibility cannot be observed regarding soundscape approach, i.e. a governmental operation on soundscape approach could not be found in Turkey.

In the scope of indoor soundscaping, it is not found an advanced attitude regarding integration to design process both in Turkey and EU. This study aims to discuss on a proposal of indoor soundscaping application that depends on the evaluation of existing policies on urban scale soundscaping and noise management. When these policies are considered, repeated process was observed respectively, and this process can be demonstrated in five stages while adapting to indoor soundscaping integration process;

(1) Establishment of an institution or working group relying on the subject;

(2) Preparation of a standard including definitions, indoor soundscape factors and methods;

(3) Preparation of a directive;

(4) Preparation of guidelines to provide information to public and related disciplines about the concept of indoor soundscaping and implementation of the directive;

(5) Providing maintenance and supervising by experts and authorities.

In conclusion, in order to provide a healthy and pleasant sound environments, it is more advantageous if soundscape approach would replace noise management. The most efficient method to enhance acoustic environment is the integration of soundscape to design and planning process with the governmental enforcements/operations. In European region, the first attempts of this attitude have been seen in recent years, yet indoor soundscaping should also be included in the soundscape projects to enhance the entire sound environment that people lived in.

Limited time is one of the reason that prevents this thesis to be more comprehensive. Besides, the access barrier of ISO standards has obstructed to detailed analysis of acoustical standards. In order to enhance and develop this research field related indoor soundscape integration, further studies are needed. Contents of ISO standards are needed to be evaluated more in detail, to find out the relation between acoustical standards and indoor soundscaping and which ones would be used in integration process.

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APPENDIX

STANDARDS USED IN REGULATIONS AND GUIDELINES

Table 19 was prepared depends on the regulations (2002/49/EC, 2010; Council directive 2002/49/EC, 2002; *Binaların gürültüye karşı*, 2017; Çalışanların gürültü ile,2013; Council directive 2003/10/EC, 2003; 2000/14/AT, 2000; Council directive 2000/14/EC, 2000), guidelines (*Çevresel gürültü*, 2011; *Gürültü azaltım*, 2015; *Gürültü haritalandırma*, 2008; WHO, 2009; WHO, 2011; WHO, 2018a; WHO, 2018b;) and the web sites of TSE and ISO (TSE Web Site; ISO Web site).

Table 19 List of standards used in regulations and guidelines.

Standard Number	**Title**	**Used Documents**
Outdoor and indoor noise measurements (on field)		
TS ISO 1996-2 ISO 1996-2	Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) *(Binaların gürültüye karşı*, 2017) *(Çevresel gürültü*, 2011) (WHO, 2009)
TS 9315 (ISO 1996-1) ISO 1996-1:2016	Acoustics -- Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017) *(Çevresel gürültü*, 2011) (WHO, 2018b)
Measurements of noise that arise from mechanical systems (on field)		
TS EN ISO 16032 ISO 16032:2004	Acoustics -- Measurement of sound pressure level from service equipment in buildings -- Engineering method	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 10052/A1 EN ISO 10052/A1	Acoustics - Field measurements of airborne and impact sound insulation and of service equipment sound - Survey method - Amendment 1	(*Binaların gürültüye karşı*, 2017)

TSEN ISO 3744 EN ISO 3744:1995	Acoustics — Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment — Engineering method'	(2000/14/AT, 2000) (Council directive 2000/14/EC, 2000) (2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017).
TSEN ISO 3746 EN ISO 3746:1995	Acoustics — Determination of sound power levels of noise sources using an enveloping measurement surface over a reflecting plane'.	(2000/14/AT, 2000) (Council directive 2000/14/EC, 2000) (2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017).
Laboratory measurements of devices and systems		
TS EN 1793-1 EN 1793-1:1997	Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics of sound absorption	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017) (*Gürültü azaltım*, 2015)
TS EN 1793-2 EN 1793-2:1997	Road traffic noise reducing devices - Test method for determining the acoustic performance - Part2: Intrinsic characteristics of airborne sound insulation	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017) (*Gürültü azaltım*, 2015)
EN 1793-3:1997 EN 1793	Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 3: Normalized traffic noise spectrum	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017)
TS EN 1793-4 BS EN 1793-4:2015	Road traffic noise reducing devices. Test method for determining the acoustic performance. Intrinsic characteristics. In situ values of sound diffraction	(*Binaların gürültüye karşı*, 2017)
TS EN 1793-5 DIN EN 1793-5	Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 5: Intrinsic characteristics - In situ values of sound reflection under direct sound field conditions (includes Corrigendum :2018)	(*Binaların gürültüye karşı*, 2017)
TS EN 1793-6 BS EN 1793-6:2018	Road traffic noise reducing devices. Test method for determining the acoustic performance. Intrinsic characteristics. In situ values of airborne sound insulation	(*Binaların gürültüye karşı*, 2017)

	under direct sound field conditions	
TS EN 14388 EN 14388	Road traffic noise reducing devices - Specifications	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 7235 ISO 7235:2003	Acoustics - Laboratory measurement procedures for ducted silencers and air-terminal units - Insertion loss, flow noise and total pressure loss (ISO 7235:2003)	(*Binaların gürültüye karşı*, 2017)
ISO/CD 19488	Acoustic classification scheme for buildings	(*Binaların gürültüye karşı*, 2017)
Sound insulation measurements (in laboratory)		
TS EN ISO 10140-1/A1 UNE EN ISO 10140-1:2016	Acoustics - Laboratory measurement of sound insulation of building elements - Part 1: Application rules for specific products (ISO 10140-1:2016)	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 10140-2 EN ISO 10140-2	Acoustics - Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 10140-3 EN ISO 10140-3	Acoustics - Laboratory measurement of sound insulation of building elements - Part 3: Measurement of impact sound insulation	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 10140-4 EN ISO 10140-4	Acoustics - Laboratory measurement of sound insulation of building elements - Part 4: Measurement procedures and requirements	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 3822-1/A1 UNE EN ISO 3822-1:2000/A1:2009	Acoustics - Laboratory tests on noise emission from appliances and equipment used in water supply installations - Part 1: Method of measurement - Amendment 1: Measurement uncertainty (ISO 3822-1:1999/Amd 1:2008	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 3822-2 EN ISO 3822-1	Acoustics-Laboratory tests on noise emission from appliances and equipment used in water supply installations part 1: Method of measurement	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 3822-3/A1 EN ISO 3822-3/A1	Acoustics - Laboratory tests on noise emission from appliances and equipment used in water supply installations - Part 3:	(*Binaların gürültüye karşı*, 2017)

	Mounting and operating conditions for in - Line valves and appliances	
TS EN ISO 3822-4 EN ISO 3822-4:1997	Acoustics - Laboratory tests on noise emission from appliances and equipment used in water supply installations - Part 4: Mounting and operating conditions for special appliances	(*Binaların gürültüye karşı*, 2017)
TS EN 14366 EN 14366	Laboratory measurement of noise from wastewater installations	(*Binaların gürültüye karşı*, 2017)
ISO 15665 /Cor 1	Acoustics -- Acoustic insulation for pipes, valves and flanges	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 354 EN ISO 354	Acoustics - Measurement of sound absorption in a reverberation room	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 10534-1 ISO 10534-1:1996	Acoustics -- Determination of sound absorption coefficient and impedance in impedance tubes -- Part 1: Method using standing wave ratio	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 10534-2 ISO 10534-2:1998	Acoustics -- Determination of sound absorption coefficient and impedance in impedance tubes -- Part 2: Transfer-function method	(*Binaların gürültüye karşı*, 2017)
TS EN 27574-1 EN 27574-1:1988	Acoustics-Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment-Part 1: General Considerations and Definitions	(*Binaların gürültüye karşı*, 2017)
TS EN 27574-2 EN 27574-2:1988	Acoustics-Statistical methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment Part 2 Methods for Stated Values for Individual Machines	(*Binaların gürültüye karşı*, 2017)
TS EN 27574-3 EN 27574-3:1988	Acoustics-Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment - Part 3: Simple (transition) Method for Stated Values for Batches of Machines	(*Binaların gürültüye karşı*, 2017)
TS EN 27574-4 EN 27574-4:1998	Acoustics-Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment -	(*Binaların gürültüye karşı*, 2017)

	Part 4: Methods for Stated Values for Batches of Machines	
ISO 13347-1 ISO 13347-1/Cor 1 & ISO 13347-1/Amd 1	Industrial fans - Determination of fan sound power levels under standardized laboratory conditions - Part 1: General overview	(*Binaların gürültüye karşı*, 2017)
ISO 13347-2 ISO 13347-2 /Cor 1	Industrial fans - Determination of fan sound power levels under standardized laboratory conditions - Part 1: General overview	(*Binaların gürültüye karşı*, 2017)
ISO 13347-2 ISO 13347-2 /Cor 1	Industrial fans - Determination of fan sound power levels under standardized laboratory conditions - Part 2: Reverberant room method	(*Binaların gürültüye karşı*, 2017)
ISO 13347-3 ISO 13347-3/Amd 1 & ISO 13347-3/Cor 1	Industrial fans - Determination of fan sound power levels under standardized laboratory conditions - Part 3: Enveloping surface methods	(*Binaların gürültüye karşı*, 2017)
ISO 13347-4	Industrial fans - Determination of fan sound power levels under standardized laboratory conditions - Part 4: Sound intensity method	(*Binaların gürültüye karşı*, 2017)
ISO 15664	Acoustics - Noise control design procedures for open plant	(*Binaların gürültüye karşı*, 2017)
Sound insulation measurements (on field)		
TS EN ISO 16283-1 ISO 16283-1:2014	Acoustics - Field measurement of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation (ISO 16283-1:2014)	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 16283-2 ISO 16283-2:2018	Acoustics - Field measurement of sound insulation in buildings and of building elements - Part 2: Impact sound insulation (ISO 16283-2:2018)	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 16283-3 ISO 16283-3:2016	Acoustics - Field measurement of sound insulation in buildings and of building elements - Part 3: Façade sound insulation	(*Binaların gürültüye karşı*, 2017)
Insulation and absorbency assessments		
TS EN ISO 717-1 EN ISO 717-1:2013	Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017)

TS EN ISO 717-2 EN ISO 717-2:1996	Acoustics - Rating of sound insulation in buildings and of building elements - Part 2: Impact sound insulation	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı*, 2017)
TS EN ISO 11654 EN ISO 11654:1997	Acoustics-Sound absorbers for use in buildings-Rating of sound absorption	(*Binaların gürültüye karşı*, 2017)
Building acoustics calculations		
TS EN 12354-1 ISO 15712-1:2005	Building acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 1: Airborne sound insulations between rooms	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı,* 2017)
TS EN 12354-2 ISO 15712-2:2005	Building acoustics -- Estimation of acoustic performance of buildings from the performance of elements -- Part 2: Impact sound insulation between rooms	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı,* 2017)
TS EN 12354-3 ISO 15712-3	Building acoustics -- Estimation of acoustic performance of buildings from the performance of elements -- Part 3: Airborne sound insulation against outdoor sound	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Binaların gürültüye karşı,* 2017)
TS EN 12354-4 ISO 15712-4	Building acoustics -- Estimation of acoustic performance of buildings from the performance of elements -- Part 4: Transmission of indoor sound to the outside	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) *(Binaların gürültüye karşı,* 2017)
Room acoustics tests and reverberation time, equivalent sound absorption, intelligibility, speech confidentiality, determination of other subjective and objective parameters measurements (in the field)		
TS EN ISO 18233 EN ISO 18233:2006	Acoustics – Application of new measurement methods in building and room acoustics	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 3382-1 EN ISO 3382-1:2009	Acoustics - Measurement of room acoustic parameters - Part 1: Performance spaces	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 3382-2 EN ISO 3382-2:2008	Acoustics - Measurement of room acoustic parameters - Part 1: Reverberation time in ordinary rooms	(*Binaların gürültüye karşı*, 2017)
TS EN ISO 3382-3 EN ISO 3382-2:2008	Acoustics - Measurement of room acoustic parameters - Part 1: Reverberation time in ordinary rooms	(*Binaların gürültüye karşı*, 2017)
Measurements of uncertainties		

TS EN ISO 12999-1 EN ISO 12999-1:2014	Acoustics - Determination and application of measurement uncertainties in building acoustics - Part 1: Sound insulation	(*Binaların gürültüye karşı*, 2017)
Others		
TS ISO 9613-2 ISO 9613-2	Acoustics — Abatement of sound propagation outdoors, Part 2: General method of calculation’	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Gürültü haritalandırma*, 2008)
TS ISO 8297 ISO 8297:1994	Acoustics — Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment — Engineering method	(2002/49/EC, 2010) (Council Directive 2002/49/EC, 2002) (*Gürültü haritalandırma*, 2008)
TS 2607 ISO 1999 ISO 1999:1990	Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment	(*Çalışanların gürültü* ile,2013) (Council directive 2003/10/EC, 2003) (WHO, 2011)