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Original Research Article

Developing a Model for Measuring the Soundscape Quality in an Urban Context Based on Contextualism Using Matrices*

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Abstract | One of the areas of interest in studies and environmental design is the soundscape. Since the sense of hearing, besides that of sight, becomes essential in understanding urban space, one research area of interest in environmental studies and design is the soundscape. The introduced methods and tools for measuring the soundscape are primarily quantitative, such as using tools or qualitative methods based on questionnaires; there are less comprehensive methods based on the contextual characteristics of the urban space. This research identifies and introduces a comprehensive framework for evaluating the soundscape in urban space based on the context of heard and perceived sound. It aims at criticizing most of the studies done on the soundscape, which primarily relied on one or two methods in their evaluation. The research emphasizes sound as a multi-dimensional phenomenon. A soundscape is an exchange between humans and the environment, and we should consider both aspects simultaneously in the evaluation process. This research examined the texts and methods used in the soundscape's evaluation and proposed a quantitative-qualitative combined method based on the indicators of the context affecting the perception of the sound. The proposed model uses the four matrices of compatibility, desirability, capacity, and dependency. Therefore, the perception of sounds in the space occurs based on the type of activity in that space. The sound tolerance threshold and the pleasant soundscape are different based on the context where the person hears the sound.

Keywords | *Landscape, Soundscape, Measuring Sound, Contextual Design.*

Introduction| The major theme of research on the soundscape is to find a suitable way to measure the area under study appropriately so that it can be effective both individually and socially as well as in terms of macro policies in an urban space. The fundamental challenge is that soundscape is a multifaceted phenomenon, so we cannot study it simply by several methods. The essential issue in this field is the human perception of sound environments and their evaluation (Kang et al., 2016). Physiologically, a sound signal has a significant changeability in the human environment, which results in a series of unconscious responses, including changes in the hormones of people's bodies (Erfanian, Mitchell, Kang & Aletta, 2019). Therefore, physical and spiritual dimensions can play an essential role in the soundscape, and in higher stages, this soundscape plays its role in people's minds and identities. The sound environment is composed of all bearable sound sources, and its formation depends on the path and changes that occur in the sound sources. The sound environment of any place depends on the resources, the position of the receiver, and the conditions of sound propagation from moment to moment, from day to night, and from season to season. The soundscape paradigm focuses on individuals' acoustic perception and understanding of the space environment (Kogan et al., 2016). In evaluating the soundscape, one usually attempts to calculate the decibel level of sound in the space with the help of current technologies or by producing sound maps to identify the noisy points, which is a critical issue in designing to achieve a desirable soundscape. What is essential in the studies on the soundscape at the level of the urban space is that it is affected by everything happening in

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the urban space. In urban spaces, the occurrence of accidents or the repetition of certain activities is always observable, each of which significantly impacts the behavior of individuals or research. Therefore, there are always deficiencies in soundscape research. The soundscape experience results from the contextual factors of the environment and the inherent characteristics of each individual (ibid.). Our research attempts to identify the steps and find the methods used in soundscape measurement by reviewing the research. An essential thing in the research on the soundscape is the perception of the users in the environment, which is the most vital indicator to find the quality level and evaluate the soundscape of a range. This research identifies and introduces a comprehensive framework for evaluating the soundscape in urban spaces. Its major question is how to consider contextual features, such as spatial features, in producing and measuring soundscape quality. What are these contextual features? To answer the question, we should first examine the history of soundscape evaluation methods and their shortcomings.

Research Background

In every soundscape project, the four factors of perception and sound quality of the place, spatial and sound limitations, repetition and time sequence, and people's interaction are important and require careful analysis (Belgiojoso, 2014). Most of the studies on soundscapes carry out their analysis with quantitative methods and qualitative measurements through questionnaires and field surveys. Depending on their goal and problem, each researcher tries to design questionnaires with questions based on the problems and find the challenges in the space to get the required data through statistical models or options limited to the Likert spectrum. Most research measures humans as the first and most important effective factor in soundscape perception and investigates the influencing factors in perception. Herranz-Pascual et al. (Herranz-Pascual, García, Diez, Santander & Aspuru, 2017) considers four factors effective in measuring the soundscape. 1) Congruence between soundscape and visual landscape 2) Physical characteristics of the space (presence of special elements and evaluation of the natural elements such as water, vegetation, and open space). 3) Examining and evaluating specific sound variables in various forms and situations (for accidents or events) 4) The balance between the identity of sound sources and their perception ISO 12913- 1 states that the assessment of the soundscape is not only under the influence of the sound but also of the context in which the person is present. Although the perception of sound depends on the physical factors of sound, such as amplitude and frequency, as most studies show, the importance of the impact of visual factors on the perception and evaluation of sound has also been clear (Puyana Romero, Maffei, Brambilla & Ciaburro, 2016). The sound quality protocol, as a tool for evaluating and classifying sound environments according to their sound perception by people, uses two strategies: fixed location and sound walks, depending on the conditions of the area under study. Studies have shown that even with large datasets and several acoustic indicators, models that satisfy objective or measurable criteria have lower performance than models based on perceptual responses in predicting soundscape evaluation (Mitchell et al., 2020). In response to questions on the soundscape, as Kang et al. state, "all measurement methods, including physical or perceptual data collection, must be closely related to the human's perception of the sound environment" (Kang et al., 2016). This subject becomes important in the study of the soundscape. We have used a complementary qualitative-quantitative approach to evaluate Khayyam's soundscape. We used a questionnaire containing the range of auditory potentials and their pleasantness from people's points of view with three questions of signal sound, sound mark, and keynote to evaluate the quality (Ghalenoie & Mohsen Haghighi, 2017). Abedi (2015) states that there is a direct two-way relationship between the users' mental perception of the acoustic environment and the physical characteristics of the acoustic environment in the urban spaces of Tehran. During the year, when the heat factor dominates over other factors, as in the summer, this relationship is not established. This shows that it is impossible to investigate and evaluate the sound environment in urban spaces through the characteristics of one of the two crucial dimensions (mental and physical) of the sound environment. The simultaneous and parallel evaluation of both dimensions is mandatory.As shown in Table 1, some audio research takes place with different methods such as listening to sounds, recording audio, filming, audio walking, sound measurement, objective perception, and questionnaires to measure sound and its perception. In addition, some researchers, like Hermida and Alvez, have tried to show the effect of identity index and context on sound perception.

Context and Sound Connection

As the World Standard Organization shows, sound evaluation is dependent on sound and under the influence of the context in which a person is present (Puyana Romero et al., 2016). Soundscape evaluation is a part of aesthetic research whose primary concern is the pleasantness of emotions received from the sounds of the environment (Shahabian & Larmian, 2017, 36). The context is a physical place with the sounds of the environment. ISO defines it as the mutual relationships between the person, activity, and place in space that are perceivable through the sense of hearing, the interpretation of the sense of hearing, and the reaction to the sound environment (Herranz-Pascual et al., 2017). In describing the acoustic environment in an urban open space, one should consider many things, such as spatial characteristics, activities that occur there, people and vehicles, and its historical period. One should also consider the viewpoints of different people

Table 1. A summary of the research on soundscape measurement. Source: Authors.

Researcher	Methods	Aspects of the focus
Herranz-Pascual et al. (2017)	Audio method (ordered methods with acoustic and non-acoustic factors), objective methods of perception, field investigations Camping, panoramic photos of the area, psychological experts at the campsite. Using 2D maps and assigning a percentage to each of the elements and uses	Use of quantitative methods and imaging and filming
Zhao, Zhang, Meng & Kang (2018)	Photographing, checking, and counting the people in the environment through camera and video recording of 3 desirable sections of the pedestrian under study with degree 94, examining the conversations and sounds that are produced by people in the time (between 25 and 30 minutes), Required analyses of films in the laboratory	Investigating the effect of time on sound perception
Hermida, Pavón, Lobo Soares & Bento-Coelho (2019)	By examining environmental experiences in a laboratory and researching two groups of people to investigate the reactions of people to the sounds of their city and the sound of a city with which they have no experience. Using the audio method to investigate the spatial distribution of sound sources and the amount of sound reproduction by this method. The existence of differences in people's behavior originates from the identity of their place of residence.	Impact of Usage, culture, and Society on Perception
Kogan et al. (2016)	Evaluation of daily, weekly, and seasonal dynamics and identification of sound signs in each environment through Soundwalk and the fixed location method	Investigating the effect of time on sound perception
Mitchell et al. (2020)	Filling in the questionnaire (questions about the sound environment and as Likert spectrum coding), participant group ID, level of education, start and end time for each participant (in electronic form) or each group, GPS location (in electronic form) Environmental information collection: measurement duration, 10 seconds: (temperature (C), light intensity, lux (LI), air quality (CO_2), relative humidity (RH), etc.; sound level measurement (using a microphone), Binaural recording system), 360-degree filming and photography	Effect of environmental characteristics on sound perception
Alves, Estévez-Mauriz, Aletta, Echevarria-Sanchez & Romero (2015)	Camp of experts on site, field surveys, and evaluation of audio data from questionnaires and interviews. Placement of 55 receivers in the area under study, finally producing a sound map, traffic map, geographic location information, questionnaire, building a model through sound behavior prediction software, Soundwalk method. In the beginning, the two-phase research was devoted to the knowledge of the space and the history of the space, and the second phase studied what is happening in the urban space by creating a survey camp and field investigation, data evaluation, studies on traffic and population density, as well as studying Sound propagation model in space	Human differences in sound perception and the impact of environmental characteristics such as density and space design
Blanco, Igone, Saloga & Garcia (2012)	Introducing two approaches: 1) SEI physical sound assessment, 2) Psychoacoustic (questionnaire) in evaluating soundscape parameters.	Division of sound measurement approaches quantitatively and qualitatively
Abedi (2015)	The sound environment has two perceptual and physical dimensions: The users of the space obtain the perceptual dimension. Artificial measurement tools can measure the physical dimension. Using the facilities that the sound environment provides for urban designers requires knowing, investigating, and analyzing the mutual relationships of these dimensions in the city space.	Impact of human perception and physical frustration
Ghaffari, Mirgholami & Shafai (2021)	Several indicators are effective in assessing the soundscape quality of urban spaces. The acoustic behavior of the space is one of the environmental factors influencing the sound landscape. Several components are relevant to the acoustic behavior of places. The form of the materials and the volume of the space are among the most important.	Effect of the physical environment on sound perception

who deal with such environments. Soundscape studies include sound and contextual factors that affect human perception of the sound environment. The spatial, temporal, and functional factors of the context are some factors of more interest. The variety of sound sources in different places and regions can influence the evaluation of citizens. Time factors encompass factors such as time of day or seasons and, in some studies, the effect of temperature in different seasons. The activity factor refers to commercial, residential, and recreational usage (Zhao et al., 2018). The spatial effects under study are reverberation, reflection, background noise, and surrounding sounds. For example, noise is more annoying when its reverberation lasts longer than usual; a duration of one or two seconds is the ideal duration of the reverberation time of noise in the street

(Belgium). Huso, 2016). As ISO 12913- 1 states, the evaluation of the soundscape is not only under the influence of the sound but also of the context in which the person is present. Although the perception of sound depends on the physical factors of sound, such as amplitude and frequency, which have been the subject of most studies, the importance of visual factors is influential in the perception and evaluation of sound (Puyana Romero et al., 2016). If a place gains "meaning" based on the use of that space, the "meaning" of the acoustic environment is under the influence of person-place reactions (contextual aspects) (Hermida et al., 2019). Table 2 shows factors that have led to the construction of contextual indicators of soundscape perception in Figure 1.

Research Method

Soundscapes in the urban context have been evaluated using quantitative and qualitative methods so far. Soundscapes in the urban context have been evaluated using quantitative and qualitative methods so far. The quantitative method uses different technology and tools and produces a map or measures the sound volume. Qualitative methods examine the soundscape quality with the help of survey methods and questionnaires. By asking questions or accompanying the person visiting the space, this method tries to discover what the person understands about the space and the feeling that the space creates in him. Because of the multifaceted nature of sound and the impact that this non-visual factor has on the urban space from its surroundings, one should pay attention to each of the basic and cross-sectional influencing factors (depending on time, activities, and events) that are strengthening depending on the type of research. Therefore, we require a combined perspective with simultaneous positive and negative attitudes toward the subject of the sound environment and a multifaceted method for designing the sound environment. Thus, we plan and design an optimal sound environment in urban spaces through a two-step method to measure the level of sound intensity quantitatively and examine qualitative factors such as attendance motivation, momentary assessment, dominant sounds, air warmth, lighting, radiation, and finally visibility and vision (Abadi, 2015). However, a review of the relevant research background shows that, depending on the purpose of the research and the need for access to sound information, the quantitative and qualitative methods are limited to a few cases. Interviews, sound walks, and field surveys carried out by the research team often occur through the direct communication of the researcher with the people using the environment or through the presentation of questionnaires. These methods are qualitative. Quantitative methods require sound measurement tools and the use of software for measuring and monitoring sound components. According to the type of research, such software is not limited to sound measurement

Table 2. Contextual factors affecting sound perception. Source: Authors.

Contextual factors	Indicator
Spatial (Zhao et al., 2018)	Reverberation, reflection and background noise, and surrounding sounds
Time (Zhao et al., 2018)	Year, season, day
Functional (Zhao et al., 2018)	Activities and uses
Visual factors (Puyana Romero et al., 2016)	Visual elements, materials, or urban furniture
Psychological, social, and individual characteristics and experiences (Belgiojoso, 2014) Culture (Hermida et al., 2019)	Duration of a person's residence, the person's life expectations, the influence of economic factors
Meaning (Hermida et al., 2019)	Based on the use of that space, the meaning of the sound environment is influenced by the reaction of the person and the place.

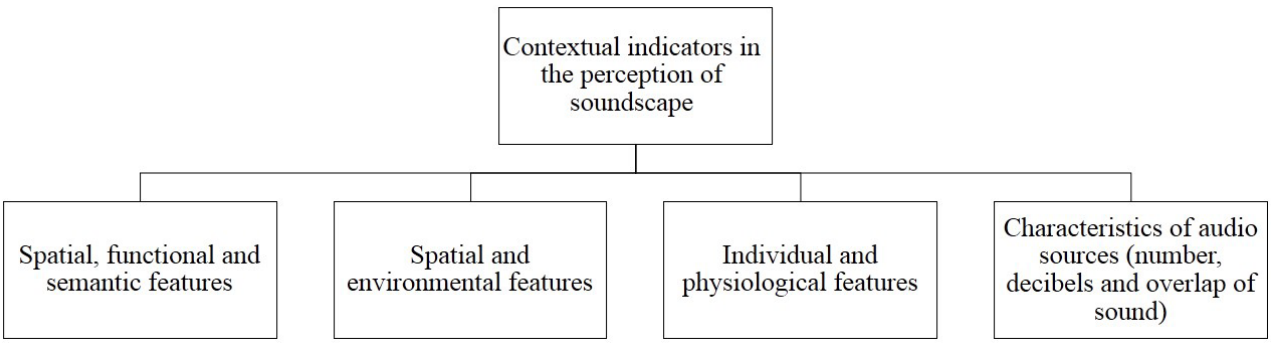


Fig. 1. Contextual indicators in sound perception. Source: Authors.

software, and depending on the needs, the researchers make the software. By examining the methods used in soundscape research in recent years, the major challenge in the study of soundscape is the measurement of the soundscape. Because of the multifaceted nature of the soundscape, it is necessary to measure, examine, and evaluate it through human perception of the sound environment. The soundscape approach and its measurement in collecting information, whether through physical or perceptual data, depend on the human perception of the sound environment (Kang et al., 2016). Measuring the soundscape in urban space is subject to two factors: subjective and objective indicators. Sometimes research uses methods such as questionnaires for qualitative-subjective measurement of sound and sometimes tools for quantitative-objective measurement of sound. This research proposes the four matrixes of compatibility, desirability, capacity, and dependency, almost the same as evaluating sound subjectively and objectively and using simultaneous quantitative and qualitative methods. Since most soundscape evaluation is done by quantitative or subjective methods such as questionnaires, this method can examine soundscape quality by combining different tools. Considerably most of the sounds in the space are formed by the type of use and activity that occurs there, and the sound tolerance threshold and the pleasant soundscape are different based on the context in which a person lives there (without considering the individual's personality and mentality background).

Constructing a Qualitative Framework for Sound Measurement in Urban Space through Four Matrices

It is necessary to know all the uses in the space to have an area with good sound quality. Familiarity with the street design and the quality of the green space, etc., is necessary. Usage assessment matrices are one of the quality measurement methods. As for the compatibility criteria, examining the compatibility of each usage with another one is essential. In terms of sound, naturally, those usages can be next to each other that do not cause any disturbance to other usages. As for the compatibility matrix, each usage can produce the desired sound with the neighboring usages because of the activity in that area. Like the compatibility and dependency matrices, the capacity and desirability matrices also require conditions to be suitable for usage within the context. We will explain them in the following (Fig. 2).

Research Findings

• Compatibility matrix

The compatibility matrix tries to evaluate usages acoustically. It calls compatible usages that are compatible with each other in terms of noise. It does not know other usages appropriate for the neighborhood regarding sound and sound production. For example, noisy usage should not be next to sensitive usages such as hospitals. What is of interest in the sound compatibility matrix is the sound decibels that each usage (or each sound stream) produces. Usages such as grocery stores, fruit shops, and bakeries normally have the noise only when unloading (of course, if the shopkeepers do not shout for advertising). As for this type of matrix, the suggestion is to prepare a list of existing usages in the urban space by field survey and then measure the amount of created sound and the overlap of the sounds based on the sound intensity of compatible to incompatible usages. The diagram in Fig. 3 is an example of a compatibility matrix in Tehran Railway Square.

• Completely compatible sound

two usages have a common sound harmony, and the intensity of the created sound is completely consistent in sound intensity and activity and even helps each other sometimes. We must define each activity's field of influence and effectiveness according to its characteristics. They should not have harmful effects and be outside the sphere of influence of others (such as local commercial shops).

Relatively consistent sound: the created sounds belong to the same group, but they differ in details (such as elementary school and university).

Relatively inconsistent sound: the amount of expected sound inconsistency between two activities is greater than compatibility (such as a residential space compared to an educational space).

Completely inconsistent sound: The sounds are incompatible and in opposition (such as residential usage with an industrial or workshop unit).

• Desirability matrix

it evaluates the compatibility between the required sound intensity and the site. It deals with the effect of physical factors, the type of materials, the geometric shape of sound barriers, and their use of them for more efficiency in buildings and urban spaces. In the urban context, the traffic of motorized vehicles, pedestrians, and cyclists are all intertwined in the street. Often, urban designers and architects are unaware of the consequences of sounds of urban life in busy urban spaces for people exposed to or even nearby residents with these sounds. Accuracy in the facade's design of the buildings, the size of the width of the streets, the type of design and placement of the urban furniture, and green spaces of the area all impact sound reflection and create desirable changes (Kropp, Forssén & Estévez-Mauriz, 2016). The studies on the acoustic behavior of urban spaces should be paid attention to the frequency spectrum of the sounds in the space. The effective factors of the acoustic behavior of the micro-space are under the influence of the indicators of metric characteristics (volume, dimensions, spatial proportions, and enclosure), shells (floor, materials, walls including geometric form), physical barriers (dimensions and size, materials, and location) and sound barriers (sound intensity and frequency spectrum) (Ghaffari, Mirgholami & Shafai, 2021). Table 3 shows the spatial and

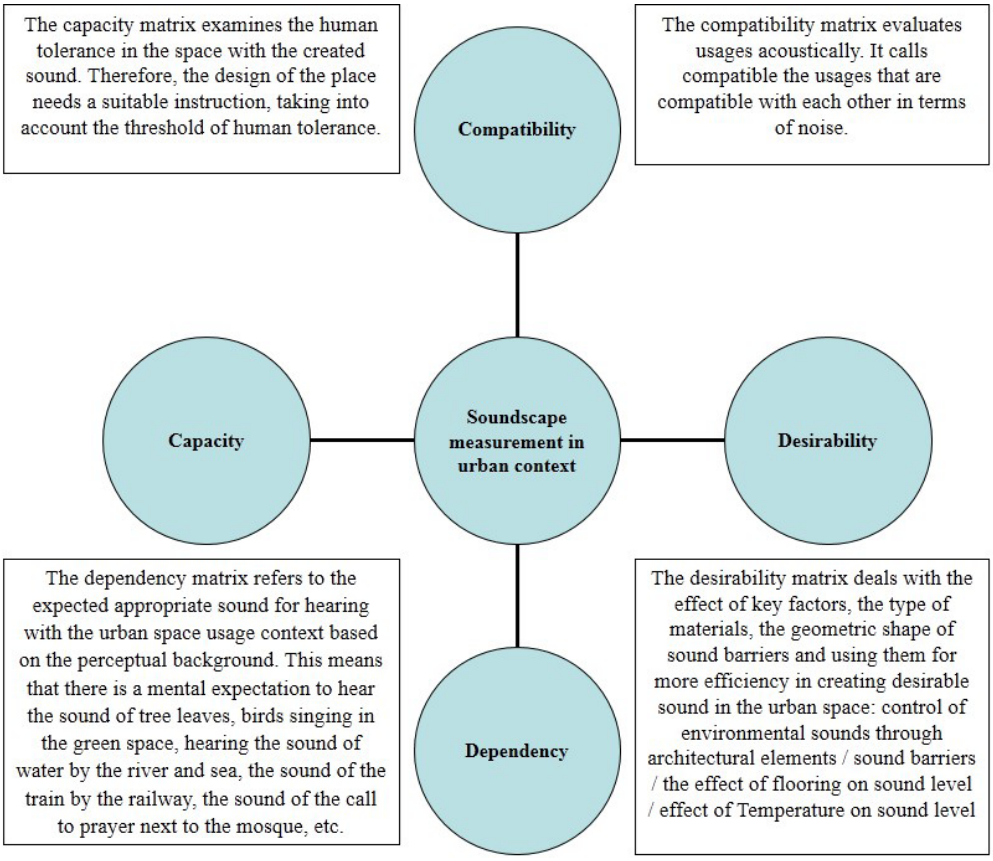


Fig. 2. Analytical framework of soundscape measurement in an urban context. Source: Authors.

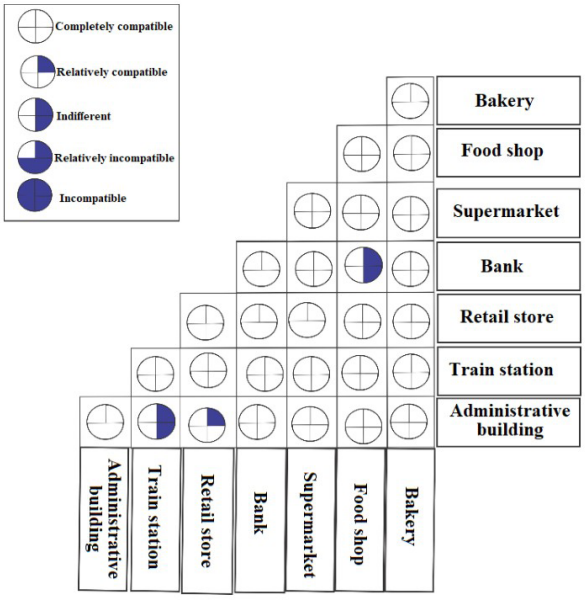


Fig. 3. Example of a compatibility matrix based on usages' sound. Source: Authors.

environmental factors that affect sound control through architectural elements, sound barriers, vegetation, panels, flooring, and temperature.

• **Dependency matrix**

This type of matrix aims to eliminate the expectation and even create the expectation of hearing a sound appropriate to the identity and related activities of that urban space. The green space is hearing the sound of tree leaves, birds singing, and the sound of water next to the river and the sea, the sound of the train next to the railway, the sound of the call to prayer next to the mosque, and a mental expectation to be heard.

• **Capacity matrix**

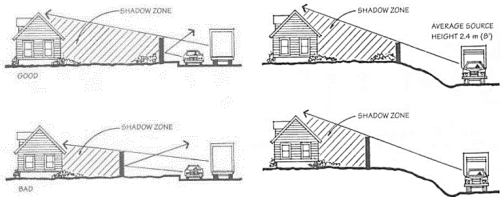
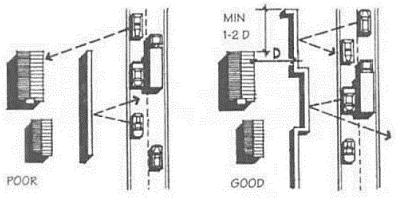
It examines the human tolerance in space with a certain usage. Therefore, we need suitable instruction for the design of the place, considering the threshold of human tolerance. The following table is an excerpt from the planned plan table for San Diego states.

Conclusion and Suggestions

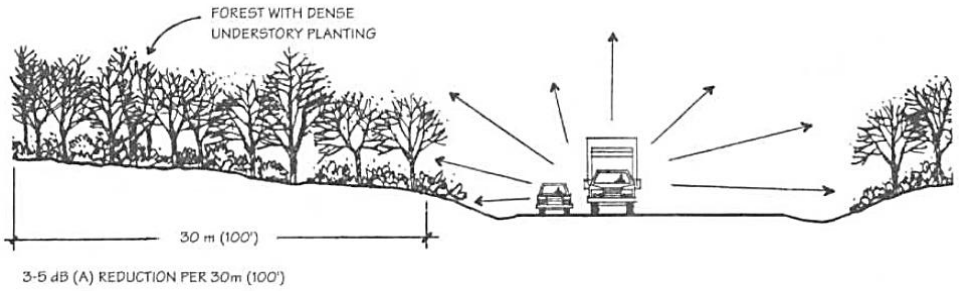
The human experience of urban spaces occurs through the senses. The citizens' perception of urban space can give it a positive or negative identity. Although the sound factor becomes a habit after a time, it has a very high impact power in the long term. Lack of considering the soundscape of the environment can be a suitable platform for creating disturbances and destroying the identity and values of the urban space. The soundscape should proceed with human testing or with audio equipment, so, in the first case, testing the hearing, feelings, and interests of people is important; in the second case, the type of device and the method of

measurement and simulation. Since the mental background of people in audio research is a very important and basic issue, its examination and finding different methods for its evaluation are always necessary. The method we introduce in this research tries to investigate individuals' perceptions in the urban space. As mentioned above, models based on individuals' perceptions are more efficient than quantitative models. Therefore, the matrix of soundscape quality evaluation can play a complementary role in quantitative evaluation models. As a response to the research question, if the sound

Table 3. Sound control with environmental design. Source: Authors.

Sound control	Reduction of sound intensity
Environmental sound control through architectural elements	- In the design of facades, facades with an upward slope (F1. 3) and concave facades (F1. 7) are suitable for creating a desirable sound space for pedestrians. Sloping bodies with a downward slope (F1. 2) increase the intensity of the sound.  - Pedestrian sidewalks should be as far away from the sound source as possible - The facade of the building should not have glass material - The setback on the lower floor may reduce noise (a setback with a depth of 5 meters and a height of 2 floors) (increasing the depth of the setback reduces noise for pedestrians) - Combined use of sloping balconies with absorbent roofs on the ground floor (F3. 5). Setback with a depth of 5 meters and a height of 2 floors is the best way to achieve the result. Figure (F2. 4) (Kropp et al., 2016). 
Controlling environmental sounds through sound barriers	- The minimum height of the barrier should not break the line of sight between the source and the receiver (a). - The sound barrier should have the shortest possible distance from the noise source or receiver to maximize the diffraction angle (b).  (b) (a) - The barrier must be free of any seams and holes (c). - The length of the sound barrier should be at least 1 to 2 times more than the distance for the barrier, and the structure should be protected against noise to minimize sound diffraction around the two ends of the barrier (c).  (c) - Designing and determining the exact location of earth piles effectively reduces traffic noise or construction operations. The absorbent coating on the top surface of the barrier (in S2. 2 or S2. 4), despite the small surface it has, reduces 1 dBA for pedestrians. The maximum sound reduction with barrier walls equipped with sound-absorbing panels is approximately 9 dBA (S2. 5) compared to the space without sound barrier walls (Kropp et al., 2016). 

Rest of Table 3.

Sound control	Reduction of sound intensity
Controlling environmental sounds through vegetation	Green space can be a positive element in sound reduction. We should note that the type of greenery, the density of green space, and the distance of the area protected by the green space all directly impact the improvement of the result. Areas covered with grass or other vegetation absorb sound more, but hard and paved surfaces do not reflect sound. Taller plants, such as hedges or fences, will have little effect on reducing the level, although they may completely block the view of the sound source. Of course, dense trees with short bushes under them will reduce the sound level by 3 to 5 decibels for every 30 meters deep from the sound source. Surfaces covered with grass or other short vegetation absorb sound more than hard, paved surfaces (Harris et al., 2014). 
Plate, mass, and context as important elements in sound control	Times standard refers to these two elements. The plate is a sound barrier around the streets and alleys, and its uniform appearance gives people a feeling of being confined in the space. As stated in the Times-Standard, "relatively smooth (fine-textured) surfaces reflect light and sound unfavorable" (Harris et al., 2014).
Flooring for Sound Reduction	The materials used in the streets are very important in the sound produced by passaging vehicles. The softness and roughness of the materials: roughness of the street surface, which prevents the risk of slipping, produces more noise than the soft surface. Soft asphalt produces about 3 dB less noise. A street with a stone floor will create about 5 decibels more noise than a concrete floor. Soft asphalt produces about 3 dB less noise. However, rain and wetness increase the sound level for asphalt by 13 to 18 dB and for concrete by 5 to 12 dB (Qarib, 2014).
Effect of temperature on sound	As the temperature increases, the speed of sound in the air increases. As the lower layers of the atmosphere heat, the sound travels upwards. Thus, the effect of the earth's heat, compared to the direct propagation of sound, reduces the level of noise pollution around the road (Safarzadeh Parizi, 1998).

perception process falls into two parts, the sound transmitter and the sound receiver, perceived by the sense of hearing, the sound transmitter is the entire physical environment and the sound sources are all the physical characteristics in which they are located (context). In this environment, the sounds must be in harmony with each other regarding usage and resonance of the produced music (compatibility matrix), and the relevant body must have a design that can control and direct appropriate and inappropriate sounds (desirability matrix). The receiver is also a human being with a limited capacity to hear sounds (capacity matrix); based on the mental expectations of the urban context where the sound is heard (dependency matrix), the sound is perceivable, and the soundscape takes shape for him. Therefore, we can say that the sound landscape has been created in proportion to the urban context when sound perception can take place in this perception process (Fig. 4).

Contextual indicators in perceiving the soundscape include:

1) Characteristics of the sound sources (number, decibels, and overlap of the sound) are proposed to evaluate their effect on the compatibility matrix. Here, we should identify the congruent and mutual usages of sounds, measure the number of sound decibels, and eliminate them in the case of the predominance of incongruent sounds (quantitative methods).

2) Individual and physiological characteristics, which are recommendable for evaluating their effect on the capacity matrix (see Table 4) (quantitative-qualitative methods).

3) Spatial and environmental characteristics, which for evaluating their effect the desirability matrix is recommendable, are measurable through sound control tools, or are controllable by examining physical characteristics and using sound reference books (quantitative methods such as measuring acoustic behavior and using a device to measure sound intensity and volume).

4) Spatial, functional, and semantic features, which for evaluating their effect on the dependency matrix is recommendable; we can use complementary methods such as questionnaires to identify the sound expected by citizens (quantitative-qualitative methods).

Therefore, on the one hand, the human being is, in our model, the crucial element in the process of sound and soundscape perception, and the environment is the transmitter of sound, whose objective characteristics are at stake. Finally, the interaction between objectivity-subjectivity, man, and the environment creates the quality of a soundscape. The

complementary role of this model (matrices) is usable, for example, to produce sound maps or evaluation questionnaires in both fixed location and sound walk modes. Since most soundscape evaluation gets by quantitative methods or subjective methods such as questionnaires, this method can examine the quality of soundscape professionally by combining different tools. Considerably most of the sounds in the space take shape through the type of usage and activity that occurs there. The sound tolerance threshold and the pleasant soundscape are different based on the context in which a person lives there (without considering the individual's personality and mentality).

Authors' Conflict of Interest

The authors have observed the publishing ethics and avoided plagiarism, misconduct, falsification of data, or double posting and publication. No commercial interests exist, and the authors have not received payment for presenting their work.

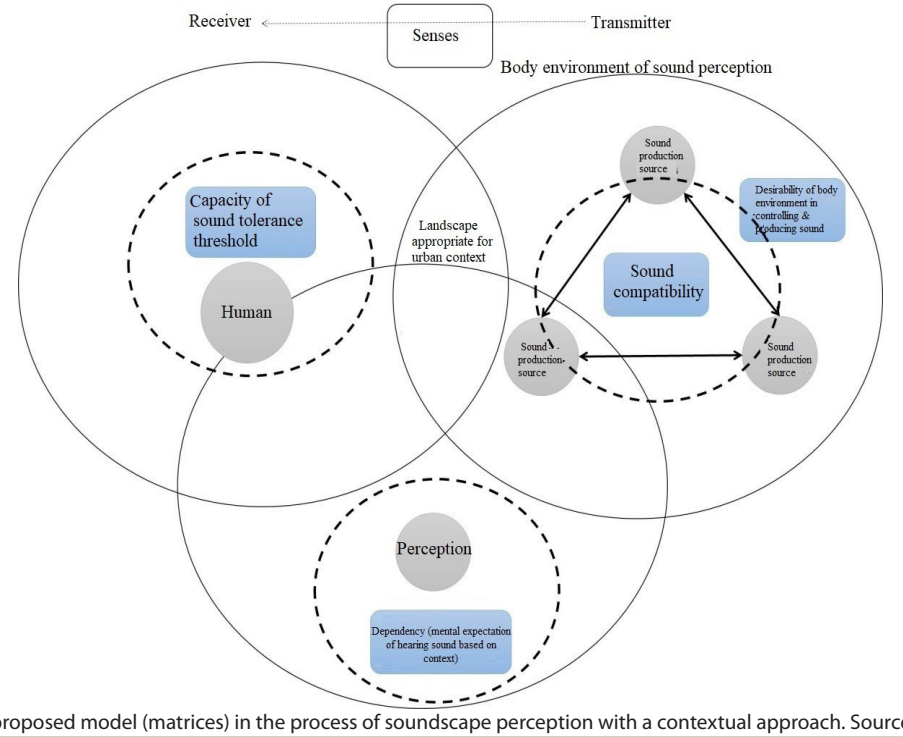


Fig. 4. Position of the proposed model (matrices) in the process of soundscape perception with a contextual approach. Source: Authors.

Table 4. Capacity Matrix for San Diego County General Plan–Noise Elements. Source: Sandiegocounty.gov, 2020.

Sound compatibility of usages				
Usages Acceptable		Sound intensity (decibel)		
		Acceptable	Acceptable (conditioned)	Unacceptable
A	Residential (single-family, large houses, etc.)	60 - 45	75 - 60	75 – 80
B	Residential (multi-family), mixed usages (commercial/residential)	65 - 45	75 - 65	75 – 80
C	Rented House (hotel, motel, resort)	65 - 45	75 - 65	75 – 80
D	Schools, kindergartens and children's service centers, religious places, hospitals	65 - 45	75 - 65	75 – 80
E	Inactive residential parks, protected nature centers, contemplative centers (requiring peace of mind), cemeteries	65 - 45	75 - 65	75 – 80
F	Active parks, golf courses, sports centers, stadiums, water parks	70 - 45	75 -70	75 - 80
G	Administrative centers, government centers, medical and dental centers, commercial centers, retail stores, laboratories	70 - 45	75 -70	80-85
H	Industrial and manufacturing centers, welfare services, agriculture, mining, stables, animal husbandry, warehouse, repairs/mechanics	70 - 45	75 -80	-

Endnote

*This article extracted from master's thesis of "Mitra Maleki Eshlaghi" entitled "Sound scape design in urban public space with contextualism approach case study:Rah Ahan squre tehran" that under supervision of Dr. Maryam Ghalambor Dezfuly which has been done at Pardis Branch, Islamic Azad University in 2020.

Reference list

• Abedi, M. (2015). *Mutual influence of the physics of the acoustic environment and individuals' perception in urban spaces* (Unpublished Ph.D. Thesis in Urbanism). School of Architecture & Urban Planning, Iran University of Science and Technology (IUST), Tehran, Iran.

• Alves, S., Estévez-Mauriz, L., Aletta, F., Echevarria-Sanchez, G. M. & Puyana Romero, V. (2015). Towards the integration of urban sound planning in urban development processes: the study of four test sites within the SONORUS project. *Noise Mapping*, 2(1), 57-85.

• Belgiojoso, R. (2014). *Constructing urban space with sounds and music* (A. Pousti & B. Khosravi, Trans.).Ashgate Publishing, Ltd. [in Persian]

• Blanco, G., Igone, G., Saloga, A. & Garcia, I. (2012). Actions to improve soundscape in the "Plaza NEUVA" in Bilbao. In *AESOP 26th Annual Congress*, Ankara.

• Erfanian, M., Mitchell, A. J., Kang, J. & Aletta, F. (2019). The psychophysiological implications of soundscape: A systematic review of empirical literature and a research agenda. *International Journal of Environmental Research and Public Health*, 16(19), 3533.

• Ghaffari, A., Mirgholami, M. & Shafaei, B. (2021). Effect of spatial features on the soundscapes of Tabriz bazaar houses. *Culture of Islamic Architecture and Urbanism Journal*, 6(1), 139-155.

• Ghalenoie, M. & Mohsen Haghighi, N. (2017). Arzyabi-ye manzar-e soutu dar faza-ye shahri (nemone moredi: piade rah-e Khayyam, Urmia)[Evaluation of the sound landscape in urban spaces (a case study of Khayyam Road, Urmia city)]. *Journal of Iranian Architecture & Urbanism(JIAU)*, 7(2), 127-138.

• Gharib, F. (2015) . Street network in urban design. Tehran: University of Tehran.

• Harris, C. W. & Dines, N. T. (2014). *Time-saver standards for landscape architecture : design and construction data* (Jaberian, A. Trans.). Tehran: Azarakhsh. [In Persian]

• Hermida, L., Pavón, I., Lobo Soares, A. C. & Bento-Coelho, J. L. (2019). On the Person-Place Interaction and Its Relationship with the Responses/Outcomes of Listeners of Urban Soundscape (Compared Cases of Lisbon and Bogotá): Contextual and Semiotic Aspects. *International Journal of Environmental Research and Public Health*, 16(4), 551.

• Herranz-Pascual, K., García, I., Diez, I., Santander, A. & Aspuru, I. (2017). Analysis of field data to describe the effect of context (Acoustic and Non-Acoustic Factors) on urban soundscapes. *Applied Sciences*, 7(2), 173.

• Kang, J., Aletta, F., Gjestland, T. T., Brown, L. A., Botteldooren, D., Schulte-Fortkamp, B., ... & Coelho, J. L. B. (2016). Ten questions on the soundscapes of the built environment. *Building and Environment*, 108, 284-294.

• Kogan, P., Turra, B., Arenas, J. P., Zeballos, F., Hinalaf, M. & Pérez, J. (2016). Application of the swedish soundscape-quality protocol in one european and three latin-american cities. In *22nd International Congress on Acoustics - ICA, Soundscape, Quality of Life, and Health Session: Paper ICA2016-226* (pp. 1–8). Buenos Aires, AR.

• Kropp, W. , Forssén, J. & Estévez-Mauriz, L. (Eds.). (2016). *Urban sound planning: The sonorus project. Chalmers University, Gothenburg, Sweden.* http://publications.lib.chalmers.se/records/fulltext/242257/local_242257.pdf

• Mitchell, A., Oberman, T., Aletta, F., Erfanian, M., Kachlicka, M., Lionello, M. & Kang, J. (2020). The Soundscape Indices (SSID) Protocol: A Method for Urban Soundscape Surveys—Questionnaires with Acoustical and Contextual Information. *Applied Sciences*, 10(7), 2397.

• Puyana Romero, V., Maffei, L., Brambilla, G. & Ciaburro, G. (2016). Acoustic, visual and spatial indicators for the description of the soundscape of waterfront areas with and without road traffic flow. *International Journal of Environmental Research and Public Health*, 13(9), 934.

• Safarzadeh Parizi, M. (1998). A new method of urban roads sound estimation with considering weather conditions. *Journal of Environmental Studies*, 24(21), 69-78.

• Shahabian, P., & Larmian, F.(2017). *Manzar-e souti, magahim va ravesh-ha* [City sounds]. Tehran: Azarakhsh.

• Zhao, X., Zhang, S., Meng, Q. & Kang, J. (2018). Influence of Contextual Factors on Soundscape in Urban Open Spaces. *Applied Sciences*, 8(12), 2524.

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