

Review Article

# Landscape Perception Based on Auditory Processing

## (An Investigation in the Role of Sound in Landscape Reading)\*

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Received: 01/10/2024

Accepted: 04/03/2025

Available online: 22/06/2025

**Abstract** | Humans communicate with their environment through their senses, which leads to sensory perception. Researchers have focused more on the process of visual perception of the landscape and have paid less attention to concepts such as sound landscape and sound perception. Sound and sound landscape as sensory stimuli affect people's behavior, space selection, and landscape perception. Today, the increasing diversity of sound sources in cities, which often creates an unpleasant sound landscape, causes confusing auditory perception in people, which shows the importance of addressing the sound landscape and the role of the sense of hearing in the landscape. This research attempts to present an organized view of the role and results of the sense of hearing in interacting with elements of the sound landscape by identifying and paying attention to the process of landscape perception. This research is qualitative, applied in purpose, and qualitative content analysis in the research method. Data was collected using a library method by reviewing texts, critiquing the written works, and analyzing their qualitative content. It examined the role of the sense of hearing in the perception of landscapes through the interaction of the senses of sight and hearing, using a deductive and inferential approach. The results obtained indicate that the characteristics of sound and human hearing along with the elements and factors of the acoustic landscape play an effective role in the formation of the acoustic perception of the landscape. In addition to these factors, visual elements also affect the perception of the landscape in interaction with the acoustic elements and can change the individual's perception and cognition of the landscape. Also, natural sound sources play an effective role in the pleasantness of the space and, along with natural visual factors, increase the user's presence in the landscape and role creation and dynamism.

**Keywords** | *Landscape, Sensory perception, Sound landscape, Sound perception.*

**Introduction and Statement of the Problem** | The study of landscape perception requires attention to landscape elements and the process of human perception. The relationship between humans and the environment has created complications in landscape definitions that sometimes lead the definition of landscape towards an ecological perspective, sometimes consider it an objectivity independent of humans and their minds,

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and sometimes consider it an abstract subjectivity (Mahan & Mansouri, 2017). The first level of human perception is formed through his senses. In the definition of "emotion", we can refer to the research of Iravan and Khodapanahi (2000), which called it affected by human sensory receptors objectively and transmitted to the central nervous system. Therefore, "emotion" can be considered a reaction to external stimuli. Human senses are the way to communicate, behave, act, and obtain

information from the surrounding environment. Human senses were first divided by Aristotle into five senses, which include the senses of sight, hearing, smell, taste, and touch. These five senses are perceived by the eyes, ears, skin, nose, and tongue, which transmit information to the brain to perceive the environment and are the most direct way to perceive (He et al., 2022). Some researchers have considered the number of human senses to be higher and have also considered factors such as heat, dryness, humidity, and characteristics that affect the sense of touch as a single sense (Ibn Sina, 1996). In perception through the sense of touch, it has been shown that people with hearing impairments have stronger tactile perception (Chan et al., 2022). Few studies have been conducted on the perception of elements and features of different landscapes through the sense of smell. Most studies have focused on visual perception, and multisensory perception requires more research.

Sensory perception is a mental stage in which humans perceive elements and the relationships between them. In the definition of sensory perception of landscape, it can also be stated that landscape perception occurs through human communication with the space around them in a mental process (Sarmadi et al., 2010). This process of organizing and interpreting sensory information occurs by giving meaning to them through human communication with the landscape. By stimulating the sensory organs, the impact of space increases human perception of space becomes more complete, and human involvement in the environment and its memorability increase. The stimuli in the acoustic and visual landscape help humans understand the landscape, and given the multisensory nature of landscape perception, the process of sensory perception of landscape requires the use of all senses. This process is not achieved only by the sense of sight, and several mental and sensory factors play a role in it. Therefore, it is assumed that the sense of hearing affects visual perception and plays an important role in understanding the acoustic landscape. Since the concept of acoustic landscape was proposed, studies of sound in public places and noise control have received more attention from researchers. Soundscape research can be used to assess people's perception of environmental sounds. Soundscape is the acoustic effect of a place, where sounds give people a sense of place, and the acoustic quality of a place is shaped by the activities of its inhabitants. Soundscape is a concept that is the auditory equivalent of the word landscape and includes all the sounds present in a place (Dixon, 2010). Sound and soundscape, as sensory stimuli, overshadow the quality of the landscape. This is because physical and sensory components are effective in creating the pattern of the soundscape. Lack of attention to the soundscape causes noise in the environment, and

the quality of the environment depends on the sounds heard in that environment (Habibi et al., 2021). Noisy environments can increase anxiety and psychological problems in people (Kou et al., 2021). In contrast, exposure to positive sound environments such as nature sounds and music improves mental and physical health. In many soundscape studies, natural sounds have been shown to have a stronger restorative effect (Li & Kang, 2019).

Considering the impact of landscape perception on people's satisfaction with the quality of space, sense of belonging, presence, and dynamic role-playing in the environment, the necessity of addressing the perception process and the factors affecting it by focusing on the human senses requires special attention. This study attempts to investigate the role of the sense of hearing in interacting with the sense of sight in landscape perception, by identifying the elements of the acoustic landscape. For this purpose, the main question in the present study is what role the sense of hearing plays in interacting with the sense of sight in landscape perception. To answer the main question, the sub-question of the study is what elements of the acoustic landscape affect the sensory perception of sight and hearing of landscape.

## Research Background

Sound is created by the movement of particles of matter; when a particle collides with another particle, it sets it in motion and emits sound. Sound is a type of vibrational energy that is perceived by the ear (human sense of hearing) (American Heritage, 2010). By converting energy into a sound wave, the sound indicates an event in an area and helps us perceive distant events (Blessner & Salter, 2009). Sound can cause nervous excitement and increase heart rate and blood pressure, which have adverse effects on the functioning of body systems (Karimi et al., 2013). Sound affects people's behavior, the choice of space to stay or pass, people's perception of the landscape, and the quality of the landscape in general. Sound brings a sense of dynamism helps us know the progress of time and the proportions of space, and creates a three-dimensional experience of space (Leus, 2011). Table 1 shows the types of sound classification.

In this study, the categories are based on the source of the sound and its effect on the auditory sensory perception of landscape elements. In terms of sound sources, sounds are divided into three categories: biological sounds (sounds of living organisms), geophysical sounds (sounds of the earth and inanimate nature, such as the sound of wind when it hits natural elements), and human sounds (man-made sounds such as traffic and machinery) (Farina, 2015). Because loud noise is a sign of danger, humans and animals react to it by increasing the sound level. It is noteworthy that reducing the noise level does not improve satisfaction

Table 1. Sound classification. Source: Habibi et al., 2021.

Row	Sound classification based on	Components
1	Source of sound production	Biological, Geophysical, Human
2	Frequency value of sound wave	Absorbed, Audible, Infrasonic
3	Effect on the human psyche	Calm, Excitement, Turbulence and Anger, Boring and Monotonous, etc.
4	Relationship with the environment	Controlled and Uncontrolled Interference
5	Frequency order	Pure Sound, Voice
6	Geometry of sources	Point, Line, and Surface

with the environment (Aletta et al., 2018). People expect different sounds from different spaces. Environmental sounds are meaningful and contain information such as road traffic, nature, and people, and some of them have positive or negative effects on people (Aletta et al., 2016). Natural, diverse, and quiet sound sources are among the pleasant sounds of the environment, and the vagueness of the sound and the loudness are negative auditory characteristics of the space (Shafii & Zamani, 2022). Natural sounds have attracted more attention from people than artificial sounds, among which, the sounds of birds, water, wind, and rustling leaves are known as pleasant sounds, and the sounds of insects and frogs are considered unpleasant in the soundscape (Yuan et al., 2023; Krzywicka & Byrka, 2017; Liu et al., 2019). Among artificial sounds, street traffic noise has the lowest acoustic preference among people and is classified as an unpleasant sound (Liu et al., 2019). Considering the increase in noise pollution, the decline in sound quality in open spaces, and the impact of the soundscape on people's perceptions and behavioral patterns, in this study, we approach the research goal by examining the sense of hearing and the soundscape and its interaction with the sense of vision in landscape perception.

The sense of hearing is essential for obtaining information, experiencing, and understanding the environment (He et al., 2022). Due to the effects that sound has on stress, sleep, and heart disease, it has become a key component in urban landscape design (Stansfeld & Matheson, 2003; Kempen et al., 2018). The human ear receives different auditory sensory stimuli separately and perceives them as sound or noise (Sarmadi et al., 2019). Duration, frequency, and intensity of sound are factors that cause sound to be heard by the auditory mechanism, and the frequency range that can be perceived by humans is between 16 and 20,000 Hz (Zarei et al., 1402).

Most studies on acoustic and visual landscapes have provided

design guidelines considering the interaction of these two senses (Jeon & Jo, 2020; Li & Lau, 2020; Liu et al., 2014). The natural environment, with its set of visual and acoustic components, affects the ability to recognize the environment, improve positive emotions, and reduce stress (Korpela & Ratcliffe, 2021). In different landscape shapes and forms, visual factors create differences in acoustic landscape preferences (Preis et al., 2015). The dominance of visual factors affects auditory perception.

## Theoretical Foundations

### •Soundscape

Soundscape is an acoustic environment that is experienced and perceived by people (Iso, 2014). In another definition, it is said that the sound environment includes both natural and artificial (man-made) environments (Kalthornia & Habibian, 2014). The soundscape is one of the effective factors in forming people's mental image, which includes all the desirable and undesirable sounds of the environment (Shahabian & Larimian, 2016). The term soundscape, proposed by Schafer, deals with the physical aspects of sound, its social meanings, and the relationship between the person perceiving sound and the environment (sound) (Truax, 2001). Most research on soundscape focuses on the background soundscape of the landscape (Li et al., 2021). All the sound sources of this background include all the desirable and undesirable sounds of the environment. In terms of the quality of sound propagation, its different types and soundscapes are divided into three groups: background sounds, specific background sounds, and foreground sounds. Background sound, in a soundscape, is the natural sound of the wind surrounded by traffic in cities. Specific background sounds include sounds of interest to the community and its viewers, which are introduced as sound cues, like signs in a visual landscape. Foreground sounds, or signals, have the task of attracting attention (Truxe, 1978; Gustavino, 2007). Three factors affect the construction of people's mental

image of a soundscape: sound information, the context in which the sound is perceived, and the sound level (Shahabian & Larimian, 2016). People's experiences of environmental sounds play an important role in their sound preferences (Kang & Yang, 2002). Therefore, people with diverse personality traits have different experiences of space. Soundscape is not simply about controlling the sound level or eliminating unnecessary sounds in the environment; it is also about achieving a balance between the visual landscape and the acoustic perception of the landscape (Yong et al., 2013). Considering the correlation between the level of sound intensity and the quality of the soundscape, the higher the level of sound tranquility in the environment, the higher the level of satisfaction of people with the quality of the soundscape (Yazdanpanah Shahabadi et al., 2022).

Soundscapes facilitate the perception of the environment by adding information to visual elements. For example, the physical elements used in the spatial geometry of the landscape are among the quality indicators of the soundscape, and there is a significant relationship between the physical and psychological perceptions of users (Habibi et al., 2021). The reason for being in the landscape, as shown in the subjective assessments of users by Brambilla et al. (2013), is a calm and quiet space, which refers to the concept of tranquility in the soundscape. Other sound elements in the landscape include the wind blowing through the leaves, the sound of stems hitting each other, and the rustling of grass (He et al., 2022). Sounds such as the sounds of water and birdsong are vital in the perception of the soundscape (Buxton et al., 2021). The sounds produced by water features improve the quality of the soundscape (Brown & Rutherford, 1994; Brown & Muhar, 2004). Also, the sound of water may be used to mask unwanted background sounds, especially road traffic (Axelsson et al., 2014). In general, the auditory elements of the soundscape include the sounds of birds, wind, children's play, and activity, the sounds of people walking and talking, the sounds of bicycles, motorbikes, and cars, the sounds of audio and visual equipment, population and building density, distance from the road network and administrative and law enforcement, educational, commercial, industrial, urban facilities and equipment.

#### •Sensory perception

Perception is a mental or psychological process that actively selects and organizes sensory information and ultimately adapts it to mental meanings (Carmona et al., 2010). Among the basic theories in environmental perception are Gestalt, probabilistic functionalism, interaction, level of adaptation, and environmental capability theories. In Gestalt theory, the approach to the objective world is concerned with human perceptual processes, and visual

information is simplified in the mind by Gestalt principles (Behrens, 2004). In Brunswick's probabilistic functionalist theory (1956), individuals' perception depends on physical cues in the environment that organize scattered groups of environmental stimuli into an orderly perceptual form (Peyken & Rafiian, 2017). Ittelson's interaction theory (1960) emphasizes the experiential role of perception and considers the relationship between the individual and the environment to be dynamic. In Cohen's (1973) adaptation level theory, the adaptation of the most dominant environmental stimuli is discussed, so that individuals adapt by tolerating unpredictable conditions and controlling stimuli. Gibson's (1979) environmental capability theory considers what the environment offers to individuals as the capability of the environment, which also includes the human contexts of culture and society. Among the theories of environmental perception, Eitelson's theory, which introduces four cognitive, emotional, interpretive, and evaluative perceptual dimensions, deals with the cognitive dimension of organizing information into categories coming from the senses and thinking.

In the perceptual view, landscape has a dictionary definition and is a perspective for seeing. In the subjective approach, landscape is considered a poetic manifestation in the mind and is formed in the thoughts and mind of the viewer (Mahan & Mansouri, 2017). Landscape perception is an objective-subjective approach that, with a comprehensive look at the subject of landscape, considers it to be related to physical, and functional issues and the human perception process. Therefore, landscape is not only an objective element, and people's mental and cultural dimensions are effective in its formation (Mansouri, 2004). In studies on the subject of non-visual perception, sound perception has received more attention from researchers (Korpilo et al., 2023). Sound perception is a sensory system that works by receiving and processing sound information (Chen & Kang, 2023). Human perception of sound wave energy is carried out with components of pitch, rhythm, and echo, which form auditory sensory perception in the form of a sound or a specific pattern (Bach & Dorostkar, 2017). Sound level is not necessarily the main factor affecting the perception of soundscape, and spaces have sound backgrounds, sound sources, space users, and social factors that play an important role in auditory sensory perception (Botteldooren et al., 2008). Sound perception concerning landscape elements can be divided into three aspects: compositional, configurational, and contextual (Hasegawa et al., 2022). When the level and intensity of ambient sounds are low, increasing brightness leads to the perception of greater noise and noise pollution (Yang & Jeon, 2023).

#### •Visual and auditory elements of the landscape

Due to the relationship between landscape elements and

the interaction of the visual and auditory senses, visual factors can be examined to study auditory perception. For example, visual and auditory landscape elements include characteristics of weather, nature, light, sky, landscape, materials and textures, surrounding environment, water space, natural and artificial sound sources, open and closed space, communication space, semi-private space, height above ground level, geometry and form of space, wind circulation, shade, furniture, proportions, pattern, human scale, area, proximity, skyline, obstacles, entrance, loudness, environmental noise level, bird sounds, wind blowing in vegetation, traffic and vehicle noise. Among natural and environmental sounds, street traffic noise, vehicle noise, bird singing, and water sound have the greatest impact on visual landscape preferences (Liu et al., 2013). Also, the use of green spaces and vegetation reduces negative perceptions of environmental noise (Van Renterghem, 2019). Acoustic landscape preferences depend on the use of vegetation and hydroponics (water-based vegetation) (Hong et al., 2020). Sound levels and visual coverage are inversely related, hence, when sound levels increase, the visual impact of vegetation decreases (Haapakangas et al., 2020). Increasing natural visual elements and reducing artificial elements such as vehicles are effective in improving acoustic and visual satisfaction (Jo & Jeon, 2021), such that open views, sounds, and regular features cause differences in visual landscape preferences (Yuan et al., 2023). Also, light affects sound perception and sound affects light perception (Ma & Nie, 2014).

## Research Method

This research is qualitative, applied in purpose, and qualitative in content analysis in research method. The results of this systematic literature review study can lead to increased landscape responsiveness by identifying the process of perception and human senses in landscape perception. Due to the lack of sufficient attention to all senses and the focus of studies on the sense of sight, in the first step, a study was conducted on the sense of hearing and sound landscape, and in the second step, the sensory perception of the landscape was examined through the sense of hearing.

The data was collected through a library and documentary method by reviewing texts, and existing documents and criticizing the written works. For this purpose, three databases, Google Scholar, ScienceDirect, and SID, were extracted and reviewed in the field of landscape perception and auditory perception with related keywords from 2000 to 2024 (articles published in the past 24 years). In the past decades, topics such as sound landscape, human perception, recognizing the importance of environmental psychology, and landscape design have been addressed

more. Most of the articles were from the Journal of Landscape and Urban Planning (12 articles), International Journal of Environmental Research and Public Health (11 articles), and Building and Environment (11 articles), and other publications had a smaller contribution to this study. Fig. 1 The data analysis method was inferred from studies conducted on landscape perception through the sense of hearing in interaction with the sense of sight, as shown in (Fig.2).

To better investigate the research gaps in this field, the type of landscape, the elements of the soundscape, the visual and auditory elements, the target group, and the methods of studying the soundscape require further research.

## Discussion

The combination of visual and auditory senses is an objective-subjective system. The information received by the visual sense includes color and light, and the information received by the auditory sense includes the type of sound, direction, distance, intensity, and type of sound source, which can be perceived as pleasant or unpleasant. The sense of sight, which provides humans with the most environmental information, enables them to recognize and interpret the environment using light reflected from objects. In the structure of the human eye, cone cells are stimulated in bright light to detect color, and rod cells are stimulated in low light to detect brightness. To identify the role of the auditory sense in landscape perception, the theoretical foundations section was divided into two steps. In the first step, the nature of sound, auditory sense, and acoustic landscape was identified, and in the second step, the sensory perception of landscape through the visual and auditory senses was addressed. The scope of the study of soundscape factors includes sound sources (natural and environmental sounds, traffic noise, speech, and a set of artificial sound sources), which, according to the study of the interaction of the visual and auditory senses in public open spaces, speech sounds are more likely to disrupt people's presence and interaction with each other. Also, the presence of speech in the background of sound affects the performance of recognizing and recognizing the environment. The study of the soundscape and its effect on human perception with the interaction of the visual and auditory senses showed that visual elements of the landscape such as water, green space, plants, light, sky, landscape, materials and textures, surrounding environment, and water space affect auditory perception and preference. In the study of visual elements of the landscape, it was also determined that the elements of the soundscape including the sound source (natural, artificial), loudness, level of environmental noise, bird sounds, water, the collision of branches and leaves and wind blowing in vegetation,

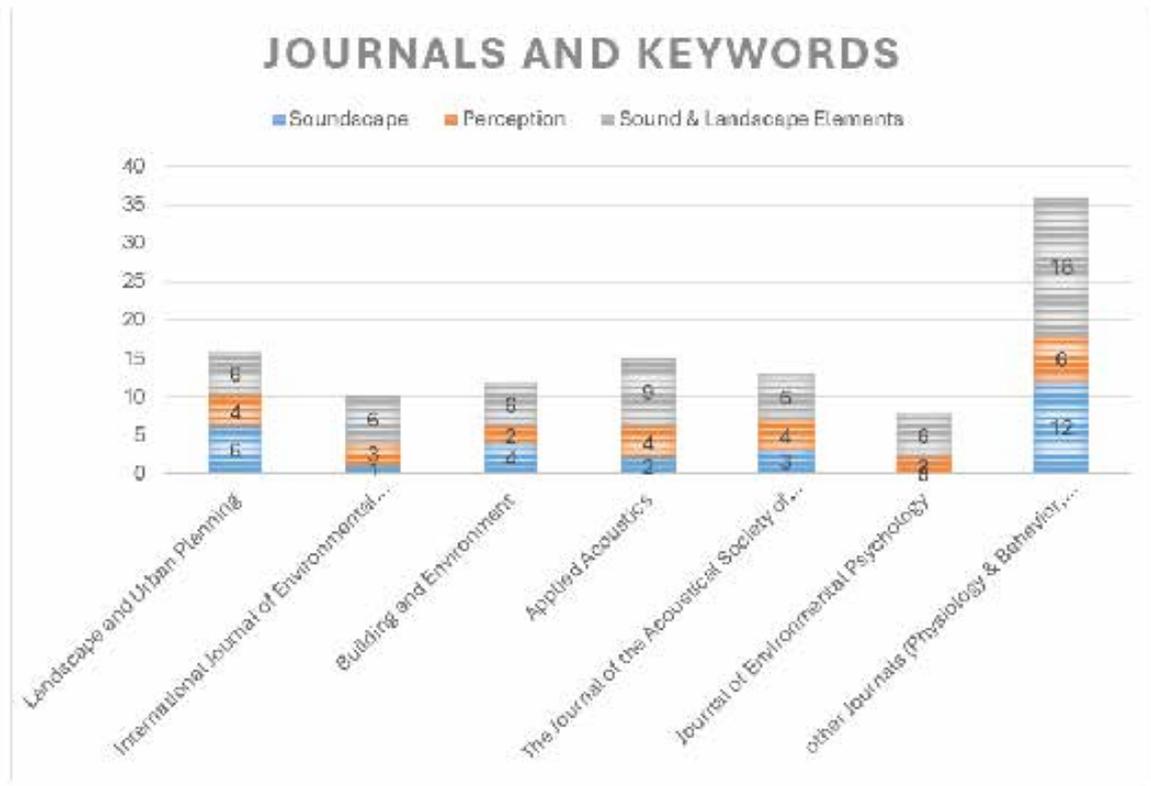


Fig. 1. Summary of the frequency of articles in journals with related keywords. Source: Authors.

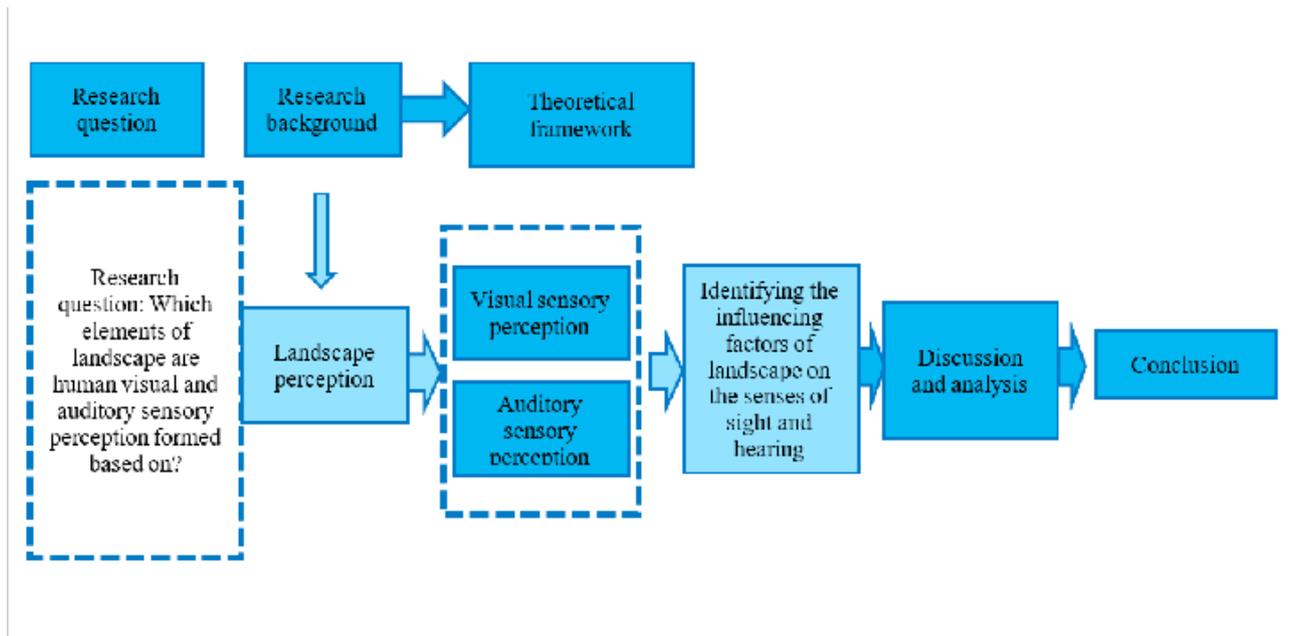


Fig. 2. Research content process. Source: Authors.

traffic and vehicle sounds affect people's visual perception and preference of landscape elements. In short, among the various acoustic and visual elements and factors of the landscape, natural elements have a positive effect on landscape perception and, in interaction with other senses, cause a change in landscape preference and perception. Therefore, in the landscape perception process, there is an interactive and two-way relationship between the visual and auditory elements of the landscape and human perception. In the sensory perception stage, first the acoustic and visual features of the landscape, such as environmental information received by the visual and auditory senses, are stored and classified in the brain based on their characteristics and are perceived by humans in the first stage, then this sensory perception leads to rational perception by the human brain. Fig. 3 shows the conceptual model of the research.

To improve the responsiveness and effectiveness of sound elements on landscape perception, we must consider both acoustic and visual factors. A summary of the visual and acoustic elements that affect people's visual and auditory sensory perception is presented in Table 2. Natural sounds are evaluated as pleasant factors of the sound landscape, and man-made sounds such as conversation and talking, the sound of people moving, mobile phone rings, and music are evaluated as negative acoustic stimuli.

Man-made sounds outside the acoustic comfort range (70 decibels), such as traffic sounds, cars, strong wind noise, and annoying noise, increase the pleasantness of the soundscape. The research hypothesis that the elements of the soundscape affect auditory perception has been confirmed, and to determine the effect of each of these elements, we need to conduct a quantitative study in future research.

## Conclusion

Visual and auditory elements of the landscape are effective in its visual and auditory perception and preference. Considering the mental process of perception and selection of information, visual perception is carried out by simplifying information and using environmental cues, but the role and effect of experience in visual and auditory perception cannot be ignored. The cognitive dimension of perception, which is formed through the human senses, can be perceived as pleasant or unpleasant. Among them, information on sound level, sound background, sound sources, and space users play the most important role in auditory sensory perception. Also, the level and intensity of environmental sounds are directly related to the level of illumination, and with increasing illumination, the level and intensity of environmental noise perception also increases. Considering the importance of information, sound level, and background, in examining sound sources, it was found that specific background sounds and foreground sounds are more of interest to landscape users. Background sounds are influenced by natural and environmental sounds, and users pay the most attention to specific background sounds because they are signs. Sound has a significant impact on people's performance. The acoustic perception resulting from the elements of the soundscape can be used as a unit of analysis for visual perception, but based on the literature review, studies in this field are rarely found. In addition, in this article, various types of visual and auditory elements of the landscape were also categorized and examined. According to these categories, natural sound elements and sources affect the positive perception of the environment and create a pleasant feeling in people. This causes more people to be present in the landscape, to play a role, and to feel a

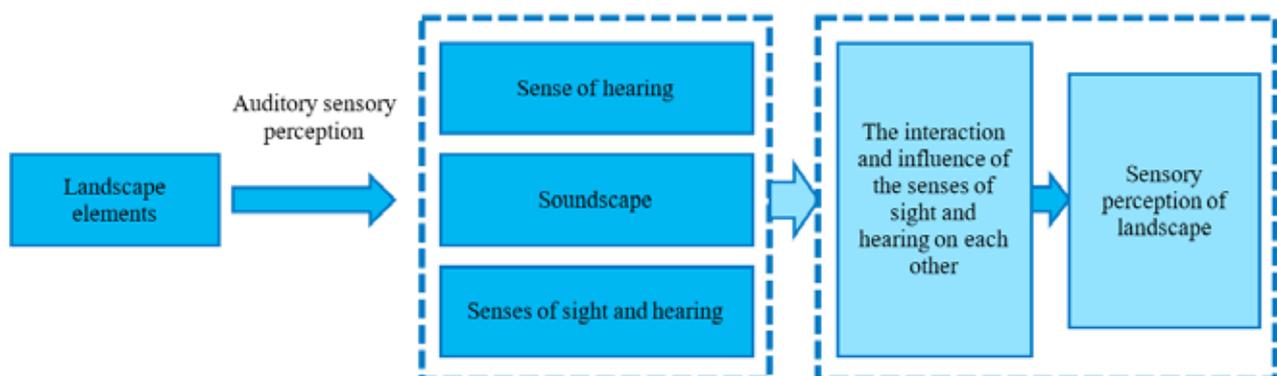


Fig. 3. The process of visual and auditory sensory perception of the landscape. Source: Authors.

greater sense of belonging to the environment. Of course, sound characteristics such as loudness, echo, source, level, and reverberation also affect the preference for acoustic and visual landscapes. Acoustic landscape elements affect visual perception, visual landscape elements affect auditory perception, and they can be used as a positive cover for unpleasant factors in the landscape. In general, considering only one sense in landscape perception, regardless of other human senses, results in recording a superficial experience of the landscape. To have a correct perception and knowledge of the environment, we need the interaction

of all human senses. It is recommended that future research use psychological indicators to obtain empirical results. This mutual recognition of visual and auditory elements facilitates landscape perception and with the perception of the acoustic landscape and the contrast between different visual and auditory elements, an integrated perception is created.

### Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

Table 2. Visual and audio elements of the landscape. Source: Authors.

Landscape Elements	Components
Environmental Landscape Elements	Weather, nature, plants, green space, trees, light, warmth and coldness of the air, sky, landscape, orientation, materials and textures, surrounding environment, water space, visual attention, natural sound elements (birds, leaves, etc.)
Architectural Elements	Open and closed space, communication space, semi-private space, height from ground level, roof garden, geometry and form of space, wind circulation, shades, furniture.
Geometry and Proportions	Proportions, pattern, human scale, area, proximity, skyline, obstacles, entrance
Sound Landscape Elements	The sound source (natural, artificial), loudness, ambient noise level, bird sounds, water, leaves, and wind blowing through vegetation, traffic and vehicle noise

### Endnotes

\* This article is based on the literature of Farnaz Razani's doctoral dissertation entitled "Explanation of Visual-Auditory Perception Patterns in the Landscape of Residential Complexes (Case Study: of Babolsar City)", which is being conducted under the guidance of Dr. Ali Sharghi and the consultation of Dr. Reza Ebrahimpour at the Faculty of Architecture and Urban Planning, Shahid Rajaei Teacher Training University.

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**ERRATUM****ERRATUM**

Perception of Landscape Based on Auditory Processing (Examining the Role of Phonetics in Landscape Reading)

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**Article Information:** This article was previously published in MANZAR, Year: 2025, Volume 17, Issue 71, Pages 34-43.

DOI: <https://doi.org/10.22034/manzar.2025.481255.2315>

**Erratum Text:** In the above article, the affiliation of the author Ali Sharghi was incorrectly listed as:

“Assistant Professor, Architecture Department, School of Architecture & Urban Planning, Shahid Rajaei Teacher Training University, Tehran, Iran”

**The correct affiliation should read:**

“Associate Professor, Architecture Department, School of Architecture & Urban Planning, Shahid Rajaei Teacher Training University, Tehran, Iran”

**Editorial Office of:** MANZAR, *The Scientific Journal of Landscape*

**Erratum Publication Date:** 2025/09/26

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**HOW TO CITE THIS ARTICLE**

Razani, F., & Sharghi, A. (2025). Landscape Perception Based on Auditory Processing (An Investigation in the Role of Sound in Landscape Reading) *MANZAR, The Scientific Journal of Landscape*, 17(71), 34-43.

DOI: [10.22034/manzar.2025.481255.2315](https://doi.org/10.22034/manzar.2025.481255.2315)

URL: [https://www.manzar-sj.com/article\\_216728.html?lang=en](https://www.manzar-sj.com/article_216728.html?lang=en)

