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A REVIEW ON THE SOUNDSCAPE INDICATORS OF PARKS

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ABSTRACT

Soundscape aids in reducing noise pollution, but is also a resource to create pleasing space at parks. Soundscape approach considers the perception and preference of people on environmental sound. However, different indicators vary based on their aims and context undertaken in a soundscape study. Therefore, a systematic review was carried out to identify and differentiate the indicators used to study the park soundscape. The main objective is to investigate how a park's soundscape is measured and the strength and weaknesses of the indicators were compared. The review processes involved four stages which were identification, screening, eligibility, and inclusion. Review works of literature were identified in available open access journals with keywords of "soundscape", "perception", and "park". Results showed that soundscape indicators could be differentiated into objective indicators such as sound pressure level and psychoacoustic measures; subjective indicators, including soundscape descriptors, acoustic evaluation, sound awareness, and sound preference. Subjective evaluation for soundscape was to study the quality of the environment, while objective and subjective evaluations investigated the relationship between soundscape and other factors. It was found that sound level is more straightforward due to its

objective measures but lacks the subjective evaluation of the acoustic environment represented by psychoacoustic metrics. Soundscape descriptors rely on how people perceive the area. Acoustic comfort was used concerning noise or annoyance, while sound preference and awareness identified sound marks of the area. Therefore, a proper selection of physical metrics and subjective variables is needed to predict the environment-human interaction better.

Keywords*: Soundscape, Perception, and Park*

INTRODUCTION

According to Ahmad Halmi and Ismail (2017), noise can cause a series of detrimental health effects on human beings, with hearing loss being the most studied effect of excessive noise exposure. As a result, there is a growing interest in the importance of soundscape perception to understand the connection between humans and the environment, which is in line with the growth of socio-ecological perspectives in urban planning (Moscoso et al., 2018). The impact of well-being is also increasingly recognised with the emphasis of the Sustainable Development Goal. Studies have shown that pleasant sounds can reduce stress and aid in mental restoration (Gygi and Shafiro, 2008; Alvarsson et al., 2010; and Abbott et al., 2015). This is particularly relevant in a open space such as park.

A park is an open space, an area of natural, semi-natural or planted space set aside for human enjoyment and recreation (Hassan, 2017). Soundscape plays a role in reducing noise pollution and as a practical environmental resource for pleasing park space. As aptly put by Guo (2019), in addition to reducing noise physically at urban parks, it is necessary to investigate park-users' subjective evaluation of the acoustic environment and the impacts of sounds in parks on their overall visiting experience. The importance and impact of park soundscapes are gradually recognised (Zhao et al., 2020).

The literature available on soundscape and parks mainly focuses on

analysing the perceptual attributes of soundscapes in parks with different indicators of categorising and analysing the respondent's perception of the soundscape. This raises questions on the categories of soundscape indicators used in a particular study and what differentiates them (Payne et al., 2009; Aletta et al., 2014; Aletta and Kang, 2016). For instance, Aletta and Kang (2016) reviewed soundscape descriptors and indicators to propose soundscape indices for comparison across soundscapes. To date, there is an absence of a comprehensive comparison between the different types of soundscape indicators under different conditions. Acknowledging the gap in the literature, this review proposes extending findings to recent studies of soundscape perception indicators in parks and comparing the strengths and weaknesses between the different indicators used.

Therefore, this review aims to examine and distinguish the many soundscape indicators employed in soundscape research. The objective of this review was to identify the indicators and research design used in park soundscape research and to compare the strengths and weaknesses of the indicators as a reference in the selection of methodologies in various studies.

Soundscape Perception Factors

Truax (2001) identifies two (2) distinct approaches to managing the acoustic environment of the external acoustic environment. The first is the environmental noise management model focuses on noise reduction or management at the source. The second one is soundscape approach, which regards sound as a resource in contributing to the quality of life of the people (Brown, 2012). Davies et al. (2009) supported the concept of Southworth by suggesting that the soundscape approach includes a complete sound environment in an area and how people respond to the sounds, dependent on the context of place, time and activity, and who is listening. According to Ricciardi et al. (2015) and Ismail (2014), perceptual parameters can characterise the quality of the acoustic environment.

Sound sources create meanings and influence human activities, thoughts, and feelings (Lercher and Schulte-Fortkamp, 2003). Therefore, soundscape indicators should be specified based on the different study approaches. Soundscape study represents a shift involving physical measurements and the cooperation of human and social sciences to consider

environmental sounds as a resource rather than a waste. In other words, it relies on human perception before applying physical assessments. Brooks et al. (2014) also reported that while classical noise indicators may have limitations under certain sound conditions, it is central to soundscape research and implementation to fit the applied indicators to the perception and appraisal of the concerned people. The fit of indicators also depends on the type of investigated soundscape, which reflects the situation and context. Therefore, this study compared the strengths and weaknesses of each indicator potentially used in a soundscape study.

Part 1 of ISO 12913, the International Standard for Soundscape studies, described the conceptual framework of soundscape structured according to three elements: person, activity, and place (International Organization for Standardization, 2014). Soundscape is defined as "the acoustic environment perceived and understood by people, in context". The ISO also further details the perceptual construct of a soundscape study. It emphasises integrated aspects such as context, sound sources, acoustic environment, auditory sensation, perception, responses, and outcomes.

In addition, Herranz-Pascual et al. (2010) produced a conceptual model of the environmental experience based on three concepts: people, activity, and place, where they interrelate. Nonetheless, Steele et al. (2015) further investigated the model by looking into how urban activities influence soundscape perception and found that activity significantly affects pleasantness and contributes to people's mood, attention, and efforts. Their findings also strengthen the justification on the importance of soundscape over physical measures in urban planning.

However, Aburawis and Yarukonglu (2018) believe that soundscape perception is more complex and depends on the area's expectation, mood, preference, and activities. Their detailed framework of soundscape perception factors explains the differences in categorising soundscapes from six (6) factors: sonic, spatial, temporal, psychological, behavioural, and personal (Refer to Table 1). They futher elaborated that soundscape evaluation should be combined with expectation analysis and psychological evaluations to account for factors related to soundscape perception. A study by Fang et al. (2021) is consistent with the findings that soundscape perception is not specifically related to decibel levels, but to the type of

soundscape and people's preferences and sensitivity.

Table 1. Soundscape Perception Factors

Soundscape Perception Factors	Factors Influencing Perception
Sonic	Type, level, loudness
Spatial	Characteristic, space type, activities
Temporal	Time spent, usage frequency, preferred time
Psychological	Attention, expectation
Behavioural	Reaction, response, preference
Personal	Individual, social-cultural

Source: Aburawis and Yarukonglu, (2018)

METHODOLOGY

The methodology adopted in the review is the Systematic Literature Review, where it collected and critically analysed multiple research studies or papers through a systematic process, as shown in Figure 1. The purpose of adopting the SLR method is to provide an exhaustive summary of the available literature relevant to the research objective. The result obtained from this approach can lead to an understanding of the different types of indicators used in a soundscape study.

This review's keyword search strategy or terms were 'soundscape; 'sound' OR 'noise' AND 'perception' AND 'parks'. Only English published articles were considered in this review. All the identified articles were screened by their titles to remove the duplicate or similar articles found in the different interdisciplinary health and environmental databases and urban planning databases of Web of Science, Scopus, and Science Direct from the institution subscriptions and Google Scholar. Peer-reviewed journal articles and full-paper conference proceedings in English up to August 2021 were eligible in the database query. The peer-reviewed journals cover health, urban planning, and acoustics topics, such as those from the Journal of the Acoustical Society of America, Applied Acoustics, International Journal of Environmental Research and Public Health, Noise and Health and the Journal of Urban Design. Conference proceedings such as those from INTER-NOISE and EURONOISE have been included so that soundscape studies' significant emerging research trends were not missed.

Then from the titles and abstracts, irrelevant articles such as those without results on soundscape perceptions and studies that do not involve soundscape in parks were excluded from the review. The exclusion and inclusion criteria were stated in Figure 1. Information was extracted from each study to include the soundscape indicators, study design, and key research findings. The data were then synthesised to answer the review objectives.

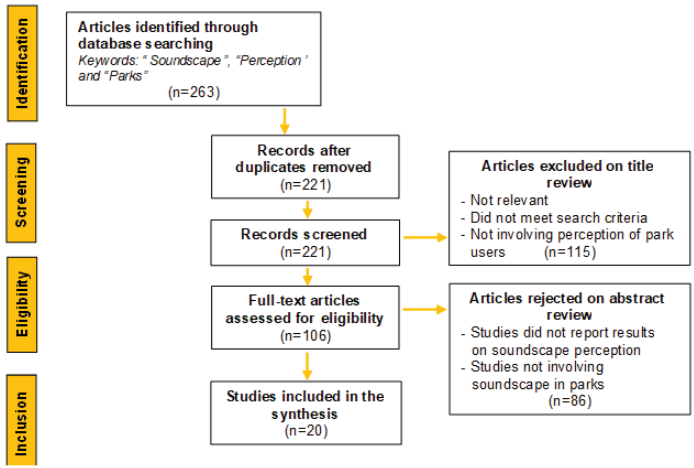

Figure 1. Systematic Review Flowchart

Source: Author, (2021)

RESULTS AND DISCUSSION

Indicators used in Soundscape Studies

A total of 20 publications were screened using the systematic literature review and were filtered according to the desired objectives to analyse the different categories of indicators used in a park soundscape study. The results of the extracted data from preview studies were summarised in Figure 2 according to the types of soundscape indicators used to study the soundscape of parks. The most common indicator was the sound pressure level measurement (13), while the acoustic evaluation was the least, with only three (3) studies adopting it. All of the studies included in the review utilised a combination of at least two (2) different indicators in their

evaluation of the park's soundscape. Table 2 lists the studies included in the review and their key findings.

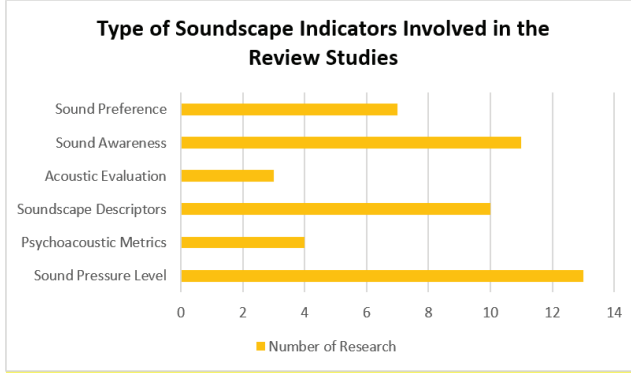

Figure 2. Type of Indicators Involved Soundscape Studies
Source: Author, (2021)

Table 2. List of Studies Included in The Review in Chronological Order of Publication

Reference	Soundscape Indicators	Study Design	Key Findings
Payne (2008)	Sound Level, Soundscape Classification, Pleasantness, Stressfulness	Socio-acoustic survey	Affection and cognition in everyday life influences how people experience the environmental sounds
Szeremeta and Zannin (2009)	Sound Level, Pleasantness, Dominance, Familiarity	Socio-acoustic survey	The level of acoustic comfort is not necessarily connected to only sound levels but includes other factors in the environment and the receiver
Tse et al. (2012)	Sound Level, Acoustic Comfort, Perceived Loudness	Socio-acoustic survey	Acoustic comfort can better predict park users' preference to stay in urban parks.
Brambilla et al. (2013)	Sound Pressure Level, Psychoacoustic Metrics, Sounds Perceived, Perceived Loudness	Socio-acoustic survey	The sound environment of parks may be perceived as good and very good despite the higher sound level in the area
Axelsson et al. (2014)	Sound Pressure Level, Dominance, Soundscape Preference	Socio-acoustic survey	While sounds perceived influence the soundscape quality, water sounds and ratings of soundscape quality were not directly related
Medvedev et al. (2015)	Pleasantness, Eventfulness, Familiarity, Arousal, Dominance	Laboratory experiment	Pleasant soundscapes facilitate faster recovery from stress compared to an unpleasant soundscape
Liu and Kang (2015)	Psychoacoustic Measure, Perceived Loudness, Perceived Occurrence, Soundscape Diversity Index	Soundwalk	Soundscape composition parameters and the psychoacoustic parameters show that fluctuation strength was not related to any of the soundscape composition parameters

Bahali and Tamer-Bayazit (2016)	Sound Pressure Level, Psychoacoustic Parameters Expectations, Sound Preference, Acoustic Comfort	Soundwalk	Partial sounds come into prominence in comparison with holistic sounds when it comes to the classification of the soundscape
Filipan et al. (2017)	Sound Identification, Dominance, Soundscape Preference, Expectations, Tranquillity	Socio-acoustic survey	Park visitors pay attention more to the sounds they do not expect to hear, and the higher their expectations about the soundscape, the more critical they become in their appraisal of the soundscape
Cadena et al. (2017)	Sound Pressure Level, Sound Preference, Peacefulness, Pleasantness	Laboratory experiment and socio-acoustic survey	Significant differences have been found between in situ and laboratory subjective experiments in urban park soundscape evaluation results.
Bjerre et al. (2017)	Loudness, Acceptance, Stressfulness, Comfort	Laboratory experiment and socio-acoustic survey	Laboratory evaluations may not fully reflect how subjective loudness, acceptance, stressfulness and comfort are affected by sound level
Kogan et al. (2018)	Dominance, Pleasantness, Eventfulness	Socio-acoustic survey	The green soundscape index has the potential to be used as a soundscape classification criterion
Liu et al. (2018)	Dominance, Harmonious Degree	Socio-acoustic survey	Sound dominant degree and harmonious degree are proposed as soundscape experience indicators
Van Renterghem et al. (2019)	Sound Pressure Level, Sound Preference	Virtual Reality and Augmented Reality	The preferred soundscape was assessed interactively in virtual reality and augmented reality, where natural sounds improve the overall appreciation of the sound environment
Puspagarini et al. (2019)	Sound Pressure Level, Calmness, Dynamic, Communication, Natural or Spatiality, Directionality, Sound Source Identification	Socio-acoustic survey	Acoustic factors and non-acoustic factors influence soundscape evaluation
Ma et al. (2021)	Sound Pressure Level, Pleasantness, Loudness, Variation, Satisfaction	Socio-acoustic survey	Loudness and pleasantness perceptions are associated with the maximum noise levels
Masullo et al. (2021)	Pleasantness, Eventfulness, Familiarity Emotional Dimension,	Socio-acoustic survey	Questionnaires built from emotional dimension can represent the positive and negative dimensions more clearly as compared to those by the soundscape perception model
Jaszczak et al. (2021)	Sound Pressure Level, Pleasantness, Soundscape Preference	Soundwalk Socio-acoustic survey	There is a relation between the visual and sound perception of parks from the psychological point of view
Fisher et al. (2021)	Sound Pressure Level, Soundscape Preference, Perceived Biodiversity, Perceived Naturalness, Perceived Restorativeness	Socio-acoustic survey	Park-users' perceived restorativeness influences how perceptions are related to human well-being.

Source: Author, (2021)

The indicators used in soundscape studies can be differentiated into objective and subjective measurements. Objective measurements include calculating the sound pressure level and the psychoacoustic metrics of the soundscape. However, it is found in the review that no soundscape studies

rely solely on objective measurements (Figure 3). 30% of the research is carried out only by subjective measures to focus on the type of soundscape's impact on stress recovery, expectations of soundscape in a park, soundscape experience and the effectiveness of laboratory tests on the soundscape. The indicators commonly used during subjective measures include the soundscape descriptor and sound awareness to identify the type of sounds they perceived in the area and how it influences their perceptions. On the other hand, 70% of the reviews employed a combination of both objective and subjective measurements looking into how sound level and soundscape influence the restorativeness, stress recovery in the parks, the relationship between soundscape quality and sound level, and how loudness influences the acoustic comfort in the parks.

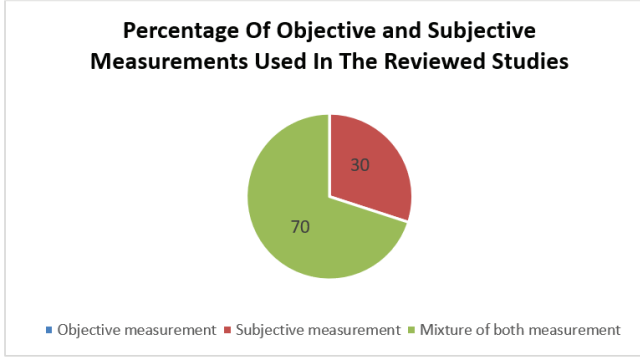

Figure 3. Soundscape Assessment Measurements in the Reviewed Studies
Source: Author, (2021)

Categories of Soundscape Indicators

Soundscape studies commonly employed the sound pressure level indicator, sound descriptor, and soundscape identification indicator to investigate the relationship between the objective sound level and how people perceive them. Psychoacoustic measures and acoustic comfort indicators may also be used to study how the type of sound influences the composition of sounds and their classifications. This reflects the fact that a simple measurement cannot determine the assessment of a sound environment. Human perception of noise relies on the meaning of sounds with the sources emitting noise and people exposed to it (Kang, 2007). Therefore, measurement and assessment methods need to account for the subjective impact of noise in correlation with acoustic parameters to define

the acoustic quality of an environment. The different indicators are discussed further to understand their differences better.

i.Sound pressure level

Most soundscape studies rely on the sound pressure level as a physical measurement of soundscape in the parks measured with a sound level meter software. (Szeremeta and Zannin, 2009; Tse et al., 2012; Brambilla et al., 2013; Axelsson et al., 2014, Bahali and Tamer-Bayazit, 2016; Cadena et al., 2017; Van Reterghem et al., 2019; Puspagarini et al., 2019; Ma et al., 2021; Jaszezak et al., 2021; Jo et al., 2021; Fisher et al., 2021). Requirements for quiet urban areas are typically based on sound level limits, with the recommended limit values for day-evening-night average sound level (Lden) being around 50-55dB(A) (European Environment Agency, 2014). It was found that only 20% of people perceived acoustic quality at an area of 60dB(A) and above as "good" or "very good" (European Environment Agency, 2014). However, there is evidence that sound level alone does not determine the acoustic quality (Szeremeta and Zannin, 2009; Bjerre et al., 2017). The sound pressure level indicator is often used together with other indicators, including the psychoacoustic soundscape metrics or a subjective evaluation of the soundscape in the park. Ma et al. (2021) concluded that there is a relationship between loudness and perceived pleasantness with the sound level of the park.

ii. Psychoacoustic metrics

Psychoacoustic metrics such as roughness, tonality, fluctuation, and other acoustic parameters were used to describe better the character of a soundscape quality (Brambilla et al., 2013; Liu and Kang, 2015; Bahali and Tamer-Bayazit, 2016). The psychoacoustic metrics of an acoustic environment is calculated from the recorded sound pressure level of the parks before the conversion method based on ISO 532-1 (International Organization for Standardization, 2017). Kang et al. (2016) explain that psychoacoustic deals with the quantitative link between physical stimuli or hearing sensation caused by them to enable the description of the character of an acoustic environment in detail and allow the relation of the physical phenomenon to the perceptual construct of the acoustic environment. Liu and Kang (2015) highlight that a soundscape's physical and psychoacoustic parameters relate differently to the type of sound sources. The explanatory abilities of physical and psychoacoustic parameters are limited. Mancini

(2021) suggests psychoacoustic as bridging the gap between physically measurable quantities and subjective evaluation.

iii. Soundscape descriptors

Aletta and Kang (2016) outline descriptors for soundscape studies into a few categories: noise annoyance, pleasantness, quietness or tranquillity, perceived music-likeness, perceived affective quality, and restorativeness soundscape quality and appropriateness. While most of the soundscape descriptor is consistent with the review's findings, it was also observed that the perceived music-likeness is not found in recent soundscapes studies of urban parks. A semantic differential scale was proposed by Osgood (1952) to aid in quantifying the meaning of things. This is often used in soundscape studies of parks but varies according to different perceptual responses.

The respondent's satisfaction and expectations towards the park is also an indicator to measure the quality of the urban park, where their preference is associated with their visiting experiences (Bahali and Tamer-Bayazit, 2016; Ou et al., 2017). Ma et al. (2021) measures the park's soundscape with the variables pleasantness, loudness, and sound variation, representing the evaluation on the three fundamental perceptual dimensions of sounds, Evaluation, Potency, and Activity, respectively.

A study by Masullo et al. (2021) revealed that soundscape questionnaires created to focus on the emotional dimensions of sounds could capture more reliably the positive dimensions of sounds compared to the questionnaire built from the circumplex of soundscape perception. On the other hand, Jo et al. (2021) pointed out that the pleasantness of a park can be increased, and eventfulness appropriately controlled by adding birdsongs and vegetations to increase the environmental satisfaction of the parks.

iv.Acoustic evaluation

Acoustic comfort is often used in relation to noise or annoyance (Jo et al., 2021). It can be increased by introducing pleasant sounds in the area even when the sound level is high. The assessment of soundscape by acoustic comfort suggests that people tend to show more tolerance in terms of acoustic comfort evaluation than sound level (Yang and Kang, 2004).

Bahali and Tamer-Bayazit (2016) conducted a study on acoustic

comfort and the subjective evaluation of loudness in different parks. Their study discovered that sound level might not influence the perceived loudness directly as parks with a lower sound level according to the sound level measurement can be perceived as a noisier location. Therefore, while subjective evaluation of loudness in the park might differ from results of sound pressure level, it is parallel to soundscape descriptor and acoustic comfort of the area.

v.Sound awareness

Sound awareness and preference enable the identification of keynote sounds, sound signals and sound marks. Therefore, it is suitable for a qualitative approach for acoustic studies that identify the uniqueness in the acoustic environment. The dominance of the sound sources in the soundscapes is often used to measure soundscape awareness in parks (Szeremeta and Zannin, 2009; Axelsson et al., 2013; Filipan et al., 2017; Kogan et al., 2018; Liu et al., 2018). As the sound environment of the parks is composed of different kinds of sounds with different sound identities, thus, judging the acoustic quality of parks are based on a comparison of sound levels and legal limits or merely on the visitors' judgement of these levels would be arbitrary.

Green Soundscape Index by Kogar et al. (2018) measured the ratio of perceived extents of natural sounds to traffic noises to help assess the overall soundscape of the area as they can separate environmental sound sources. Fisher et al. (2021) also classified soundscapes by their perceived biodiversity and naturalness of the park, which is linked to the perceived restorativeness of the site. The perception of green and blue characteristics of the area was then compared to the objective measurements of the soundscapes to provide recommendations on how city planners might be able to make use of this knowledge in improving the well-being of urban dwellers.

vi.Sound preference

Recent studies have revealed that the perception of soundscape is not specifically linked to the sound level of the area but to the type of soundscape and people's personal preferences and sensitivity (Kang, 2017; Kang et al., 2016; Liu and Kang, 2016; Filipan et al., 2017). A few studies concluded that participants exhibit a higher preference for natural sounds and lesser

preferences for artificial sounds (Jeon and Jo, 2020; Liu et al., 2019; Bruce and Davies, 2014). Therefore, soundscape study is also commonly linked to sound preference and experiences.

In short, the development of soundscape research has allowed the emergence of different indicators which uses physical acoustics measures and subjective perception measures to assess the soundscape of parks. However, high sound levels are not always caused by the sounds from anthrophony sources. The assessment of the acoustic environment should not be based only on the objective parameters in the form of equivalent sound level values (Puspagarini et al., 2019). Studies have reported no strong relationship between the results of objective measurements with the perceptions of respondents given the overall soundscape evaluation. Therefore, a successful soundscape study should consider both objective and subjective indicators of the acoustic environment.

Data Collection Approach for Soundscape Studies in Parks

The most common and traditional indicator used in noise management and soundscape approaches is sound level measurements. An in-situ study is required to record the sound level of the area. However, recent soundscape research proposes studies to characterise soundscape with acoustic indicators and psychoacoustic indicators for a better descriptor of soundscape quality (Bruce and Davies, 2014; Cerwen et al., 2016). Although the sound level is more straightforward to measure due to its objective measures, it lacks the subjective evaluation of the acoustic environment.

On the other hand, the psychoacoustical metrics represent a subjective auditory evaluation and the variance in unpleasantness assessment better. However, results from psychoacoustical metrics of soundscape on their own is not dependent on the sound sources. Correlation analysis is often carried out when using this sound level measure to identify the relationship between sound level and the physiological responses towards the soundscape. On the other hand, regression analysis is undertaken for psychoacoustic measures as it is dependent on more than one factor such as roughness, fluctuation strength and sharpness.

Jeon et al. (2012) also used laboratory experiments to identify the

relationship between sound preference and soundscape descriptors. Bruce et al. (2009) and Bruce and Davies (2014) considered using a simulator to investigate soundscape perception to understand the relationship between sound sources and the acoustic environment. Soundscape descriptors used in the research have allowed the respondents to describe the soundscape based on bipolar adjectives such as unpleasant – pleasant, noisy – calm, stressful – relaxing. This indicator is always used in quantitative studies that relate to soundscape perception and other study parameters. Therefore, regression analysis is the primary analysis used to relate soundscape with other measures such as the predictors of emotional responses or perceived restoration.

The assessment of soundscape by acoustic comfort suggests that people tend to show more tolerance in terms of acoustic comfort evaluation than sound level (Yang and Kang, 2004). The acoustic comfort can be increased by introducing pleasant sounds in the area even when the sound level is high. Acoustic comfort reflects the state of well-being satisfaction towards the environment, while considering all individual differences. Similar to the assessment of sound level, measuring soundscape by acoustic comfort requires an in-situ study. It is often followed by an ANOVA analysis to identify the relationship between acoustic comfort and the different psychological responses of the respondents.

Soundscape indicators described from the sound awareness and preference enable identification of keynote sounds, sound signals and sound marks, suitable for a qualitative approach for acoustic studies that identify the uniqueness in the acoustic environment. Additionally, soundscape preference is used to study the correlation with other variables, such as identifying the relationship between soundscape preference and emotional restoration. When using the soundscape perception as an exploratory approach, content analysis is often used to gather the soundscape identifications from the community. Van Renterghem et al. (2019) explored the potential of adding natural sounds interactively through virtual reality and augmented reality, where the sound preference of the respondents and how they influenced the environmental noise perception were analysed. Soundwalk is also used commonly in an exploratory approach to analyse the perception of urban soundscape, where respondents rely on sound awareness and sound preference to identify and characterise the soundscapes (Davies

et al., 2009; Bruce et al., 2009).

Comparison of Soundscape Indicators

A comparison of the soundscape indicators shows the strength and limitation of each indicator (see Table 3). An in-situ experiment offers realism where listeners were exposed to the natural soundscape. All the sensory stimuli are authentic and may influence the auditory senses for a better experience. The soundwalk method also faces issues when repeating the experiment and faces temporal change effect. There is a limited variation of the acoustic environment with in-situ experiments, which makes it challenging to model the interaction between the sound sources and how people perceive them. In addition, laboratory tests offer control over the study parameters so that each listener is exposed to the same sound and that the research can be repeated for validation study. The interview by memory approach helps in the investigation when one cannot be present at the actual environment settings and cannot perform the laboratory study. Cadena et al. (2017) concluded in their study that although in-situ tests allowed a systematic evaluation of the environment, laboratory tests allowed a specific and more focused analysis of different sound components. Therefore, both methodologies help evaluate soundscape depending on the application and need of study. Both methods are potentially helpful and can complement one another in evaluating urban acoustic environments.

Table 3. Strength and Weakness of Different Soundscape Indicators

Soundscape Indicators	Enquired Items	Strength	Weakness
OBJECTIVE MEASUREMENT OF SOUNDSCAPE			
SOUND PRESSURE LEVEL	Leq and Leq(A)	Easy to measure due to the objective nature of the data	Ineffective quantifiers of subjective evaluation of soundscape
PSYCHOACOUSTIC METRICS	Loudness, roughness, sharpness, fluctuation strength	Better represent subjective auditory evaluation and better explain the differences in the variances of unpleasantness assessment	Not dependent on the sound sources
SUBJECTIVE MEASUREMENT OF SOUNDSCAPE			

SOUNDSCAPE DESCRIPTORS (BIPOLAR ADJECTIVES)	Unpleasant – Pleasant, Noisy – Calm, Stressful – Relaxing, Artificial – Natural, Monotonous – Vibrant, Informative – Uninformative Inappropriate – Appropriate	Provides detailed descriptions of soundscapes and complementary information beyond the perceived affective quality	It depends mainly on the context of the soundscape
ACOUSTIC EVALUATION	Acoustic comfort	Perceived state of well-being and satisfaction with the environment and covers the consideration of individual differences such as noise sensitivity	Weak statistical association with soundscape as people tend to show more tolerance with acoustic comfort evaluation
SOUND AWARENESS	Perceived sound events, noise detection, dominance	Enable identification of keynote sounds, sound signals and sound marks	Requires focus and in-situ studies, results may differ according to the individual differences and preferences
SOUND PREFERENCE	Preferred sounds	The preferences of soundscape elements influenced people's choices and caused them to evaluate the same environment differently	In different places and different contexts, a person's preferred outcome concerning the acoustic environment may differ

Source: Author, (2021)

The study found various soundscape perception assessment indicators in parks, classified into objective and subjective measurements. The ideal strategy to use in soundscape research of parks, according to this review, is a combination of objective and subjective measures. The different indicators can be used to provide a more comprehensive understanding of the park's environment.

This review also supports the findings from Szeremeta and Zannin (2009), who concluded that the population's opinion in conjunction with the analysis of quantitative parameters is effective and essential for a better understanding and identification of the qualities that confer environmental comfort to provide effective support for urban projects. Syamsiyah et al. (2019) mentioned that in a mixed-method strategy, sound pressure level gives an idea if the area has met its acoustic comfort requirements, while subjective measurements are needed to strengthen the objective findings of the user perceptions. The subjective approach will provide information

about the perception of sound, the presence of interference or sound comfort.

It is also in line with Ma et al. (2021), who stated that a soundscape approach emphasises that environmental sounds are regarded as resources. The perception of sounds should not be based on loudness, but responses to different sound sources should also be differentiated as reducing noise level on its own is not equal to improving the acoustic environment. Figure 4 shows the multiparty needs in a holistic soundscape evaluation proposed by Ma et al. (2020). The proposed soundscape evaluation strengthens the review's findings by requiring different soundscape indicators from different parties involved in the soundscape evaluation, such as the importance of subjective responses from city users and objective measurements of the acoustic environment from acousticians to evaluate the soundscape of the area. Therefore, a proper selection of physical metrics and subjective variables is the first step in establishing the predictable relationship for environment-human interactions.

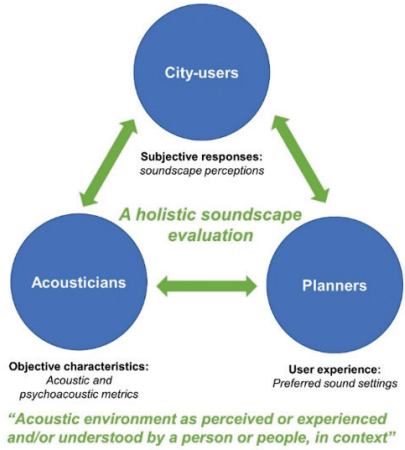

Figure 4. Schematic Diagram of a Holistic Soundscape Evaluation
Source: Ma et al., (2021)

LIMITATION AND FURTHER RESEARCH

This review has some limitations whereby only English-language publications were included, and studies from non-English-speaking countries may have been overlooked. This review also encountered some

difficulties where only one soundscape study that employed virtual and augmented reality was considered, limiting the understanding of the indicators used in such research design. Therefore, a further in-depth review should be carried out for studies involving such research design. Another limitation to the study is that it focuses mainly on the different soundscape indicators in parks to investigate how researchers collect the subjective evaluation of soundscapes. As the soundscape indicators depend much on the context and aim of the study, it is necessary to create a more detailed perceptual model in future studies to focus on applying suitable soundscape perception parameters and other factors related to well-being of the community. Further research should investigate the application of the indicators in different scenarios to provide more information for selecting the appropriate parameters to be used in a soundscape study. Nevertheless, this review provides an understanding of the different approaches undertaken in a soundscape study and discusses the strength and weaknesses of both objective and subjective indicators. Therefore, further research in this scope would benefit by considering how the different categories of soundscape indicators work together and to look further into the newer models such as the Green Soundscape Index and the Red Soundscape Index proposed to assess the overall soundscape of the parks.

CONCLUSION

This review investigates and differentiates the various soundscape indicators used in soundscape studies. Besides, this review has demonstrated the different categories of indicators in the study of park soundscape. The research approach of soundscape studies also influences the indicators used in the study. Factors that influence soundscape perception and the strength and weaknesses of the different soundscape indicators undertaken when studying the community's perception regarding the park's soundscape were discussed. Subjective evaluation of soundscape relates to the research's purpose on the types of soundscape was also conducted. In contrast, objective and subjective indicators were employed, when the research involved soundscape quality in the area. Environmental sounds are a resource in a soundscape approach; the perception of sounds should be differentiated together with the application of objective measurements of the soundscape. Although quantitative methods or qualitative methods can be carried out on

their own in a soundscape study, the application of a mixed method would yield a more comprehensive result, explaining the relationship between the two types of indicators. This review contributes to a better understanding of the indicators' differences, strengths and weaknesses. It also provides further insight into the benefits of the technological approach, especially when it is difficult to carry out in-situ studies. This review justifies and contributes to a better understanding of including soundscape perception in urban planning environmental management. However, this review only discusses soundscape indicators and does not discuss the correlation between soundscape perception and other factors in environmental studies. Therefore, future studies should focus on the application of suitable soundscape indicators and the relationship between perception and other factors related to the community's well-being. Besides, further studies on this can also improve the proposed soundscape index introduced on the topic.

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CONFLICT OF INTEREST

This manuscript has not been submitted to, nor is under review at, another

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