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SOUNDSCAPE PRACTICE AND INTERVENTIONS: A FRAMEWORK

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ABSTRACT*

Extensive research has been carried out in soundscape, corresponding to the EU Directive on Environmental Noise, which requires actions on protecting and creating quiet areas. Consequently, it is vital to establish a systematic framework for soundscape practice and interventions. This paper therefore explores such a framework by considering: 1) The overall process for soundscape participatory planning, based on data synthesis and analysis and engagement with diverse stakeholders; 2) Design targets setting, in terms of multi-dimensional targets at the design stage, and context-dependent single indices for ranking various designs; 3) Designable factors, including sounds, space, people, and environment, and their potential; 4) Mechanism of participatory design, including design generation, discussion and evaluation; 5) Collection of real-world soundscape intervention examples, including design taxonomy and database.

Keywords: *soundscape, intervention, design, practice.*

1. INTRODUCTION

Since the publication of EU Directive on Environmental Noise [1], where protecting and creating quiet areas is required, extensive research has been carried out, in terms of soundscape understanding (definition, evaluation, description, modelling), collecting and documenting, harmonizing and standardizing, designing and creating, and outreaching [2,3]. Meanwhile, there has been increasing attention and interest in applying soundscape approaches into urban planning and design, by practitioners, along with requirements in national policies [4,5]. However, many soundscape practices, including designs and interventions (any site-specific implementation of a soundscape design), are still lacking comprehensive implementation into planning and design processes as well as using full potential of the designable factors. This paper therefore aims to explore an overall framework for soundscape practice and interventions, by reviewing relevant work.

2. A FRAMEWORK

The development of a comprehensive framework for soundscape practice and interventions is critical to ensure consistency, effectiveness, and applicability in real-world scenarios [6]. The ISO 12913 series provide the foundation for soundscape standardization, establishing a structured methodology for soundscape assessment, evaluation, and implementation [7]. This framework builds on the principles of the ISO 12913 series by integrating key elements such as participatory planning, real-world case studies, design targets, designable factors, and evaluation mechanisms.

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The **overall planning process** plays a pivotal role in embedding soundscape considerations into urban and architectural design from the outset, ensuring stakeholder engagement and interdisciplinary collaboration. However, challenges such as limited awareness and fragmented regulatory policies can hinder its implementation [8]. The ISO 12913 series help address these challenges by providing standardized guidelines for assessing and incorporating soundscapes into planning practices, ensuring consistency across different projects.

Real-world examples serve as practical references, showcasing diverse interventions and best practices. However, a common issue is the lack of systematic documentation and comparability between different cases [8,9]. The ISO 12913 framework facilitates this by defining clear terminologies and methodologies, allowing for a more structured comparison and evaluation of interventions globally.

The establishment of **design targets** enables a structured approach to soundscape implementation, ensuring that interventions align with multidimensional objectives. One of the key challenges is the lack of universally accepted indicators to evaluate success [10]. The ISO 12913 framework provides a foundation for developing context-specific performance metrics, allowing practitioners to set measurable goals based on human perception and environmental conditions.

Designable factors encompass effects of sound sources, effects of space, social factors and other environmental conditions, forming the core of soundscape design strategies. A major difficulty is identifying the optimal balance between these factors in different urban contexts. The ISO 12913 framework supports this process by offering a standardized assessment structure, helping designers integrate diverse elements effectively.

Lastly, **participatory design** emphasizes the need for stakeholder involvement, iterative refinements, and validation against international standards [11]. A key obstacle is ensuring meaningful engagement from all stakeholders, particularly in communities with varying levels of expertise in soundscape concepts. The ISO 12913 framework provides structured participatory tools, such as soundwalks and surveys, which facilitate more inclusive and scientifically rigorous community engagement processes.

The following sub-sections provide an in-depth exploration of these components, emphasizing their role in advancing soundscape practice and policy.

3. OVERALL PLANNING PROCESS

Soundscape planning is essential for creating healthier and more sustainable environments, moving beyond conventional noise control to create preferable sound environment for comfort, safety, cultural, restorative and ecological values [12]. Central to the soundscape concept, human perception, soundscape planning calls for a participatory approach to involve local communities, as users of spaces, in different stages of the planning process, including establishing goals and objectives, defining design targets, making predictions and designs, implementing these and evaluating the outcome for potential future developments [13]. Soundscape planning should be integrated in the wider urban planning process from the start to ensure a sustainable development through interdisciplinary collaborations between local planning authorities, soundscape experts, artists and other interest parties. By collaborating through participatory tools like soundwalks, intercept surveys, interviews and co-design workshops, diverse perceptions of sound, both wanted and unwanted, could be gathered to identify soundscape objectives tailored to a specific environment and shape the interventions. Participatory online tools such as the Hush City app empower communities to explore sounds in the living environment as shared resources [14]. Creating soundscape literacy is a critical element to engage various stakeholders in the process [15]. An effective and meaningful outreach and engagement strategy will be essential to open up conversations between communities and other stakeholders. For example, soundscape exhibitions in the Sounding Brighton project. Identified challenges include lack of interest and awareness, language barriers and readiness of workability [8]. Lessons can be learnt from the development and implementation of Welsh Government's policy on noise and soundscape, creating "the right sound environment at the right time and place" aligning the national wellbeing and sustainable development goal [16].

Inclusivity in participatory soundscape planning is an important however debatable aspect regarding whose voices are excluded in the 'preferred' sound scenarios. Ultimately, future soundscape planning will need to consider aural diversity [17] and roles of non-humans in creating and perceiving the shared sound environment [18].

4. REAL-WORLD EXAMPLES

The soundscape approach, despite its growing recognition in urban planning, remains underutilized due to the lack of clear guidelines and its conceptual and practical development. To

address this, the Catalogue of Soundscape Interventions (CSI) Project developed an eight-dimensional taxonomy to provide practitioners with a structured framework that enhances communication among authorities, consultants, and researchers. This taxonomy includes stages, contributors, scale, period of time, intervention types, public involvement, aims and purposes, and approaches, summarizing essential elements of soundscape-related measures (Fig. 1). Derived from real-world cases, it categorizes interventions based on recurring strategies and goals, serving as an orientation aid for designing contextually appropriate soundscapes. While acknowledging its dynamic nature, the taxonomy is designed for continual refinement as more cases are documented and the field evolves. It facilitates not only the systematic evaluation of interventions but also supports the development of a holistic understanding of soundscapes [19,20]. The CSI database (https://soundscape-intervention.org/) is an innovative tool designed to address the gap in systematic documentation and analysis of real-world soundscape practices. Established as part of the CSI Project, this online repository compiles a diverse array of soundscape interventions from global contexts, providing valuable resources for researchers, policymakers, and practitioners in urban planning, environmental acoustics, and soundscape design. The database currently includes 49 detailed cases that illustrate the existing soundscape intervention practices across eight dimensions (Tab. 1).

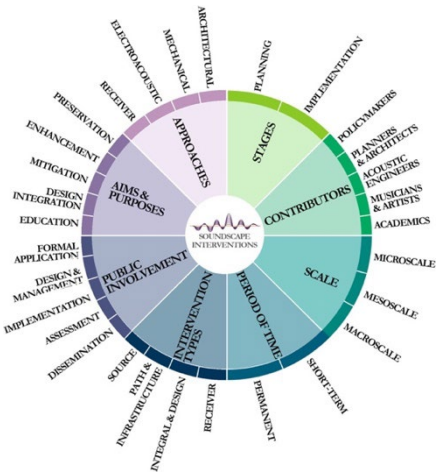

Figure 1. Eight dimensions of the taxonomy for soundscape interventions, adapted from [20].

Each entry in the database offers comprehensive metadata, including project aims, contributors, implementation stages, and specific intervention strategies. To ensure consistency and accuracy, all submissions undergo a two-stage review process, involving initial screening and criteria-based evaluation. By fostering interdisciplinary collaboration and facilitating the exchange of best practices, the CSI database serves as a critical resource for advancing soundscape research and promoting sustainable and inclusive urban sound environments. It also provides a dynamic platform for future contributions and ongoing refinement.

Table 1. Number of cases for each dimension based on 43 examples in the CSI database at the time of publishing [20].

Dimensions	Number of cases	
Stages	Planning	4
	Implementation	39
Contributors	Urban planners and architects	15
	Acoustic engineers	36
	Musicians and artists	23
	Academics	9
	Policymakers	4
Scale	Microscale	16
	Mesoscale	24
	Macroscale	3
Period of time	Short-term	9
	Permanent	34
Intervention types	Source	7
	Path/Infrastructure	14
	Integral/design	36
	Receiver	25
Public involvement	Formal application	0
	Design and management	6
	Implementation	5
	Assessment	3
	Dissemination	3
Aims and purpose	Preservation	6
	Enhancement	36
	Mitigation	17
	Design integration	14
Approaches	Education	17
	Architectural	19
	Mechanical	17
	Electroacoustic	21
	Biological/natural	6

5. DESIGN TARGETS

Establishing clear design targets is essential for effective soundscape planning and implementation. The Soundscape Perception Index (SPI) framework [21] addresses a fundamental challenge in soundscape design: how to quantify and compare the multidimensional perception of soundscapes across different contexts. At its core, the SPI

framework conceptualizes soundscape quality as the agreement between an observed soundscape perception distribution and a target distribution representing desired perceptual outcomes. This target-based approach recognizes that what makes a soundscape "good" is highly contextual, and provides a method to account for these contextual differences while still enabling meaningful comparisons between soundscapes.

The SPI methodology follows a structured process for defining targets and measuring deviations from these targets. As shown in Fig. 2, this process involves four steps: (1) define and parameterize a target distribution within the soundscape circumplex space; (2) sample this target distribution; (3) calculate the distance between the test distribution and the target using a two-dimensional Kolmogorov-Smirnov distance metric; and (4) convert this distance to an SPI score ranging from 0 to 100 [21]. This approach evaluates soundscape perception in its full multidimensionality, capturing not only the central tendency of perception but also its variability and distribution shape [22]. The SPI framework acknowledges that what constitutes a "good" soundscape varies substantially depending on context.

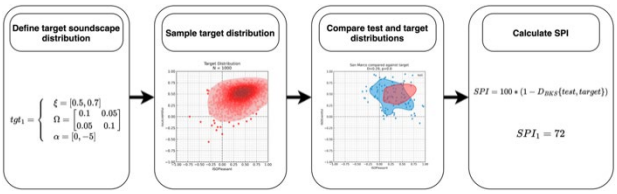

Figure 2. The SPI core method. Reproduced with permission from [21].

The SPI framework defines two types of targets to accommodate different assessment needs: bespoke targets for specific projects and reference targets for benchmarking and standardization. Bespoke targets allow stakeholders to define their own ideal perception distribution for a particular application, enabling tailored assessment of design alternatives. Reference targets represent empirically defined archetypal soundscapes for different contexts or typologies. This dual approach to target definition enables both context-specific evaluations and broader comparisons, rankings, or scorings across different soundscapes. The flexibility of the SPI framework makes it applicable to various scenarios, from urban planning and design competitions to policy development and research, providing a unified yet adaptable approach to quantifying the multidimensional perception of soundscapes.

6. DESIGNABLE FACTORS

In the design process it is important to systemically explore all the designable factors and their potential. A system for designing the soundscape of urban open spaces has been proposed, as shown in Fig. 3 [6], considering four facets, namely characteristics of each sound source, acoustic effects of the space, social aspect of the users, and other aspects of the physical conditions.

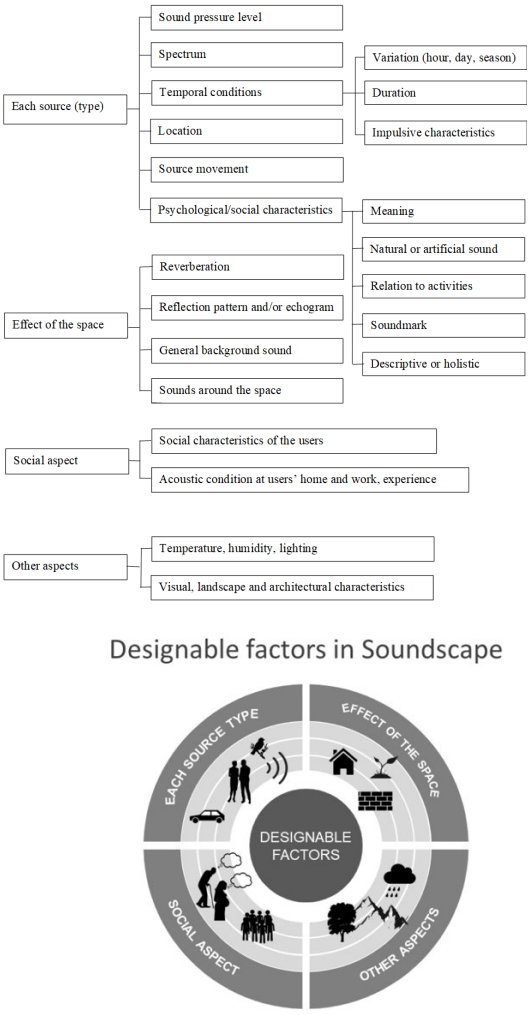

Figure 3. Designable factors for urban open public spaces [6].

Each of the four facets represent a lens through which to understand the sound environment and to identify possibilities for soundscape design. Sound sources can be broadly classified as human, technological, and natural [23].

Sources can be further understood by looking at factors like sound pressure level, temporal characteristics and location. The effect of the space concerns what happens to sound as it travels in space, including acoustical properties like reverberation, absorption and reflection patterns. Social aspects focus on the receiver and include differences in perception among users and user groups. Finally, other aspects are concerned with the wider context of the setting that might influence perception, for instance visual qualities and weather.

7. PARTICIPATORY DESIGN

Participatory design asserts the importance of engaging stakeholders and practitioners. Key elements of participatory design are identified as: (1) Assessment and Design brief: conducting the initial assessment of the soundscape to establish a design brief; (2) Design and Demonstration: engaging local experts in soundscape design using real-time, lightweight modeling guided by soundscape experts; (3) Discussion and Optimization: Facilitating collaborative discussion with local experts and soundscape stakeholders and refining proposed designs; (4) Documentation and Validation: documenting and accurately modeling designs, followed by validation in accordance with ISO/TS 12913-2 and ISO/TS 12913-3 [24,25]. It's important to recognize that participatory design is an iterative process rather than a linear one, where participants can continually re-evaluate the interventions and reflect on their impact on the soundscape until the final design is established.

However, several challenges have been identified in conventional key elements-driven participatory-based soundscape design. A major challenge lies in the limited experience or exposure of local experts to soundscape designs, which also raises their difficulty in perceiving subtle changes in the sound environment [26]. This underscores the importance of developing interactive and intuitive design prototypes capable of effectively shaping and manipulating auditory and visual environments.

In a recent study, acoustic metamaterial (AMM) structures have shown a promising ability to manipulate the sound field and improve the acoustic environment, illustrating the potential of effects of space as the designable factor contributing to a more pleasant soundscape [27]. This encourages a novel implementation of technogical solutions, such as AMM, as design prototypes for the participatory framework [28].

Another challenge resides in establishing an optimal participatory design process, especially concerning whether it should be conducted more individually or collaboratively within a group setting. This can be tackled by utilizing the SPI to compare design schemes developed by individual soundscape designers with those created collaboratively in a group, ultimately leading to the identification of the most effective approach. Considering the technical complexity and nuanced understanding required for soundscape design, determining the extent to which local experts should be empowered in the design process is crucial. This issue is examined using two approaches: one in which local experts have full control over the soundscape design and another where co-design is facilitated with professional guidance from soundscape experts.

Finally, soundscape design is investigated with varying validation methods, primarily comparing observational assessments conducted by soundscape experts and data-driven analysis performed using ISO standards such as ISO/TS 12913-2 and ISO/TS 12913-3, respectively.

8. CONCLUDING REMARKS

An overarching framework for implementing soundscape principles into practice has been illustrated by collating a number of studies and conceptual papers published by the authors. The ISO 12913 series figure as a firm basis for data collection and analysis while the theoretical work, such as applying the SPI to real world action plans completes the process - from detecting an area where a noise action plan is required, or an area where a soundscape intervention is desirable, setting the design brief that tackles the designable factors, and applying it through public participation.

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