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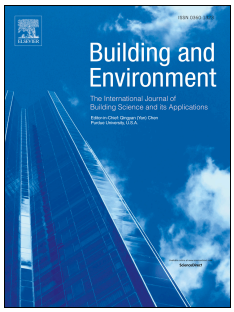

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Ten questions concerning soundscape valuation

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Abstract

The past two decades have seen an ongoing paradigm shift from noise control to soundscaping, and soundscape approaches have been applied in noise management projects. However, cost-benefit analysis (CBA), which is widely used for economic appraisal of projects that would impact on the sound environment, remains noise-based and residential-location-focused. As a result, benefits of wanted sounds are omitted from appraisal. While there is a wealth of literature seeking to place a value/cost on changes in noise exposure, little research has been done on soundscape valuation. Consequently, there is little evidence on the monetary value of soundscape, which is essential for developing soundscape-based CBA. This paper initiates a systematic discussion on this emerging topic, by addressing ten questions covering the definition and scope for soundscape valuation, potential valuation methods for

primary soundscape valuation research and required data, special concerns on private and public contexts, non-monetary valuation and soundscapes of cultural and/or historical significance, and the eventual application of soundscape values in CBA and beyond. Answers are based on reflection of existing literature on environmental valuation and soundscape, and visionary opinions by the authors from research, practice and policy sectors, and can help establish a framework to support future research in soundscape valuation and relevant areas.

Keywords: soundscape, environmental noise, environmental valuation, cost-benefit analysis

1. Introduction

1.1. Environmental cost-benefit analysis and noise valuation

Environmental cost-benefit analysis (CBA) refers to the economic appraisal of policies and projects that have environmental consequences as deliberate aims or as indirect effects. Monetary values are assigned to the costs and/or benefits of the environmental impacts arising from the appraised policies and projects, which do not have conventional market prices (Atkinson & Mourato, 2008). For example, costs and benefits of biodiversity conservation (Bräuer, 2003; Marta-Pedroso et al., 2007), water management (Birol et al., 2010; Molinos-Senante et al., 2011), and changes in noise, air quality and greenhouse gas emission as deliberate or indirect consequences of transport projects (Annema & Koopmans, 2015; Mackie et al., 2014). CBA has been widely used and played prominent roles in decision making, with advantages of providing comparable and less biased decision inputs quantified on consistent bases, across projects and types of impacts (Atkinson et al., 2018; Mackie et al., 2014).

A wealth of literature on the valuation of changes in noise levels has been developed, providing an evidence base for the monetary valuation of noise impacts for CBA. A wide range of environmental valuation methods have been used, including revealed preference, stated preference and impact pathway approaches (Bristow et al., 2015; Defra, 2014; Navrud, 2004; Nellthorp et al., 2007), and broadly

consistent values for transportation noise have been obtained that underpin national level appraisal guidance, e.g. WebTAG (Department for Transport, 2015). Such monetary noise values help ensure that noise impacts are included in CBA and thus not underweighted in decision-making (Annema & Koopmans, 2015; Mouter et al., 2015), which is important given that noise is a major environmental threat to public health (WHO, 2018), second only to fine particulate matter in western Europe (Hänninen et al., 2014).

1.2. Paradigm shift from noise control to soundscaping

The past two decades have seen an ongoing paradigm shift from noise control to soundscaping in the field of sound environment management, as noise alone cannot reflect the sound environment quality as experienced by people (Kang et al., 2016; Kang & Schulte-Fortkamp, 2016). Differing from the concept of noise as "unwanted sound", soundscape, by definition, is the 'acoustic environment as perceived or experienced and/or understood by a person or people, in context' (ISO, 2014). In addition to addressing unwanted sounds, such as transport noise in most contexts, soundscaping utilises wanted sounds, such as bird songs, running water and children playing in many contexts, to improve quality of our sound environment, considering sounds as potential 'resources' rather than just 'waste' or 'pollution' (Kang et al., 2016). Soundscape approaches are now being applied in noise management policies and projects (Cerwén et al., 2017; Margaritis & Kang, 2017; Payne et al., 2009), and in 2018, the Welsh Government became the first national government in the world to officially adopt soundscape by referring to soundscape in the title and throughout their now Noise and Soundscape Action Plan (Welsh Government, 2018).

1.3. The motivation of soundscape valuation

Despite the ongoing paradigm shift from noise control to soundscaping, uptake of soundscape approach and achieving potential benefits of it will depend on the possibility of identifying and measuring value and impact of soundscapes, and enabling the valuation of policy interventions that might enhance or degrade existing soundscapes in a common decision-making framework. This will require moving from noise valuation to soundscape valuation, covering both positive and negative soundscapes, so values of

soundscapes can replace or complement existing noise values to account for the full costs and benefits of changes in the sound environment in CBA.

Studies that seek to place a value on soundscape are only just beginning to be undertaken (Wu et al. 2021). Some previous work (URS Scott Wilson, 2011) attempted to value Quiet Areas in the UK but the results are limited. Also, current noise valuation research almost exclusively focuses on noise impacts at residential locations, i.e., noise impacts experienced by people at home (Jiang & Nellthorp, 2020). Only a very limited number of studies have attempted to value noise reductions at non-residential locations using stated preference apporaches, e.g., riverside walkways (Veisten et al., 2011), urban parks (Calleja et al., 2017) and national parks (Iglesias-Merchan et al., 2014).

Hence in CBA in current practice, only the impacts of noise are considered and positive contributions of wanted sounds are omitted, and only very limited receiver types and contexts are covered, as reflected in national guidance in the UK, US, Australia, New Zealand and most EU countries (CE Delft, 2019; Department for Transport, 2015; Mackie & Worsley, 2013; Nijland & van Wee, 2008; NZ Transport Agency, 2018; Transport for NSW, 2018; US Department of Transportation, 2011). This has implications for the ability of CBA to capture the full benefit and cost of sound environment management strategies or projects that indirectly change the sound environment.

While the first Ten-Question paper on soundscape (Kang et al., 2016) introduced the concept of soundscape and the design and management approaches, this follow-up paper moves a step further to discuss valuation of soundscape, to enable assessment of soundscape in a common decision-making framework with other environmental, social and economic impacts, and hence the uptake of soundscape approach. Based on the state of the art of environmental valuation and soundscape research, this paper will demystify the concept of soundscape valuation, and establish a framework to support future research, by answering 10 questions on the definition and scope of soundscape valuation (Q1-2), methodology for primary soundscape valuation research (Q3-8), and the applications of soundscape values (Q9-10), as illustrated in Figure 1.

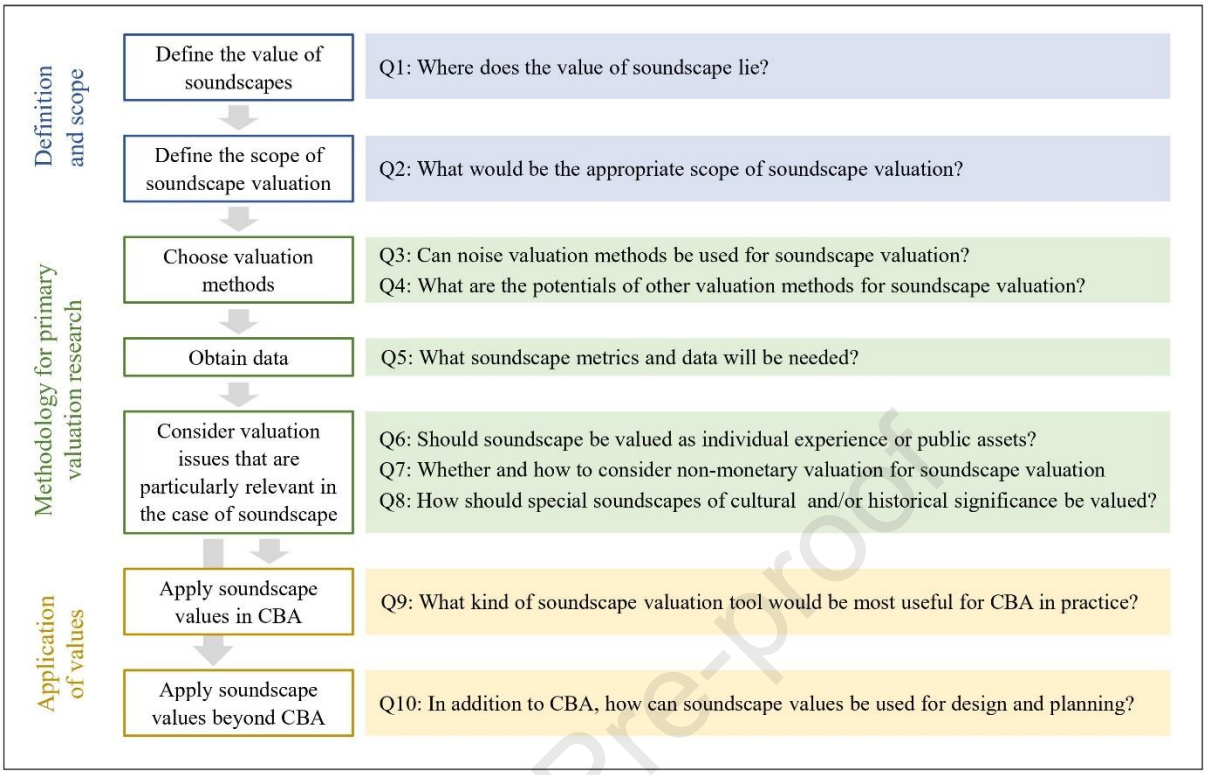

Figure 1. The ten questions concerning soundscape valuation

2. Ten questions and answers

2.1. Question 1: Where does the value of soundscape lie?

Answer: Some characteristics make soundscapes different from other more widely valued environmental resources, e.g., clean air, clean water, greenspaces, biodiversity, ecosystem services: 1) Soundscapes, or more precisely the various sounds which are main components of soundscapes, are not necessarily natural resources. While they can be biophonic (e.g., from wildlife) and geophonic (e.g., from wind, water, thunder), they can also be or contain sounds generated by human activities and facilities (e.g., from speech, music, bells, transport) (Brown et al., 2016; Yang & Kang, 2005). 2) Whether a particular sound is seen as a wanted resource or unwanted pollution, or neither, will depend on context and perception. For example, sounds of the same sources can contribute to perceived soundscape quality differently in commercial, residential, business and recreational areas and by different users (Hong & Jeon, 2015). 3) Sounds, whether wanted or unwanted, can be reproduced and do not persist and accumulate in the environment over time. If managed properly, soundscape resources

are normally renewable and their degradations reversible, unless the surrounding environment has been destroyed or degraded. Hence, a combination of different value theories might be needed to conceptualise the values of soundscapes.

The soundscape – particularly in urban contexts - will be largely formed by human activity where sound or noise is an externality or unintended consequence of the activity being undertaken. The sounds from pedestrians, shops, restaurants can contribute to a vibrant city centre environment, enhancing people's experience and promoting economic development (Southworth, 1969); whereas unwanted sounds from transport, industry, wind turbines and neighbours may impair the health, wellbeing, learning and/or productivity of some people who are not involved in these activities (WHO, 2018). From this perspective the value of soundscape may be seen as partly the combined effect of numerous positive and negative externalities of human activity.

Soundscape may also be seen as natural or cultural capital, where they are purposely protected and maintained, and/or designed and produced. For example, sounds of birds chirping and from other wildlife, and sounds of river flowing and wind in trees can be seen as natural capital; while sounds of church bells, music performances and traditional ceremonies can be seen as cultural capital. Values of these soundscapes can be captured in various ways. For example, natural soundscapes can be vital for the survival of certain species of wildlife (Sordello et al., 2020). Thus, loss of or damage to such soundscapes can threaten the functionality of ecosystems and their values can be captured through a range of affected ecosystem services. Cultural soundscapes, depending on specific types, can have the values of preserving local identity, enhancing sense of belongs, discouraging anti-social behaviours and/or promoting tourism and economic development (Brambilla, et al., 2006; Lavia et al., 2016). Both natural and cultural soundscapes also have the potential to provide tranquillity, or high quality acoustic environment more generally, which ultimately results in recreational, spiritual and/or health benefits for people (van Kamp et al., 2015; Watts, 2017).

2.2. Question 2: What would be the appropriate scope of soundscape valuation?

Answer: Soundscape valuation should consider as many of the soundscape contexts mentioned in Question 1 as possible. However, research in soundscape valuation could start with a focus on outdoor soundscapes in places such as city centre squares (Figure 2), community corners, urban parks and national parks where a high level of user diversity and a wide range of user needs are involved (Kang, 2007), and where evidence on impact values is mostly missing in current noise valuation research (Jiang & Nellthorp, 2020). It is noted, however, similar to the case of noise valuation, receptors will not necessarily be outdoors, but changes in soundscape are caused/influenced by outdoor sources and propagations. The established methods and frameworks for outdoor soundscape valuation can then be used for developing those for indoor soundscapes (Torresin et al., 2020).

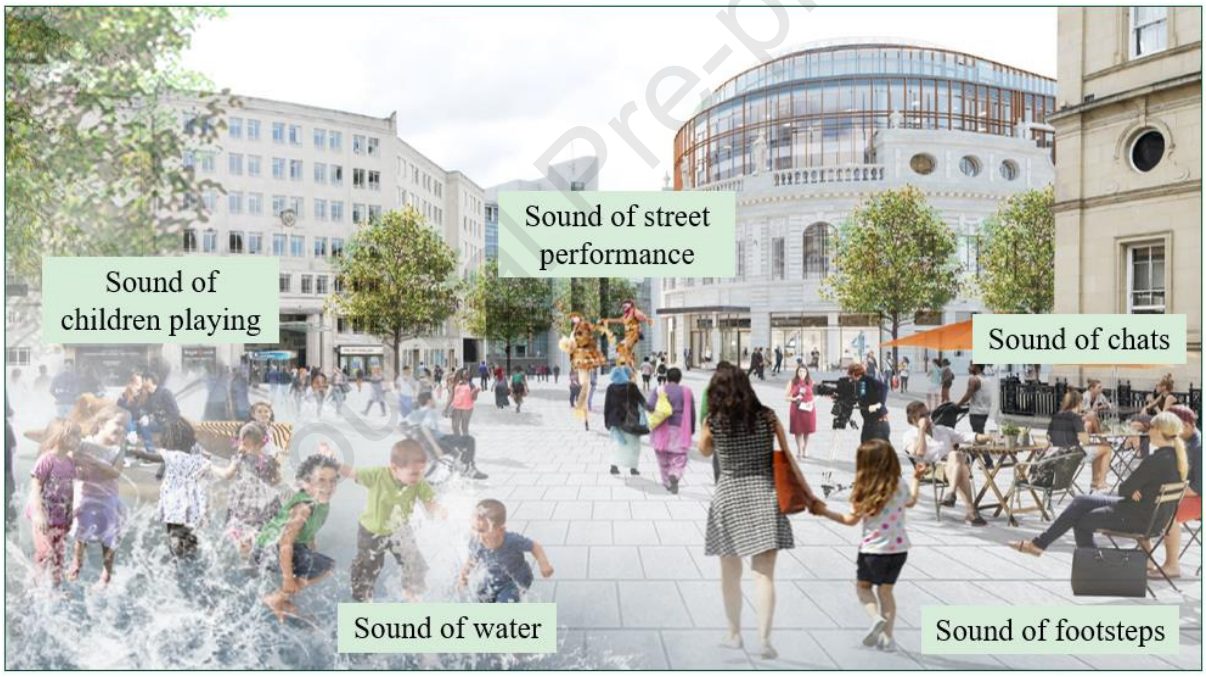

Figure 2. Soundscape of a lively urban square. Reproduced based on image from Leeds City Council (2020).

Within the scope of outdoor soundscapes, priorities might be given to benefits of wanted sounds, instead of costs of unwanted sounds. The reason is that in the near to medium term, values of noise impacts in existing noise valuation literature might be used for a large part of costs of unwanted sounds. New soundscape valuation research focusing on benefits of wanted sounds could complement existing noise

valuation research, to start constructing a bipolar value account of costs and benefits of soundscapes. This would also allow a smoother transition from current noise-based CBA to soundscape CBA. In the longer term, benefits of wanted sounds and costs of unwanted sounds could be valued concurrently with integrated study design, to adjust or replace interim values.

While most effort might be devoted to valuing everyday soundscapes that affect people's wellbeing in their daily lives, special attention should be given to soundscapes of cultural and/or historical significance, since their values are likely to be very different from everyday soundscapes, and they should not be overlooked in decision making as unique components of the cultural capital (Aletta & Kang, 2020). More detailed discussion on valuing soundscapes of cultural and/or historical significance is made in Question 8.

Impacts of soundscapes on ecological receptors should also be considered. However, this is an emerging research area (Dziak et al., 2022; Scarpelli et al., 2020), and the concept of soundscape goes beyond being human-perceived. Hence, valuation methods will probably be very different from those applied for direct impacts on human receptors, and this paper will focus the discussion on valuing soundscape from the human receptor perspective. Indeed this topic has also remained largely unaddressed in noise valuation research, despite emerging evidence on noise impacts on ecological receptors (Sordello et al., 2020).

2.3. Question 3: Can noise valuation methods be used for soundscape valuation?

Answer: It is rational to commence from the set of valuation methods usually applied in noise valuation (the first three methods in Table 1) and consider their applicability to soundscape. It is also worth noting the challenges in deriving values for changes in noise levels as these are amplified in moving to the context of soundscape. For noise there is an objective measure in the decibel (however contested that might be). This may be linked to individual perceptions (albeit not perfectly) and with health impacts (again challenging due to confounding factors). For soundscape thus far there is no appropriate metric that may be so employed (this is discussed further in Q4). A reliable measure of exposure as

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people move through many acoustic environments during their day, year and life, is also lacking. And noise levels are highly variable. Another consideration is whether the aim is to value the soundscape as is in its entirety and/or the value of changes in the soundscape – planned or unintended consequences of policy. Whilst the first might be appropriate for genuinely unique soundscapes the second is a more useful appraisal tool.

Table 1: Valuation approaches.

Method	**What does it measure?**
Hedonic pricing	Perceived amenity effects usually as experienced within the home.
Stated preference	Perceived amenity effects usually as experienced within the home – but the question and context may vary.
Impact pathway	Damage to well-being and health, including annoyance, (self-reported) sleep disturbance and a range of more objective health outcomes, through a bottom up approach.
Life Satisfaction Approach	Contribution to life satisfaction, compared to the contribution of income.
Natural capital/eco-system services	What are the services provided by natural soundscape?
Travel Cost Method	Indicates a minimum values through travel cost incurred to a site – not applicable for noise valuation but could have potential for soundscape.
Mitigation cost	Cost of reducing pollutant below a limit level.

A commonly used method to value noise nuisance is hedonic pricing (HP), a revealed preference (RP) approach which uses the market for a particular good, to estimate the value of the different component parts of the good (Rosen, 1974). In HP the price of housing is determined by the characteristics of the property, social and environmental factors and accessibility. A form of regression analysis would normally be used to estimate the influence of each characteristic on house price. The value of noise obtained is expressed as the percentage change in house prices arising from a 1dB change in noise levels (Noise Sensitivity Depreciation Index, NSDI or NDI). The approach has evolved over time as methods

have improved, for example, in allowing for spatial correlation in house prices and temporal ordering (Thanos et al, 2012).

The HP approach is broadly accepted, as it has a basis in real life decisions and transactions, and underpins many values used in public sector appraisals. The range of NSDI across studies is nevertheless large from 0 to 2.3% change in house price per dBA for both road and aircraft noise (Bristow 2018). The variation partly reflects the evolution of the method over time, meta-analyses of studies of aviation noise (Schipper *et al*, 1998; Nelson 2004; Wadud 2013) suggest that early studies tended to yield higher values as did those using linear models with less agreement on other factors. It will also reflect variations in approach and remaining challenges with regard to the treatment of noise which is usually a relatively unsophisticated approximation of a single source noise (e.g., road traffic or aviation) with assumptions (implicit and explicit) on the "cut off" point below which noise is assumed to have no cost; the treatment of background noise and addressing multiple noise sources (Franck et al., 2015; Thanos et al., 2012). The approach has other more generic limitations. For example, purchasers are unlikely to have perfect knowledge of all the attributes of the different houses they choose between; the housing market is susceptible to other imperfections most notably transaction costs; explanatory variables suffer from correlation and it is difficult to measure some intangible influences and perceptions of them (Nelson, 2008). HP is also limited in this context in that it can only give a value of disturbance as experienced at home as perceived at the time of purchase.

The arguments here apply equally, if not more so, in the case of soundscape valuation. As current methods for measuring soundscape are perceptual and largely qualitative such a revealed preference approach is unlikely to be feasible in the near to medium term. However, if wider mapping of soundscape characteristics is feasible – then the method should be explored.

The Stated Preference (SP) approach has become increasingly popular in assessing the costs of noise. These are essentially hypothetical questioning techniques, with the two main forms being the Contingent Valuation Method (CVM) and Stated Choice (SC). The CVM form usually asks a direct

question to derive a value (e.g., Barreiro et al., 2005; Bjørner, 2004; Lera-López et al., 2012) whilst SC offers respondents a choice between scenarios containing a number of factors that may vary including noise and cost (e.g., Arsenio et al., 2006; Nunes & Travisi, 2007; Thanos et al., 2011). These approaches offer some advantages over RP techniques. "Firstly, control over the experimental conditions ensures the avoidance of correlation between independent variables, sufficient variation in attribute levels, better trade-offs than might exist in the real world, investigation of levels of noise or quiet outside current experience, the avoidance of measurement error in the independent variables and the ability to ''design out'' confounding variables. Secondly, the analysis is conducted at the level of the decision maker which contributes to more precise parameter estimates not only because samples can cover many decision makers and focus on their actual decisions but also because multiple responses per decision maker can be recovered. Thirdly, such disaggregate analysis allows more detailed insights into how preferences vary according to decision makers' characteristics and circumstances" (Bristow et al., 2015). Meta-analysis of 49 SP studies identified values broadly in line with those derived from HP approaches (Bristow et al, 2015). However, hypothetical techniques also have their challenges especially with respect to the potential for various forms of bias in response – especially strategic bias, where individuals may provide a value that is artificially inflated or deflated in order to influence policy. A related issue is that of the perceived reality of the payment – again if people do not believe they will pay their values may not be true. Stated choice experiments by using trade-offs rather than direct valuation are less susceptible to such bias. The advantages over RP methods are clearly relevant to the context of soundscape where measurement is perceptual and likely to involve multiple dimensions. It will also be important to assess other environmental variables which influence perception and value of space and soundscape.

The impact pathway approach is somewhat different in concept as it seeks to identify measurable impacts on individuals' health and wellbeing and then monetise these. A standard approach is the use of Disability Adjusted Life Years (DALY) and Quality Adjusted Life Years (QALY) to apply a health impact pathway and this has been applied to noise impacts. The main steps are: (i) to identify the change in noise levels to be assessed; (ii) to identify the population affected; (iii) to identify the impact

on the health of the population; (iv) to apply a disability weight (DW) to each health outcome; (v) to estimate the number of healthy life years saved (or lost); and (vi) to apply a value of a QALY to the number of healthy life years saved (or lost). This process has many steps and a number of potential sources of error. The body of evidence on the impacts of noise on health continues to grow (e.g., Vienneau et al, 2019; van Kamp et al, 2020) and is increasingly robust. The WHO (2011) has estimated disability weights for cardiovascular disease, sleep disturbance, tinnitus and annoyance resulting from environmental noise. Whilst there is some clarity on the DW attached to various forms of heart disease, the evidence for the other areas is far less developed (Bristow, 2018). Unlike the other two approaches the value placed on the nuisance or benefit is not directly valued. At present there would be little or no such evidence on the impact of soundscape on individuals.

As soundscape valuation is at a very early developmental stage with measurements based on perception of various dimensions, and soundscape is very much part of the broader built and natural environment, the SP approach which is conducted through social surveys that can also gather other contextual and perception data is an obvious way forward. However, if appropriate soundscape metrics can be identified the range of options becomes broader.

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2.4. Question 4: What are the potentials of other valuation methods for soundscape valuation?

Answer: There are other valuation methods that are not commonly used for noise valuation (the last four methods in Table 1), but may have potential for soundscape valuation, especially in cases of some special soundscapes, e.g., soundscapes of cultural and/or natural significance, or of tourist interests.

The life satisfaction approach uses micro-econometric functions of self-reported life satisfaction, with the non-market goods to be valued as explanatory variables along with income and other covariates. Willingness to pay for the non-market goods are derived by comparing their coefficients to that of income. It has been applied to value various environmental goods and services including noise (van Praag & Baarsma, 2005). However, the range of the studies is relatively limited, and there are concerns about the reliability of self-reported life satisfaction and the complexity of its relationship with

environmental goods and services (Millard et al., 2018). Nevertheless, given the growing interests in research on soundscape, wellbeing and quality of life, opportunities of using this approach for soundscape valuation might arise.

The natural capital and related eco-system services approach are used to assess flows of services from the natural environment. This approach can be applied to assess soundscape (or sound environment), particularly natural soundscape (or sound environment), and their enhancement or protection measures, for example noise reduction in national parks (Francis et al., 2017; Levenhagen et al., 2020). However, as with the impact pathway approach, the monetary values of any soundscape-based or -relevant eco-systems services, such as biodiversity, recreational and spiritual benefits, would need to be estimated separately

Other approaches that could be considered in this context are the travel cost method which has largely been used in the context of travel and tourism to value "destinations" by considering the costs incurred to reach them. This is a challenging approach and whilst not appropriate to valuing noise nuisance could be useful in valuing significant soundscapes. Indeed Wu et al. (2021) used such an approach to identify the base value for a destination that they then decomposed, using survey responses, to identify the value of aural competent of the experience. Arguably one of the very first studies to identify a value for a unique soundscape as opposed to a change in noise levels within a soundscape.

Another possibility, especially at this early stage when metrics have yet to be determined, is mitigation cost, although this approach reflects value only in terms of willingness to pay to avoid harm. This approach may be used where there are, for example legally binding limits for a pollutant and expense must be incurred to comply. It could also be applicable here, again perhaps for unique soundscapes to provide protection.

2.5. Question 5: What soundscape metrics and data will be needed?

Answer: Quantitative soundscape metrics that link subjective perceptions to objective acoustic and contextual factors will be needed, to enable monetisation while at the same time account for the perception-based nature of soundscape. Examples of such metrics that are currently available include overall soundscape quality rating of good/bad (Ricciardi et al., 2015), tranquility (Pheasant et al., 2008), restorativeness (Payne, 2013), and affective ratings such as pleasantness and eventfulness (Axelsson et al., 2010). A comprehensive review can be found in Lionello et al. (2020).

The specific types and formats of the data will depend on what valuation methods to use. For HP methods, data of soundscape quality, measured in one or more soundscape metrics, across large geographies will be needed, typically in the format of soundscape maps (Figure 3), produced by conducting soundscape quality surveys at sample locations and then interpolating over space (e.g., Hong & Jeon, 2017; Kang et al., 2018); or by applying soundscape quality prediction models, developed based on survey data and using geo-data as predicting variables, at each grid point across the mapping area (e.g., Lavandier et al., 2016; Yu & Kang, 2009). Maps using the first approach are expensive to produce as they require inputs of large primary data of high quality. Accuracy of the interpolated values can also be a concern. Maps produced using the second approach can only be as reliable as the underlying prediction models and as accurate as the input predictor data. They may also cause collinearity issues when used as input data for HP modelling, if they share predicting variables, such as land use and land cover, with the HP modelling.

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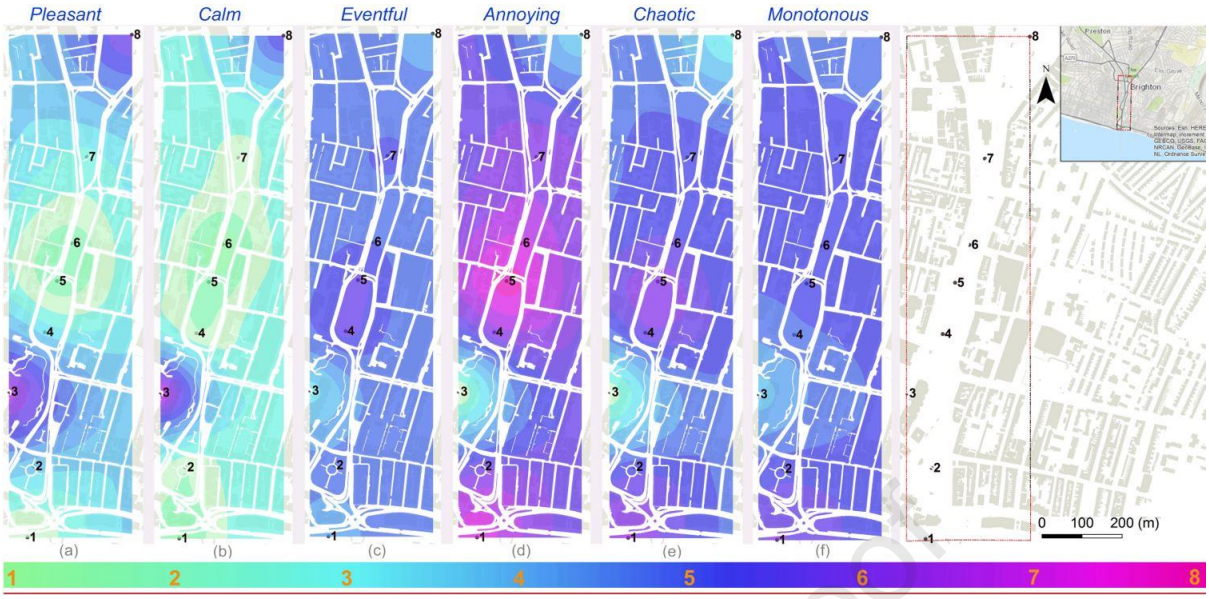

Figure 3. Soundscape maps for the Valley Gardens area of Brighton, UK, showing affective ratings of Pleasant, Calm, Eventful, Annoying, Chaotic, and Monotonous (Kang et al., 2018)

For CVM and SC methods, soundscape quality data across a large geographical area are not required, since the methods use controlled experimental designs and only a limited number of selected soundscapes needs to be presented to the participants. However, the presented soundscapes need to be measurable, and the above mentioned soundscape metrics may not be suitable as they cannot be easily controlled as inputs in experimental design, rather, they normally came as outputs in most existing soundscape preference studies (e.g., Brown et al., 2011; Jiang et al., 2018; Krzywicka & Byrka, 2017). This will become less an issue for impact pathway approach and life satisfaction approach as they do not require such experimental control, and soundscape quality can be measured or predicted by researchers depending on study design, or self-reported by participants in the case of life satisfaction approach. However, such data collection methods have rarely been used in soundscape research (Aletta et al., 2018).

Despite the varied requirements for soundscape metrics and data between and even within valuation methods, a standardised metric or set of metrics, such as dB in noise valuation and hence the pricing unit of per-dB-per-household-per-year, will allow comparison and integration of different studies and

building compatible evidence bases (e.g., Bristow et al. (2015) for noise valuation). In this respect, standardised soundscape data collection, reporting and analysis methods have been developed and suggested (ISO, 2018; 2019), and the data outputs, such as the two soundscape dimensions based on affective quality ratings, have the potential to be used as standardised soundscape metrics for valuation purpose. Nevertheless, the ISO methods are not highly practical (Heggie et al., 2019), and to define a pricing unit for soundscapes, single-value metrics like dB for noise would be preferred. However, single-value soundscape metrics that reliably and comprehensively account for acoustic, contextual, physiological and psychological factors, calculable using measurable and readily obtainable objective data (e.g., sound source and level, receiver demographics, land use), are yet to be developed (Kang et al., 2019).

2.6. Question 6: Should soundscape be valued as individual experience or public assets?

Answer: In conventional environmental valuations including typical noise valuation, the values were generally elicited from individuals in private decision contexts, concerning their own wellbeing. For example, noise attributes used in SP studies were mostly noise impacts at private home, and payment vehicles were mostly private payments such as council tax (Wardman & Bristow, 2004), housing service charge (Arsenio et al., 2006) and rent or mortgage paid (Galilea & Ortúzar, 2005); properties used in HP studies were mostly residential properties which were private assets and people made the purchase decisions in private contexts (e.g., Nellthorp et al., 2007; Nelson, 2008; Wadud, 2013). Such private values however may not reflect the values people, as members of communities, attach to environmental goods that are shared by the communities (Mouter et al., 2019), and the concepts of social valuation and shared values, which are distinct from mere aggregations of individual private values, are receiving increasing attention (Kenter, 2016). An important element in social valuation methods is group deliberation, involving diverse stakeholder groups and local and expert knowledge, to negotiate social willingness to pay in the forms such as allocation of public budgets (Orchard-Webb et al., 2016), additional tax cost at society level (Gregory & Wellman, 2001), and tax payment as a member of the public (Macmillan et al., 2002).

Soundscapes can be experienced and assessed in both private and public contexts, e.g., soundscapes at private homes and soundscapes at public urban spaces or natural conservation areas, thus, both or either of private valuation and social valuation should be used depending on the type of soundscapes. However, it should be noted that soundscape surveys and evaluations in the current literature were mostly made from individual perspectives and in private contexts, despite most of the studied soundscapes being in public settings. For example, soundscape quality of and/or preferences for public parks and urban spaces were normally evaluated by participants individually, although the individual responses might be reported in an aggregated format (e.g., Fang et al., 2021; Jeon et al., 2018; Jiang et al., 2018; Ma et al., 2021). The ISO soundscape data collection, reporting and analysis methods were also designed for such applications (ISO, 2018; 2019). While such studies are helpful for understanding people's individual preferences for soundscapes and building the foundation for estimating private soundscape values, studies incorporating group-based deliberative approaches are also needed for shared soundscape values, especially when considering the fact that most of the soundscapes that are of interest of decision-making are likely to be in public settings.

2.7. Question 7: Whether and how to consider non-monetary valuation for soundscape valuation?

While monetary valuation has enabled direct assessment of the costs and benefits of different environmental policies and projects, and non-monetisation risks the concerned impacts being omitted in CBA and underweighted in decision-making (Annema & Koopmans, 2015; Mouter et al., 2015), objections to monetary valuation are that it is not always clear what the monetary values really mean, and full values of some environmental goods cannot be usefully measured in monetary term (Dallimer et al., 2014). For these reasons, non-monetary valuations, such as by wellbeing rating (Dallimer et al., 2014), perceived value categorising (Czembrowski et al., 2016), and ranking and pairwise comparisons (Zendehdel et al., 2008), have been used in valuing complex environmental goods such as biodiversity, green spaces and ecosystem services, to provide complementary perspectives on their values.

Soundscape valuation should aim to be monetary to fit into the overarching economic appraisal paradigm. This has also been the case for noise valuation. However, given the perceptual and contextual

nature of soundscape, complementary non-monetary valuation should also be used to provide a more comprehensive account of soundscape values.

So far, evaluation of soundscape has largely been based on quantitative and subjective ratings by relevant stakeholders on multiple quality dimensions, e.g., pleasantness, eventfulness, calmness (Axelsson et al., 2010). This is also reflected in the ISO soundscape data collection and reporting requirements (ISO, 2018). Such quantitative and subjective soundscape evaluation studies can contribute to non-monetary valuations of soundscapes. A relevant attempt can be found in Engle et al. (2019) where a quantitative non-monetary soundscape 'cost index' was developed with subjective soundscape quality ratings as part of the inputs. With a more specific focus, Jia et al. (2020) identified five preservation values characterising urban soundscapes worth preservation, i.e. ecological value, comfortable value, affective value, identifiable value, and practical value, with each value measured using subjective rating of low, moderate and high.

Recently, there has been an increasing interest in associations between soundscapes and subjective wellbeing, although various definitions and measures of wellbeing were used, such as WHO-5 Well-being Index, cultural and social wellness, and health related wellbeing (Aletta et al., 2019; Bates et al., 2020; Moscoso et al., 2018). Soundscape wellbeing studies have the potential to develop non-monetary soundscape values that are comparable and compatible with existing and emerging non-monetary values of other environmental goods, if consistent wellbeing definitions and measures are used. In the UK, there is increasing acceptance of using wellbeing measures by the government for the appraisal of social or public value, and national surveys on wellbeing using standard measures have been carried out (HM Treasury, 2021a). Future soundscape wellbeing research in the UK context could use these standard wellbeing measures. Conversions between non-monetary wellbeing measures and monetary values have also been explored (HM Treasury, 2021b) which provide the potential to use the wellbeing methods for monetary valuation. This is however not equivalent to the life satisfaction approach reviewed in Question 4 which monetises non-market goods by comparing the model estimate of the good and that of income directly, although the estimate of income on wellbeing (or life satisfaction)

using the approach does provide one of the possible conversions between wellbeing and monetary values.

2.8. Question 8: How should special soundscapes of cultural and/or historical significance be valued?

Answer: So far, valuation methods and approaches have been discussed for ordinary soundscapes and sites. Questions may arise when dealing with soundscapes of cultural and/or historical relevance. How can one define the economic value of the sound of Big Ben in London or the sonic ambiance in the Grand Bazaar in Istanbul? Some soundscapes could be unique to a place or a community and be an integral part of their cultural identity, they become active elements in a place-making process (Aletta & Kang, 2020; Zheng, 2019). It is necessary to establish a framework for such extraordinary soundscapes to be adequately valued. The UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (UNESCO, 2003) is probably a good starting point for this process: it defines "intangible cultural heritage" as the "practices, representations, expressions […] that communities, groups and, in some cases, individuals recognise as part of their cultural heritage." This definition immediately gives prominence to the auditory domain, as sounds become the most intangible expression of human history and culture. Many of the records listed on the UNESCO register are indeed underpinned by a strong musical and/or sonic component. There is currently research ongoing about how to address culturally significant auditory objects as "tangible" (and hence "valuable") assets in terms of heritage and whether we have the right digitalisation methods to preserve and reconstruct acoustic heritage (Firat, 2021).

The French Parliament recently modified the national environmental code and introduced "sounds and smells" as defining characteristics of rural landscapes to protect them as cultural heritage, alongside landscapes, air quality, and biodiversity (Assemblée nationale, 2021). The Regional Government of Campania, in Italy, is considering a similar approach and is currently trying to pass legislation with a bid on "Protection and Valorization of the Soundscape in the Campania Region" (Consiglio regionale della Campania, 2019). In Italy, this kind of environmental and territorial regulations are devolved to Regions. If approved, the law would require (among other things) the creation of a soundscape archive

to be digitally and publicly accessible for urban and rural soundscapes in the Campania Region, as well as delegating City Councils to identify and promote "community soundscapes" and "soundscape footprints" for specific locations (beyond quiet areas, which are already required via the EU Environmental Noise Directive). The text of the bid explicitly mentions the ISO 12913-1 document. To the best of the authors' knowledge, this would be a first mention of the soundscape approach in an effective regulatory text (i.e., not a mere acknowledgement in policy documents or guidelines).

Heritage assets have both economic and cultural value; thus, this principle could be applied also to (heritage) intangible assets, such as historic/cultural soundscapes. The category of "cultural value" is different from economic value: the former is much more difficult to measure, and when it was attempted, it resulted most often in multi-criteria analysis, which has a number of limitations (EFTEC, 2005). For this reason, the first step towards proper valuation of historical soundscapes would be the definition of adequate tools to assess the soundscape of heritage sites (Jordan, 2017; 2019). Soundscape descriptors, like calm, pleasant and alike, are now well-established and even reported in standardized protocols (International Organization for Standardization, 2018). Yet, these are not necessarily useful in historically or culturally relevant settings, where the primary expected outcome may be different from "restoration". At historic sites the paradigm to assess and value soundscapes shifts from a preference-oriented framework to one related to historical and cultural relevance. Indeed, Jordan (2016) suggests that it is necessary to develop a new set of descriptors to describe the soundscape "value" of locations where users have different motivations or uses. So, gathering individual responses about the experience of historical and cultural soundscape could be mediated using different descriptors, such as "authentic", "meaningful", "significant" etc. (Jordan and Fiebig, 2020). Once consensus is found around protocols to assess soundscapes of cultural heritage sites, data will become comparable across different regions and communities, paving the way for more "objective" soundscape valuations.

2.9. Question 9: What kind of soundscape valuation tool would be most useful for CBA in practice?

Answer: If a soundscape valuation tool is to be successfully and widely implemented, required input data, including acoustics data as well as receiver and context data, need to be obtainable at reasonably

low costs. While standard soundscape metrics and data requirements are suggested for soundscape valuation primary research, as discussed in Question 5, some flexibility might be needed for the valuation tool, so that its applications can be proportionate depending on the level of investment and impact of the project, e.g., small community park redesign VS large national park conservation (Department for Transport, 2018). For example, possible sources of input soundscape data may range from small scale surveys and/or measurements to large scale advanced modelling. Moreover, similar to the case of noise CBA which relies on noise impact assessment to provide the underlying noise data, data issues of soundscape valuation tool need to be considered in integration with soundscape impact assessment in the upstream workflow.

It must also be able to integrate into multidisciplinary methods of assessment and valuation, so comparisons can be made with different environmental impacts such as carbon emission, air quality, biodiversity, landscape etc., as well as social and economic impacts such as accessibility, productivity, security, etc., to apply CBA across them (Department for Transport, 2015). There are also questions of whether the soundscape valuation tool should replace or complement the current noise valuation tool, and how to achieve a smooth transition or integration. Discussion in Question 2 regarding scope of soundscape valuation partly answered the questions, that the complement and integration approach might be more efficient and practical in the near to medium term.

While there is already good practice to align costs of unwanted sounds, particularly transport noise, with other pollution, e.g., through DALY values (Jiang & Nellthorp, 2020), it is likely to be more difficult to align contributions of wanted sounds with other positive impacts, especially positive outcomes from other design disciplines such as landscape design, lighting design and heritage conservation, which are difficult to quantify and do not currently have well-defined and resolute values (Anciaes & Jones, 2020; Rudokas et al., 2019). Whilst it would be out of the scope of a soundscape valuation tool to assess the value of all aspects, there is a need to interface and align with such disciplines if the tool is to be fairly applied to projects. Care must be taken to clarify the overall value and contribution from the soundscape and ensure that positive outcomes are not double counted.

2.10. Question 10: In addition to CBA, how can soundscape values be used for design and planning?

Answer: If soundscape values were to become an established and well-defined concept, they would likely cascade into urban planning and design everyday practice. Soundscape values and their associated indices can be used to more clearly define design intent in terms of goals and desirable outcomes for a built environment project, for example, whether and/or how soundscape improvement can be part of the design intent of a shared street design. This could possibly incorporate soundscape descriptors such as "pleasantness" and "eventfulness" as desirable outcomes, as well as more holistic outcomes such as "safety" and "vibrancy". It would also be possible to have inventories of high-value soundscapes, and these could serve as reference to identify opportunities to improve the soundscapes or reserve the existing desirable ones with the project. However, it should also be noted that goals and desirable outcomes can sometimes be equivocal or conflicting between projects and/or stakeholders, and we are living in a time when the value of projects is being continually scrutinised and challenged in terms of our knowledge and understanding of sustainable development.

Like all other values, soundscape values can be sensitive to fluctuations over time, because of ordinary or extraordinary market cycles. The design and planning domains would then need to track such variations to build up time series and historical datasets of soundscape values in both urban and rural contexts. This core knowledge of factors that can affect the soundscape values will then pave the way to more structured and formal assessment exercises that are common in the design profession and could lead to "accredited" and/or "certified" soundscapes. The impact of soundscape valuation would then reach beyond a mere design/planning framework and affect the economy of a place, aspects related to tourism, and broader societal ramifications (Wu et al., 2021).

3. Conclusions

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This paper considered limitations in current noise-based CBA, and proposed moving towards soundscape valuation and its application in CBA. To demystify the concept and establish a framework to support future research, this paper discussed definition and scope for soundscape valuation, potential methodologies for primary soundscape valuation research, and the eventual application of soundscape values.

Soundscapes may be seen as positive or negative externalities of human activities, or as natural or cultural capitals, and hence a combination of different value theories might be needed to conceptualise their values. This implies that a wide range of soundscape contexts should be considered. However, initial effort could focus on outdoor soundscapes where high user diversity is involved, and where evidence on impact values is mostly missing in current noise valuation research.

Concerning methods for soundscape valuation, stated preference methods seem to be the way forward in the near and medium term, given the perception- and context-based nature of soundscape, and limited advance in currently available soundscape measurements. Whichever valuation method is used, quantitative soundscape metrics that link subjective perceptions to objective acoustic and contextual factors will be needed to enable monetisation. Where soundscapes are shared by the communities and societies, social valuation should be considered to estimate shared values. For soundscapes of cultural/historical significance, a different assessment and valuation framework might be needed, shifting the focus from perceptual preference to cultural and historical relevance.

For successful and wide use of soundscape values in CBA, required input data, with some flexibility for proportionate applications, need to be obtainable at low cost. It must also be able to integrate into multidisciplinary methods of assessment and valuation, so comparisons can be made with different environmental impacts as well as social and economic impacts, to apply CBA across them. There is also potential for soundscape values to be used beyond CBA, such as inventories of high-value soundscapes for identifying opportunities for sound environment improvements in urban design and planning.

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Ten questions concerning soundscape valuation

Highlights

- The needs for soundscape valuation are explained and scope suggested.
- Potential valuation methods for soundscape valuation are compared.
- Data requirements, social and non-monetary values, and special soundscapes are also discussed.
- Applications of soundscape values for cost-benefit analysis and beyond are suggested.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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