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From the costs of noise to the value of soundscape?

Like Jiang[1]
Institute for Transport Studies, University of Leeds, Leeds, UK.

Abigail Bristow[2]
Department of Civil and Environmental Engineering, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, UK.

Jian Kang[3], Francesco Aletta[4]
Institute for Environmental Design and Engineering, University College London, London, UK.

Rhian Thomas[5], Hilary Notley[6]
Noise and Statutory Nuisance Team, Department for Environment, Food and Rural Affairs (England), London, UK.

Adam Thomas[7]
Acoustics Audio, Visual and Theatre Team, Arup, Manchester, UK.

John Nellthorp[8]
Institute for Transport Studies, University of Leeds, Leeds, UK.

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 appraisals of projects that would impact on the sound environment, is still noise-based and residential-location-focused. As a result, benefits of wanted sounds are omitted, and only very limited receiver types and contexts are covered. While there is a wealth of literature on valuing the costs of noise and the benefits

[1] l.jiang2@leeds.ac.uk

[2] a.l.bristow@surrey.ac.uk

[3] j.kang@ucl.ac.uk;

[4] f.aletta@ucl.ac.uk

[5] rhian.thomas@defra.gov.uk;

[6] hilary.notley@defra.gov.uk

[7] adam.thomas@arup.com

[8] j.nellthorp@its.leeds.ac.uk

of noise reduction little research has been done on soundscape valuation, and consequently there is little evidence on the monetary value of soundscape, which is essential for developing soundscape-based CBA. Starting from the costs of noise this paper will discuss the motivation of soundscape valuation, methodology for primary soundscape valuation research, and the use of soundscape values, to contribute to the development of holistic soundscape CBA.

1. INTRODUCTION

Environmental cost-benefit analysis (CBA) refers to economic appraisals of policies and projects that have environmental consequences as deliberate aims or as indirect effects. It assigns monetary values to the costs and/or benefits of the environmental impacts arising from the appraised policies and projects, in particular, impacts without conventional market prices [1]. CBA is widely used and often plays a prominent role in public sector decision making, with advantages of providing comparable and consistent appraisals across projects and types of impacts. A wealth of literature on noise valuation provides the evidence base for monetary values of noise impacts for CBA [2,3]. Such monetary noise values help ensure that noise impacts are not omitted in CBA and thus not underweighted in decision-making.

The past two decades have seen an ongoing paradigm shift from noise control to soundscaping. In addition to addressing unwanted sounds, such as transport noise in most contexts, soundscaping utilises wanted sounds, such as bird song, running water and children playing in many contexts, to improve the quality of our sound environment, considering sounds as potential ‘resources’ rather than just ‘waste’ or ‘pollution’ [4]. Soundscape approaches have now been increasingly applied in noise management policies and projects. 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 Noise and Soundscape Action Plan [5].

Responding to the paradigm shift from noise control to soundscaping, economic appraisals of policies and projects that would have consequences on the sound environment should not only consider costs and benefits of changes in ‘noise’, but also changes in soundscapes and their component sounds as environmental resources. However, soundscape valuation studies are currently rare, and values of soundscapes need to be understood and estimated to achieve soundscape-based CBA. This paper will provide an overview of noise valuation and discuss the motivation of soundscape valuation and methodological considerations for primary soundscape valuation research, to contribute to the development of soundscape-based CBA.

2. POTENTIAL VALUATION APPROACHES

Here we consider the available set of valuation approaches that might be applicable to soundscape valuation. Particular attention is paid to methods commonly applied in noise valuation research, including revealed preference, stated preference and impact pathway approaches however we consider a broader set as soundscape is a distinctly different proposition from noise mitigation. (Table 1). Each approach is discussed in turn below, with context specific examples.

2.1 The hedonic pricing method

Hedonic pricing (HP) is 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. HP studies often utilize the housing market to determine values for attributes without a market price and 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. This method has commonly been applied to value noise expressed as the percentage change in house prices arising from a 1dB change in noise levels (Noise Sensitivity Depreciation Index, NSDI or NDI).

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. However, the range of NSDI is large from 0 to 2.3% change in house price per dBA for both road and aircraft noise and this variation is largely unexplained 6,7,8,9]. The approach may be criticised in that 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.

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/ecosystem services	What are the services provided by natural soundscape?
Travel Cost Method	Indicates a minimum value through travel cost incurred in accessing a site.
Mitigation cost	Cost of reducing pollutant below a limit level.

2.2 The stated preference methods

The stated preference (SP) approach is a hypothetical questioning technique, 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 whilst SC offers respondents a choice between scenarios containing a number of factors that may vary including noise and cost. Bristow et al. [2] estimated £33.32 (<55 dB), £66.06 (55-64 dB) and £126.35 (>65 dB) per dB per household per year in 2010 prices for road and aircraft noise based on meta-analysis of 49 SP studies.

These SP approaches offer some advantages over RP techniques. Firstly, control over the experimental conditions enables 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.

2.3 The impact pathway method

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. The main steps of a standard approach are: (i) to identify the change in noise levels to be assessed; (ii) to identify the population affected; (iii) to estimate the impact on the health of the population using dose-response functions; (iv) to apply a disability weight (DW) to each health outcome; (v) to estimate the number of healthy life years saved (or lost) in Disability Adjusted Life Years (DALY); and (vi) to apply a value of a Quality Adjusted Life Years (QALY) to the number of healthy life years saved (or lost). As an example, estimated using the impact pathway method and accounting for noise impacts on sleep disturbance, annoyance and a set of health impacts (heart attack, stroke and dementia), marginal costs of road noise in current UK guidance range from £11.28 (45-46 LA10,18h) to £195.03 (80-81 LA10,18h) for per dB increase per household per year in 2014 prices [10].

This impact pathway method has many steps and hence potential sources of error. Unlike HP and SP the value placed on the nuisance or benefit is not directly valued. The WHO [11] 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 [6].

It is also possible to add other noise impact endpoints, such as productivity, in addition to the above-mentioned health and wellbeing endpoint, to the impact pathway approach. However, much less evidence is available in these areas and further research is needed [12].

2.4 The life satisfaction approach

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 [13]. 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 [14]. Nevertheless, given the growing interest in research on soundscape, wellbeing and quality of life, opportunities might arise.

2.5 Natural capital and eco-system services

The natural capital and related eco-system services approach are used to assess flows of services from the natural environment. This approach could be applied to assess soundscape and particularly natural soundscape and enhancement or protection measures, for example noise reduction in national parks [15, 16]. However, as with the impact pathway approach the monetary values of any eco-systems services would need to be estimated separately.

2.6 Travel cost method

The travel cost method has been widely applied 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. [17] 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.

2.7 Mitigation or abatement cost

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 is used in the UK's Transport Appraisal Guidance for NO_2 exceedances where a marginal abatement cost is applied (unless the impact is very large when a separate study would be required) [18]. The method can give an indication of cost of preservation and could be utilised where a soundscape has legal protection.

2.8. Limitations of current noise valuation research and practice

A key limitation of current noise valuation research is the omission of the values of positive sounds or soundscapes. Of relevance is the extensive review by URS Scott Wilson [19] which sought to value Quiet Areas in the UK but found it difficult to separate the benefits of the sound/noise characteristic of quiet areas from their other characteristics, e.g., landscape, ecosystem services and air quality. Another limitation is that the current literature almost exclusively focuses on noise impacts at residential locations, i.e., noise impacts experienced by people at home [20]. Only a very limited number of SP studies have attempted to value noise reductions at non-residential locations, e.g., riverside walkways [21], urban parks [22] national parks [23] and while travelling [24].

Hence in CBA in current practice, only 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 [20]. 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.

3. CHALLENGES FOR SOUNDSCPE VALUATION

For soundscape valuation, 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.

Initially data availability is likely to determine the valuation methods that may be applied. 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. Measurement-based maps are expensive to produce as they require inputs of large primary data of high quality. Accuracy of interpolated values can also be a concern. Prediction-based maps can only be as reliable as the underlying prediction models and as accurate as the input predictor data. They may also cause collinearity issues in HP modelling if they share predicting variables with the HP modelling. For CV and SC methods, the soundscapes and their quality presented in the surveys need to be measurable and controllable. Commonly used soundscape metrics such as pleasantness, eventfulness and tranquility may not be suitable for such purposes as they normally came as outputs of soundscape preference studies rather than controlled inputs in experimental design. The impact pathway method necessitates the identification of measurable impacts on the population – could annoyance reduction be a proxy here as with noise?

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. However, soundscape metrics that reliably and comprehensively account for acoustic, contextual, physiological and psychological factors, calculable using measurable and readily obtainable objective data, are yet to be developed [25].

4. CONCLUSIONS

The extensive experience over time in valuing the costs of noise can be utilized to start to experiment with valuation of positive aspects of soundscape. A key challenge is the identification of suitable metrics that lend themselves to economic valuation. Approaches that combine perception surveys with stated preference valuation may be a promising first step.

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