The evolution of a lexicon for Sustainable Acoustics

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ABSTRACT

Articulating how sustainability and acoustics fit together has been a challenge, with acoustics facing the image problem that it can't solve climate change or global overcrowding of the planet, creating a perceived lack of importance in the big picture. This paper focuses on understanding how the ubiquitous nature of acoustics is central to a sustainable future, relying heavily on acoustics solutions as a tool to tackle problems faced by humanity on land, air, and water. Sound provided humanity's first early warning system and listening from space is an example of exactly how acoustics can do more in its many areas of influence, when considering healthy cities, natural capital and the need to monitor and adapt to extreme events. Lindsay's Wheel has served acoustics well, explaining how such a broad field connects up, but it is in isolation from the central existential threats humanity now faces in climate change and determining what sustainable living for humanity means for the future. To evolve and expand the understanding of how acoustics can help deliver sustainable outcomes a new version of the lexicon is proposed, intended to aid the paradigm shift and acceleration required of acousticians to engage in the local and global solutions needed.

1. INTRODUCTION

This paper presents a conceptual model that aims to articulate how sustainability and acoustics combine and fit well for the practitioner and academic. Once a problem is placed in context numerous ways are available for the specialism of acoustics to contribute significantly to humanity's more sustainable future globally.

2. SUSTAINABILITY

Sustainability is a term that has lost its potency over the years, yet it remains essential to our species' survival, as we know it. As a concept it began as a radical challenge commonly understood since 1987 as a result of the United Nations Bruntland Commission, which was "meeting the needs of the present without compromising the ability of future generations to meet their own" [15]. This statement has stood the test of time to some extent, with various iterations with the UN since setting out an aspirational blueprint for how to achieve the main challenges through 17 Sustainable Development Goals (SPG). The UK in 2019 produced its first Voluntary National Review of progress

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towards the SDG's, identifying the goals as neatly encapsulating the "five P's": People, Planet, Prosperity, Peace & Partnership [17], the last of which is often replaced by Place [16] but perhaps the conflict in Ukraine in this year illustrates how fundamental peace and partnership are to enabling meaningful progress globally. In 2021 the UK held the UN 26th Conference of the Parties (COP26) at the SEC Centre, Glasgow, Scotland, United Kingdom - the very place Inter-noise 2022 is being held. Beyond this parallel the connections may appear less obvious between sustainability and acoustics, which is the topic explored within this paper.

Humanity remains some way from achieving the goal set in 1987 of a sustainable future, with the current efforts focused on trying to tackle climate change, with a net zero carbon strategy by 2050 for many counties including the UK.

Obstacles such as the Covid pandemic and recent geo-political events appear to be dangerously hampering progress to limit warming to 1.5 degrees Celsius, and in the IPPC latest report in 2022 urgent action is recommended without further delay. Dealing with climate change is only the tip of the problem, leaving the larger part of the metaphorical melting iceberg below the water line. This refers to the other aspects of delivering sustainability into the implementations of policies from global governance right through to a project by project basis locally, where a more joined up holistic and global approach is required at a pace that seems unlikely to occur in reality without a huge effort by humanity.

3. RELEVANT GUIDANCE

3.1 WHO 2018

The World Health Organisation has long since recognize noise pollution as a major cause of harm with "*excessive noise seriously harms human health and interferes with people's daily activities at school, at work, at home and during leisure time. It can disturb sleep cause cardiovascular and psychological effects, reduce performance and provoke annoyance responses and changes in social behaviour"* [21]. It ranks noise as an important public health issue second only to air pollution, recommending a strong evidential basis for noise from road traffic, railway noise, aircraft noise, and risk of hearing impairment from personal listening devices, with recommended exposure levels. Whilst providing the red flag needed for many years on the growing links between noise and human health it does not provide any specific guidance on the other side of the coin, addressing the case for improved soundscapes and the positive effects of sound on health and wellbeing.

3.2 UN Frontier Report 2022

The fourth edition of the United Nations Environment Programme Fronter Report [17], published in February 2022 identifies three environmental issues that merit attention and action from governments and the public at large, highlighting the "*urgent need to address the triple planetary crisis of climate change, pollution and biodiversity loss".* Noise pollution is identified in the first section of the report called Listening to Cities: From Noisy Environments to Positive Soundscapes. It identifies noise as a growing hazard to human health, impairing human health and wellbeing (including chronic annoyance and sleep disturbance), with Algiers, New York, London, Damascus, Dakar, Bangkok, and Ho Chi Minh City amongst the worst in their regions.

Crutially it recognizes that a tendency to silence is not desirable in the main and that the potential of a soundscaping approach to focus on *wanted* rather than unwanted sound has merit and should be encouraged to create acoustic comfort as part of a broader understanding. The value of natural sound is recognized as anxiety reducing, signaling a safe environment and a chance for mental recouperation. This introduces the idea of

ecosystems services being of use in soundscape, which also translates to a benefit from natural capital. Also the idea of placemaking using recognizable soundmarks to help create a distinct sense of place and identity.
The recognition that policy makers have focused on reducing noise levels as a reactive approach has led to a lack of focus on promoting sounds that provide comfort, and this has to be urgently addressed using experts in environmental acoustics "to achieve livable cities." Environmental sound should be considered at the earliest possible stage of planning and design, with growing research indicating that a focus on this approach is "the most sustainable path". This in an important link for the acoustics industry to recognise.
The Welsh Government are cited as a leading example in the UK for policy makers. With their adoption of a soundscape lead action plan, they are leading the way for others to follow [19].
This approach is aligned with the framework proposed in this paper.

4. DISCUSSION OF ACOUSTICS RELEVANCE FOR A SUSTAINABLE FUTURE

The challenge faced by the field of acoustics is to see how sound fits into the challenges set out in the SDG's, which include grand challenges such as climate change and living within the planet's means. Whilst this may seem like an overambitious stretch, acoustics academics and practitioners have begun to find ways to achieve meaningful contributions in a variety of ways as identified in section 4. Whilst the specifics of how to do this are left for others to set out it is argued in this paper that the starting point is to understand:

1. why acoustics holds one of the keys to sustainable success,
2. how acoustics can be deployed in a new framework to help acousticians accelerate their understanding and influence to make a meaningful difference.

4.1 Evolution

Humans evolved sensation and hearing as an early warning system in our evolutionary past full of risks, prompting chemical changes that resulted in action to keep us safe, even when we were asleep [7]. We are still unable to escape that programming, with constant scanning of our environment. It remains impossible for us to evade the reality that sound affects how we feel and how well and healthy we are, as much as any other nutrient we rely on, such as food. The evidence base for noise and health is catching up in that regard but is not repeated here.

4.2 Ubiquity & the Legacy of Antiquity

Acoustics is ubiquitous, underpinning much of human endeavor shaping and supporting every aspect of our lives [14]. How well sound is managed or even curated in the case of a concert hall or product like a car, is often integrated into the design process to optimize project quality. Unfortunately, many opportunities are missed to achieve an optimal outcome which has effects and consequences for human wellbeing and health, but also other species' ability to thrive in that environment. This is because until now this has not been valued or identified as something that acoustic can offer. Acoustics began in early history as ways for people to connect with each other by communication and amplify messages to unseen sources of universal power (to become religion). Latterly this also became part of the birth of politics in ancient Greece, where the communication of a message to the masses with the acoustics of the amphitheater in one moment, can still be enjoyed today through our stadiums of sport, parliamentary

chambers, theatres, churches, concert halls and cinemas. The legacy of this science was creative and resulted in good acoustic quality and comfort for the intended use.

4.3 Industrial Period to present

With the birth of the industrial revolution urbanisation caused pollution of the air quality, but also the sound environment quality, causing the natural world to be drowned out in these urban centers by unwanted industrial and transportation sound ("noise"). As the world departed from a sustainable path the profession of acoustics became largely focused on addressing this noise through control, whilst retaining the legacy understanding for how to create places with good acoustics inside structures that were supportive of good outcomes. It is only recently that the concept from Shaffer in the 1970's [13] was embraced by academics and now the emerging field of soundscape has begun to flourish, bringing to reality the paradigm shift in thinking from noise and noise control to one more aware of soundscape quality that was foreseen by Shulte-Fortkamp in 2018[12].

4.4 The Acoustician needed for shaping a Sustainable Future

The future acoustician may therefore be able to creatively use their understanding of the science of acoustics to curate better soundscapes that are pleasing to the human ear or supportive of the other species dependant on us. A pleasing soundscape can be described as a euphonic soundscape [11], which could be more broadly thought of as one which supports species to thrive. This is being put into practice underwater in the rejuvenation of coral reefs using soundscapes [6]. This shows the potential for acousticians' skills to once again be of great assistance to humanity in shaping the new way that humans adapt to their environment. The main aim is to work within the constraints of doing more with less, but still achieve places our species can be healthy, well and thrive. This tension, as the mega trends of economic interconnectedness (#4), climate change (#7) , Resource stress (#8) and urbanization (#9) [3] are now biting, with global populations continuing to grown adding to the challenge. Dealing with noise pollution has being recognised as central requirement to deliver a sustainable future, as recognised within the UN Frontier report [17].

This paper argues it is not simply that our environments for the future should be built with a renewable energy capability and a net whole life carbon of zero [20], to be considered a sustainable asset; but that if an asset is not optimised for those using it with acoustics then this product risks becoming humanity's waste and will therefore fail the expectations of those future generations that need sustainable solutions. Early consideration of interventions as acoustic engineering solutions are therefore opportunities that should no longer be missed. This sentiment is echoed by the recommendations of UN Frontiers report of this year.

As a result of the broad applicability of acoustics to humanity's challenges within areas such as:

- medicine with cancer tumor treatment delivery [13],
- health aging & sleep [5],
- security [1],
- biosphere monitoring [4],
- ocean monitoring [9],
- environmental sound on land monitoring (including a soundscaping approach) [2,8],
- the design of buildings [6] and places,

to name a few.

For species to thrive acoustics needs to be placed at the heart and integral to any solution that aims to enable humanity to live sustainably. The framework proposed is

intended to assist acousticians accelerate their thinking and achieve action and decisive steps forward in the timeframe to deliver action now.

5. LEXICON OF SUSTAINABLE ACOUSTICS

Lindsay's Wheel of Acoustics emerged in 1966 in the Journal of the Acoustical Society of American, identifying eight specific fields [7]. It illustrates how diverse the area of acoustics is and remains relevant to this day, through the lens of acoustics alone. An updated approach to integrate sustainability, and the evolution of the lexicon to reflect current fields of acoustics with broad headings fit for the challenges of the new age of a sustainable solution, is set out in Figure 1. With some limited updates for the new and emerging fields, it is possible to create a new framework that acousticians can use to communicate how they deliver acoustics, which combines acoustics and sustainable principles as a lens through which challenges should be approached and objectively quantified at delivery.

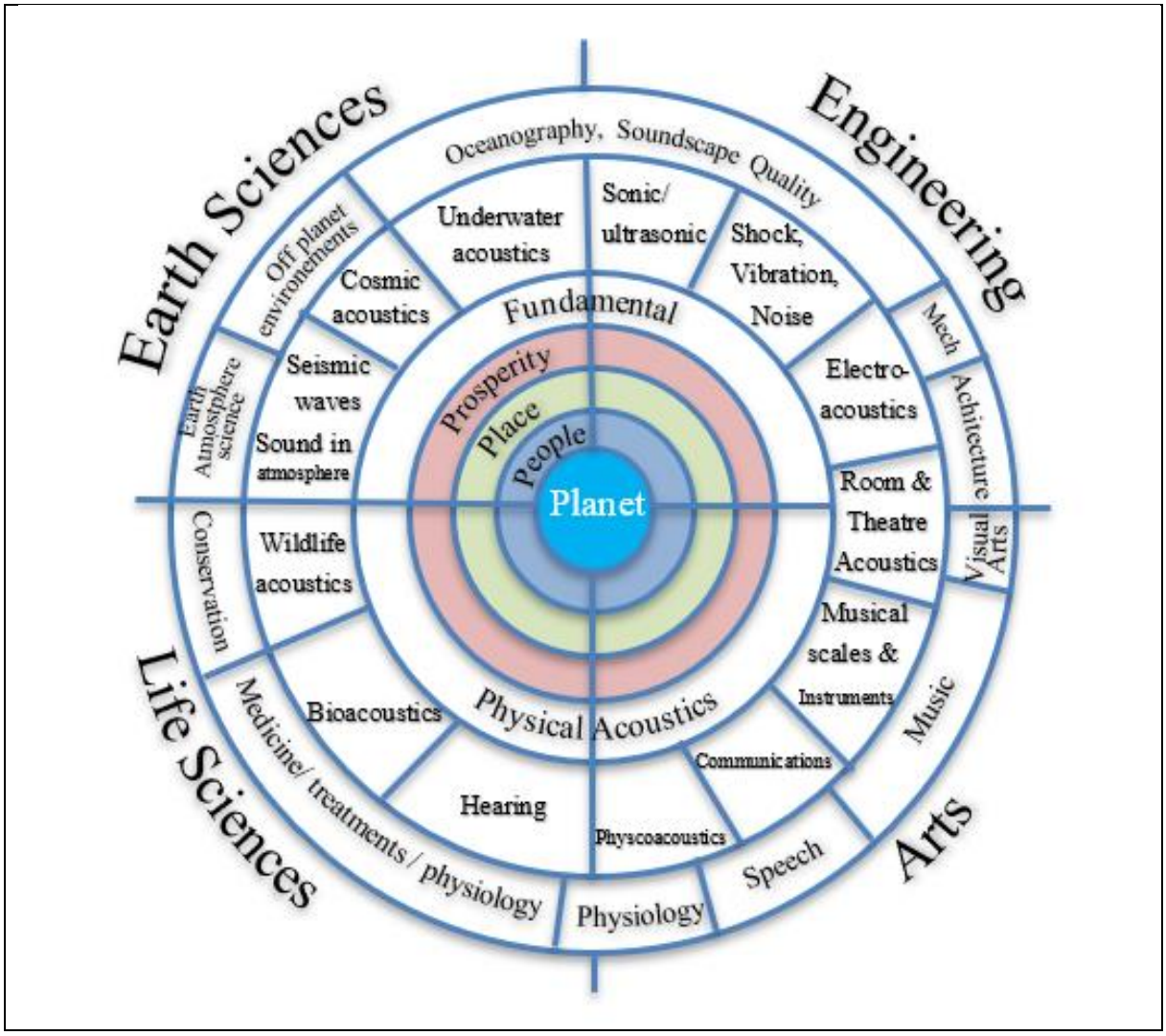

Figure 1: Rogers' Lexicon of Sustainable Acoustics

6. SPECIFIC EXAMPLES

Our endeavors to use acoustics to achieve meaningful contributions that accelerate humanity's path to sustainable living may seem a daunting task, but it is already happening.

Creating places within cities that have a clear sense of place, and which work for those living, working, playing and recuperating is an important piece of the sustainability puzzle, which acousticians can strongly influence in a positive way.

There are several ways to do this at all levels of sustainability, applying the framework to communicate areas where benefits can be achieved. Examples are minimising the embodied energy through the materials used (such as light weight low embodied carbon structures), enabling renewable energy generation to be viable close to people (such as Air Source Heat Pumps) or creating environments that people and animals can survive and thrive in closer connection. Embracing multiple ways to use sound sustainably in our environment means the 'old way' of focusing on noise control can be recognised as only one thing an acoustician can offer. The approach of reducing noise pollution and increasing the quality of soundscapes in a more balanced way can achieve multiple benefits including better connection to nature, utilization of natural capital, improved sleep quality and improved biodiversity. These benefits can combine to articulate exactly how acoustics is able to achieve contributions to the big picture by aligning solutions and enabling the balance needed to achieve sustainable outcomes, as part of a holistic approach.

To complete the picture, it is necessary to step away from Earth [8], as astronauts did to capture the image known as Earthrise from Apollo 8 by Bill Anders in 1968. To note how acoustics is used outside of the Earth's atmosphere, which is included within the lexicon, is to cater for the most recent developments that include records of sound from the Mars rover microphones on the surface. This marks the frontier of exploration for humanity with sound from beyond this world but the greatest challenge remains here on earth to achieve a sustainable future.

7. CONCLUSIONS

This paper has presented a summary of the ways in which sustainability and acoustics share common threads, which applies the ubiquitous nature of acoustics and sound as a sentinel sense which require careful consideration at an early stage to create truly sustainable solutions.

A new framework is proposed, which updates Lindsay Wheel of Acoustics with established or emerging fields within acoustics and sets them within the context of sustainability to define a more holistic model. It is intended this should be used to provide acousticians globally with a common way to communicate the benefits of acoustic interventions, and use their skills to curate euphonic soundscapes in land, air and water that assist species to survive and thrive within the constrains imposed to achieve a sustainable future. Acousticians are call to action to use this framework and make the paradigm shift that was foreseen.

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9. REFERENCES

1. Bruno, M et al., Concurrent use of satellite imaging and passive acoustics for maritime domain awareness, *International WaterSide Security Conference*, , pp. 1-8 (2010); doi: 10.1109/WSSC.2010.5730229.https://ieeexplore.ieee.org/abstract/document/5730229/citations#citations
2. Davies W, Adams M, et al., Perception of soundscapes: An interdisciplinary approach, (2013) https://doi.org/10.1016/j.apacoust.2012.05.010
3. Future State 2030: The global megatrends shaping governments, *KPMG* (2014), https://assets.kpmg/content/dam/kpmg/pdf/2014/02/future-state-2030-v3.pdf
4. Gross M report, Listening to Sounds of the Biosphere, *Science Direct*, (2018) https://www.sciencedirect.com/science/article/pii/S0960982218310479
5. Growing Older, Better, , *The Physiological Society*, p 32. (2019) https://static.physoc.org/app/uploads/2019/10/11135853/Growing-old-better-Full-report-and-summary-document.pdf
6. Harvey-Clark J, Rome Pitone R, Apex Acoustics Ltd., Acoustic Perception Evaluation in Buildings – The APEAL Method, *Institute of Acoustics, UK*, Vol. 42. Pt. 1. (2021), https://www.apexacoustics.co.uk/wp-content/uploads/2020/10/Apex-Acoustics-APEAL-Method-IOA-2020_Paper.pdf
7. Johns Hopkins University. How Do We Hear While We Sleep?. *ScienceDaily*, (30 April 1998). www.sciencedaily.com/releases/1998/04/980430044534.htm
8. Kang J, UCL, Urban Sound Planning – A soundscape approach, *Acoustic, Proceedings of Cape Schanck, Victoria, Australia* (2019)
6. Lamont, T. et al, The sound of recovery: coral reef restoration success is detectable in the soundscape (2022). https://research-information.bris.ac.uk/en/datasets/data-from-the-sound-of-recovery-coral-reef-restoration-success-is
7. Lindsay, R. B. The study of acoustics. *Journal of the Acoustical Society of America* 39, 629-644 (1966). https://doi.org/10.1121/1.1909936
8. *NASA*, Apollo 8: Earthrise, https://www.nasa.gov/image-feature/apollo-8-earthrise/
9. *NOAA* Fisheries, Ocean Noise and Soundscape Projects (last updated 2022), https://www.fisheries.noaa.gov/new-england-mid-atlantic/ocean-noise-and-soundscape-projects#
10. Oleksandr et al., Acoustic droplet vaporization is initiated by superharmonic focusing. *Proceedings of the National Academy of Sciences* (2014) ; https://phys.org/news/2014-01-breakthrough-medical-acoustics.html
11. Rogers P, Euphony – A case for evolving acoustics language to include positive or valued sound *Proceedings of the Institute of Acoustic, UK*, p. 1,2-3, Vol.41. Pt 1 (2019),
12. Schulte-Fortkamp, B Soundscape, Standardization and Application, *Euronoise* (2018), PACS No. 43.50, 43.66
13. Shaffer. M, The Soundscape – the tuning of the world, *Destiny Books*,(1977) ISBN 978-089281455-8
14. UK Acoustics: Sound Economics, *The UK Acoustics Network*, (March 2019) https://acoustics.ac.uk/wp-content/uploads/2019/05/Acoustics-sound-economy-report-May-2019.pdf
15. *UNESCO*, Sustainable Development (2021), https://en.unesco.org/themes/education-sustainable-development/what-is-esd/sd.
16. *United Nations Academic Impact*, www.un.org/en/academic-impact/sustainability#
17. *United Nations Frontier Report*, Noise, Blazes and Mismatches, (2022), https://www.unep.org/resources/frontiers-2022-noise-blazes-and-mismatches

18. Voluntary National Review of progress towards the Sustainable Development Goals, *HM Government, United Kingdom of Great Britain and Northern Ireland* (2019), www.gov.uk/sustainabledevelomentgoals
19. Welsh, Ministry of environment, Noise and soundscape Action Plan 2018-2023. *Cardiff : Ministry of Environment*. (2018). https://gov.wales/sites/default/files/publications/2019-04/noise-and-soundscape-action-plan.pdf
20. *World Green Buildings Council*, The Commitment, www.worldgbc.org/thecommitment#.
21. *World Health Organization*. Environmental Noise Guidelines for the European Region. Geneva, Switzerland (2018): https://www.euro.who.int/en/health-topics/environment-and-health/noise