UNIVERSITY OF BIRMINGHAM

MEASURING CITY PERFORMANCE AND DIAGNOSING CITY CHALLENGES: A DECISION-MAKING FRAMEWORK FOR POLICYMAKING AND URBAN DESIGN

by
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ABSTRACT

With the world's population continuing to urbanise, achieving liveable and sustainable cities is essential for our survival. Liveable sustainability brings together sustainability's long-term, large-scale goals with liveability's more immediate ones. How liveable sustainability is measured and assessed varies by scale, scope, and geography, and there are many methods from which to choose. This confusion inevitably hinders progress against the numerous problems facing cities.

Achieved through the development of a bespoke decision-making framework, this research reveals the issues with diagnosing urban challenges and with measuring and assessing urban liveability and sustainability. It exposes how existing methods fall short, largely because of how they use and manage data, and uncovers fundamental flaws in both decision-making based upon existing measurement and assessment methods, and the arising interventions in the urban landscape.

The decision-making framework comprises a means of diagnosing urban challenges (the Urban Diagnostic Method), a city analysis method linking liveable sustainability with its measurement, an indicator-based measurement and assessment method (UK City $LIFE_n$: UK City Liveable-sustainability Framework Edition N) for measuring and assessing liveable sustainability at the city scale, and a decision-making process (the Liveable Cities Method) that determines the need for, and resilience of, interventions in the urban landscape.

DEDICATION

"I may not have gone where I intended to go,
but I think I have ended up where I needed to be."

Douglas Adams
The Long Dark Tea-time of the Soul

I dedicate this thesis to my family, friends, and husband – always

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cities has meant that I have worked with some of the best researchers in urban sustainability, liveability, and resilience. I have no doubt that this has greatly benefitted this thesis.

GLOSSARY OF TERMS AND ACRONYMS

Abductive diagnostics	Gathering symptoms to infer a diagnosis (or diagnoses).
Actions	In the context of the Lens Framework, actions provide enhanced detail and desired directions of travel to achieve the goals.
Aims	In the context of a strategic management hierarchy, aims elucidate the core elements of a vision statement.
Assessment methods (urban)	Methods for appraising the performance of an urban environment. Examples include scenarios, multi-criteria analysis, and computer modelling.
CAM	City Analysis Methodology.
City Analysis Methodology	An urban analysis framework for holistically measuring the performance of UK cities with regard to sustainability and liveability. Embodied in the Lens Framework and UK City LIFE. Described in Paper 2.
Contextual indicators	Indicators that provide valuable information for the interpretation of other indicators. For example, number of inhabitants.
Deductive diagnostics	Testing of an inferred diagnosis or diagnoses.
EPSRC	Engineering and Physical Sciences Research Council. The UK research funding council that funded the Liveable Cities research programme.
GIS	Geographic Information Systems.
Goals	In the context of the Lens Framework, goals disaggregate the lenses into a small number of desired outcomes.
Indicators	A measure that provides data, such as household water demand and political affiliation.
LC	The Liveable Cities research programme.
LCM	The Liveable Cities Method.
LC Method	The Liveable Cities Method.
Lens Framework	A simplified strategic management hierarchy that views urban environments from four perspectives (lenses): society, environment, economy and finance, and governance and policy. It links each lens with associated goals, actions and measures. Described in Paper 2.
Liveable Cities Method	A nine step, systematic decision-making process for improving urban sustainability and liveability. Described in Paper 7.
Liveable sustainability	The combination of sustainability's long-term, large-scale goals with liveability's short-term, small-scale ones.
Measurement methods (urban)	Methods for measuring an urban environment, such as mathematical models, performance indicators, statistical analyses and case studies.

Measures	In the context of the Lens Framework, measures consist of metrics and indicators.
Metrics	A group of indicators that contribute to a specific area of focus. For example, the metric 'age of usual resident population' comprises the indicators: mean age of usual resident population, median age of usual resident population, percentage of the usual resident population that are children, and percentage of the usual resident population that are senior citizens.
Multiple realisability	The ability of the same input to have different outputs that result in the same outcome.
Objectives	In the context of a strategic management hierarchy, objectives are statements of desired results that contribute directly to the success of the aims.
PCA	Principal Components Analysis.
Performance indicators	Indicators that speak directly to a given area of focus. For example, healthy life expectancy.
Performance measurement	Measuring how well an urban environment functions, usually with regard to pre-defined functional areas, such the economy, provision of public services and liveability. Examples include footprinting, indicators, and material flows.
Performance parameters	Indicators that include a determination of quality, such as acceptable or desirable performance levels.
Planetary wellbeing	The ability of the planet to supply the services upon which its ecosystems and society depend.
UK City LIFE$_1$	UK City Liveable-Sustainability Indicator Framework, Edition 1. A set of indicators for measuring the liveable sustainability of urban environments. Described in Papers 3 and 4.
ULB	The Urban Living Birmingham research project.
ULP	The Urban Living Partnership. A collaboration between the UK funding councils and Innovate UK. It that funded the Urban Living Birmingham research project.
Urban challenge identification methods	Methods for identifying the problems faced in an urban environment.
Urban challenges diagnostics	Identifying the problems faced in an urban environment.
Urban Diagnostic Method	A bespoke urban challenges diagnostic method described in Papers 5 and 6.
Vision	In the context of a strategic management hierarchy, the vision is a high-level, aspirational statement of what success looks like.

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INTRODUCTION

"It is a truism to say that we live in an *information age* or an *information society*,
but it is nonetheless impossible to deny that information
(along with data and knowledge, if we wish to make the distinction)
is now central to the functioning of all developed societies."
(Buckland, 2017, p. ix)

Research agendas necessarily focus upon the generation of new data to give rise to new knowledge as well as generate new theories and frameworks of understanding. The recent report on sustainable urban systems by the US Advisory Committee for Environmental Research and Education is a good example of this approach. "This report articulates a vision and a compelling research agenda for developing the next generation of sustainable urban systems science" (Advisory Committee for Environmental Research & Education, 2018, p. 4). The report advocates studying cities at multiple scales (single cities, multiple cities and supra-aggregations of cities) for the purpose of developing new data and methods, developing the science of cities, understanding levers of change, advancing theories of change, developing models, and advancing co-production (Advisory Committee for Environmental Research & Education, 2018). It also elucidates what data and knowledge are missing in the science of cities. These include identifying and understanding the impacts of levers of change, fully understanding resource flows, modelling future scenarios, understanding trade-offs and co-benefits, and identifying regulatory and policy needs and implications (Advisory Committee for Environmental Research & Education, 2018). What this report, and many like it, does is identify that data and knowledge gaps must be filled, with some guidance as to what and how.

It is not just research agendas that approach data and knowledge in this way. Decision-making and policymaking rely upon evidence – or, at least, good decision-

making and policymaking should. Suggesting otherwise, that they can be informed by gaps in data and knowledge, sounds at best counterintuitive and at worst incorrect.

There will always be new things to learn about cities. “[Our] understanding of the city is considerably richer than it was 50 years ago, although the dynamic nature of the contextual environments in which the urban is situated will ensure that new questions will arise, posing challenges to our understanding of cities and regions besides our ability to live within them” (Paddison, 2013, p. 5). If our understanding of cities is constantly changing, and if there are always to be gaps in the data and knowledge, then we must learn how to use these characteristics to inform urban theory creation, decision-making and policymaking in ways that go beyond setting future research agendas.

The science of cities

> "It is said that there's nothing so practical as good theory.
> It may also be said that there's nothing so theoretically interesting as good practice."
> (Savery and Duffy, 1996, p. 135)

The scientific study of cities is not new, but the concepts, tools, and techniques that can be brought to bear have been transformed by the digital revolution (Batty, 2013). The science of cities is the domain of many disciplines (from complexity science to social science, engineering to geography, psychology to economics, and so on).

The field of urban design is considered by some to be pseudo-scientific (Marshall, 2012) and urban theorists are divided as to what is possible within urban theory creation. Storper and Scott (2016) explore the primary tension between those who believe that there cannot be an urban ‘theory of everything’ and those who believe that there can. “As Leitner and Sheppard write (2015), ‘Our position [that of post-colonial urbanists], then, is that there can be no single urban theory of ubiquitous remit’.” This is because “theories

must necessarily be local and confined in their empirical reach to specific segments of geographic reality" (Storper and Scott, 2016, p. 1121). Storper and Scott (2016, p. 1124) themselves refute this, stating that "...the comparative gesture can be useful and interesting, but our point is that a more theoretically self-conscious pooling of data, experiences and investigative results is essential if urban investigations are to progress beyond localism, difference and the celebration of empirical complexity for its own sake". Therefore, we see that there is a third position: those who believe in 'urban theories of not, necessarily, everything'.

The applied urban sciences are occupied with applying existing methods and knowledge in order to achieve positive outcomes for cities. Their challenge is twofold. First, the science of cities is incomplete (perhaps inevitably so given the complexity of urban systems). Second, cities demonstrate the property of 'multiple realisability'. For the first challenge, the impacts are obvious: applying incomplete methods and knowledge may lead to unpredictable, and possibly undesirable, outcomes. For the second challenge, some further explanation is required.

Multiple realisability is best explained using an example, in this case of a mousetrap. "Mousetraps catch mice and kill them. The catching and the killing can be done by several means: poisoning the mouse, crushing it, electrifying it ... Hence several mousetraps are sold, and those types of mousetraps rely on very different physical properties: mechanical ones, using springs and iron sticks; chemical ones, using poisons; or electric ones, using an electric current. ... [I]n all cases of mousetraps ... [exist] the same relationship between an input (a mouse-occupied space) and an output (a dead mouse in the mousetrap)" (Huneman, 2018, p. 38). Cities are such multiply-realised objects of study. A 'successful' or 'liveable' or 'sustainable' or 'resilient' city can be

realised in multiple ways. This presents problems for reductionists, as the pathways to success cannot be neatly simplified into singularly realisable components (Fodor, 1974; Gillett, 2003; Gillett, 2007). Although, Shapiro (2018) maintains that multiple realisability does not, de facto, rule out reductionism. For Shapiro, it is only when there is no overlap of the sciences involved in scrutinising the phenomena that reductionism is impossible.

In fact, multiple realisability is central to not only to the applied sciences, but also to the theoretical sciences. If 'A' is the mouse-occupied space and 'B' is a dead mouse then 'A' is said to realise 'B'. "Realizing B means making B real ... and this making calls for explanations, which should be scientific. Without these explanations, it's not clear how we could reliably see realization in the world" (Huneman, 2018, p. 38).

Measurement, data and cities

"Not everything that can be counted counts,
and not everything that counts can be counted."
(Attributed to Einstein)

There is a long-standing relationship between scientific theory and measurement. Should theory be based upon measurement or measurement guided by theory? "The empiricist holds the view that data collection comes first and working out its meaning comes later, while the theorist insists on having some sort of *a priori* theoretical model to guide the selection and interpretation of data" (Wong, 2006, p. 15). There exists another tension with regard to measurement: whether measurement outcomes reflect the actual state of things ('nature') or reflect human 'tools and concepts' (Mitchell *et al.*, 2017). In *The Structure of Scientific Revolutions*, Kuhn (1970, p. 27) sets out the purpose of measurement as bringing "nature and theory into closer and closer agreement".

The field of measurement has been the subject of renewed scientific interest. A recent special issue on measurement from the journal *Studies in History and Philosophy of Science* asserts "that the time is ripe for the development of a systematic approach to the humanistic study of measurement." (Mitchell *et al*., 2017, p. 1). Within this special issue, measurement is recognised as politicised and democratised (i.e., it is not solely the purview of academics) (Mitchell *et al*., 2017). It is easily arguable that this is true when measuring the performance of cities, evidenced by the provenance of the many available measurement methods, including higher education institutions, commercial organisations (e.g., engineering consultancies), charitable organisations (e.g., World Wide Fund for Nature (WWF)), the popular press (e.g., The Economist) and quasi-political global organisations (e.g., the United Nations) (see Paper 3). Such diversity means that outcomes from any one measurement method are rarely comparable with another, casting some doubt on their reliability and ability to be accurately interpreted.

Urban measurement methods take many forms, including computer and mathematical models, performance indicator sets, statistical analyses and case studies. It is the science of cities that determines what is included and how elements are linked together; and yet, this science is incomplete and may never be fully complete, in part because, in concert with the challenge of urban measurement, there exists the challenge of urban quantification: "scientific concepts that resist quantification and measurement" (Mitchell *et al*., 2017, p. 6). The complexity within and across cities, which plays out in social, physical, and economic spheres and across multiple scientific domains, inevitably includes such concepts. In other words, not all aspects of cities are quantifiable or, even, measurable.

Aims and nature of the research

The original hypothesis for this study was that it is possible to measure holistically a city's performance (encompassing economic, societal, and planetary wellbeing). The research questions focused upon reviewing the current approaches to measuring city performance and determining if any were fit for purpose. When they were found to be lacking, a bespoke measurement tool was developed and tested in the UK city of Birmingham. Through the course of this work, the link between measurement and diagnostics became inescapable, as did the link to evidence-based decision-making and policymaking, and the study was expanded to incorporate these themes.

Initially, the study considered sustainability and liveability separately. This was necessary for the consideration of existing city measurement methods, which identified with one or the other depending upon their scope and scale. Sometimes in the literature, the two concepts are conflated. As the study matured, liveable sustainability was chosen as the civic priority of focus, as it brings together sustainability's long-term, large-scale goals with liveability's more immediate ones (Gough, 2015).

The central theme of this thesis is that while measuring the performance of cities is important, it is insufficient if the end goal is to assist decision-making and policymaking. To realise the long-term liveable sustainability of cities, I argue that urban measurement must be accompanied by urban diagnostics and these must be compatible with decision-making and policymaking processes. In addition, research is needed to clarify how missing data can be incorporated into these processes.

This study hypothesises (and subsequently demonstrates) that it is possible to holistically measure a city's performance (in this case, its liveable sustainability performance) and to diagnose the particular challenges it faces and that these two

elements can be brought together to aid UK urban design decision-makers and policymakers.

The key aims of this thesis are to:

1. Describe the global landscapes of urban performance measurement and urban challenges diagnostics.
2. Determine how useful they are to urban design decision-making and policymaking in the UK.
3. Build upon them to develop bespoke methods and processes fit for the UK.

CONCEPTUAL FRAMEWORK[1]

"[S]ome form of collective, non-individual control is necessary if the city is both to avoid internal blockage and if the individuals, households and firms that it contains are to seize jointly on strategic developmental opportunities."
(Storper and Scott, 2016, p. 1118)

In order to bring about the changes needed to advance towards liveable sustainability, it is important first to understand how cities function, how they perform, and what challenges they face. This provides a baseline against which to identify and prioritise aspects that would benefit from change and assess the impact of arising interventions (such as changes to regulations, policies, the built environment, and socially supportive structures). Accepting that cities are enormously complex and individual in nature, there is a need, nevertheless, to establish a conceptual framework in which the most important indicators of functional performance can be described and assessed. The approach taken within this thesis is to view cities through a comprehensive set of different disciplinary lenses covering social, environmental, economic and governance perspectives, distil from these views sets of performance parameters that describe how cities and their citizens operate, determine what challenges the city is facing, and incorporate these into a decision-making process. The conceptual framework adopted is derived from a classic strategic planning hierarchy.

[1] This section is reproduced with permission (see Appendix A) as an abridged and updated version of Leach J. M., Lee S. E., Braithwaite P. A., Bouch C. J., Grayson N. and Rogers C. D. F. (2013) 'What makes a city liveable? Implications for next-generation infrastructure services', in Perez, P. and Campbell, P. (eds.) *Infrastructure for a Better Future: A Forum for Vision, Leadership and Action.* Wollongong, Australia: The Smart Infrastructure Facility, 397-405.

Influences upon a city

Like organisations, cities must be cognisant of and responsive to exogenous and endogenous influences (including their own unique set of challenges, global trends such as climate change, systemic rules such as governance systems, and available resources such as natural capital), and their own capabilities and capacities (for a summary of this approach from a strategic management perspective, see Moussetis (2011)). These relationships are captured in Figure 1.

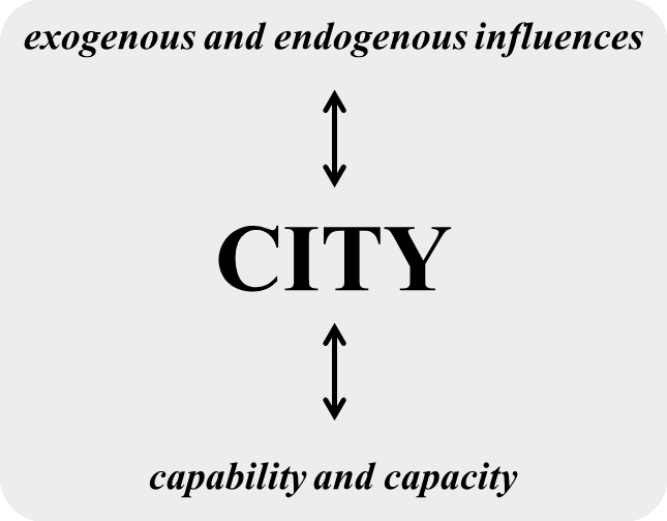

Figure 1. Influences upon the city.

Strategic management

Strategic management ensures that top-level visions link to operations, and vice versa (Bititci *et al*., 1997; Bordum, 2010). The classic strategic management hierarchy is represented by a triangle that is horizontally sliced into discrete sections that, when read from the top down, increasingly deconstructs a vision. Travelling the other way, up the triangle, builds a vision from the bottom up. Strategic management has been adapted to meet numerous organisational contexts and, I argue, can be usefully adapted by Local

Authorities. Figure 2 describes what a strategic management hierarchy can look like for a single city. Each layer reflects a level of decision-making and policymaking, deconstructs the layer above and informs the layer below, and aggregates the layer below and informs the layer above, with feedback loops between each layer.

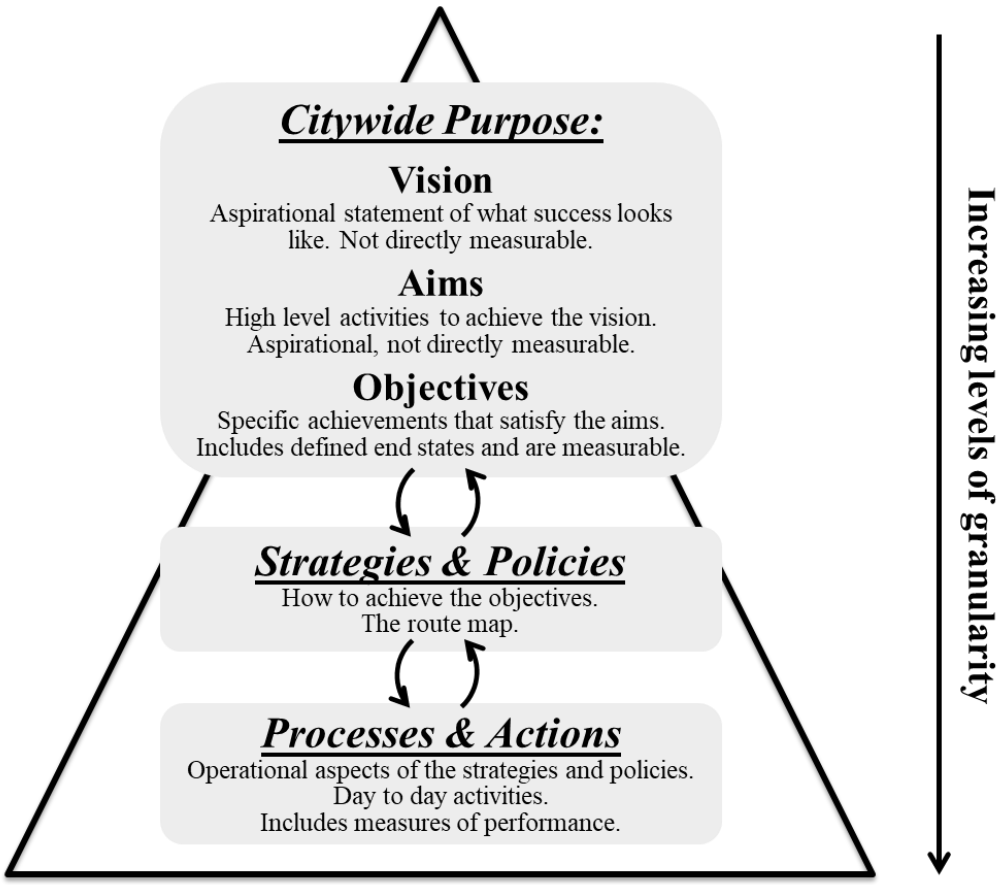

Figure 2. A strategic management hierarchy for a city.

The Citywide Purpose comprises the city's Vision, Aims, and Objectives and considers the city as a whole unit. The city's Vision statement is at the top of the triangle and is the least detailed element. A Vision statement is a high-level, aspirational statement of what success looks like. It is not, and should not be, measurable (Gallery and Waters,

2008). Many cities will, in fact, have multiple (or multi-part) visions, which may or may not be mutually supportive or cohesive.

The Vision is deconstructed into a handful of Aims: statements that elucidate the core elements of the Vision. Each Aim is further deconstructed into Objectives that contribute directly to the success of the Aims. Objectives should be cognisant of the SMART principles (Specific, Measurable, Achievable, Realistic, and Timelined), as these will be implemented at the Processes & Actions level of the hierarchy. Objectives themselves, however, do not need to be Specific, Measurable, and Timelined, although they should be Achievable and Realistic (Turner and Müller, 2003). There should be sufficient Objectives to address each Aim, but they should not be so numerous that they become unwieldy. The relationship between Aims and Objectives can be 'first order', meaning that any given Objective contributes directly to the achievement of an Aim, and 'second order', where an Objective contributes indirectly to an Aim. First order relationships form the critical path.

Following the hierarchy down to the next level sees the development of Strategies & Policies to achieve the Objectives. These form the route map to achieve each Objective without becoming mired in the operational detail of the day-to-day Processes & Actions, which is reserved for the next level of the hierarchy. First and second order relationships should be made explicit, forming an interconnecting network that increases the resilience of the hierarchy.

Finally, Processes & Actions address the day-to-day operation of the city. Their related performance measures must be fully SMART: Specific, Measurable, Achievable, Realistic, and Timelined (Turner and Müller, 2003) and indicators are frequently used for this purpose (Kitchin *et al*., 2015). It is useful here to make the distinction between

performance indicators, performance metrics, and performance parameters. All three are free-floating signifiers with no agreed meanings. For the purpose of this thesis, therefore, ‘performance indicators’ is the preferred term, where indicators focus upon providing data through measurement. The term ‘indicators’ does not imply the determination of quality, such as acceptable or desirable performance levels, in the way that the term ‘performance parameters’ does. Finally, there is no discernible difference within the literature between the terms ‘metrics’ and ‘indicators’ (although one is imposed in Paper 2), but ‘indicators’ seems to be more popular when measuring urban performance.

This strategic management hierarchy (Figure 2) can now be brought together with the influences upon the city (Figure 1) to form a static strategic management framework for a city (Figure 3).

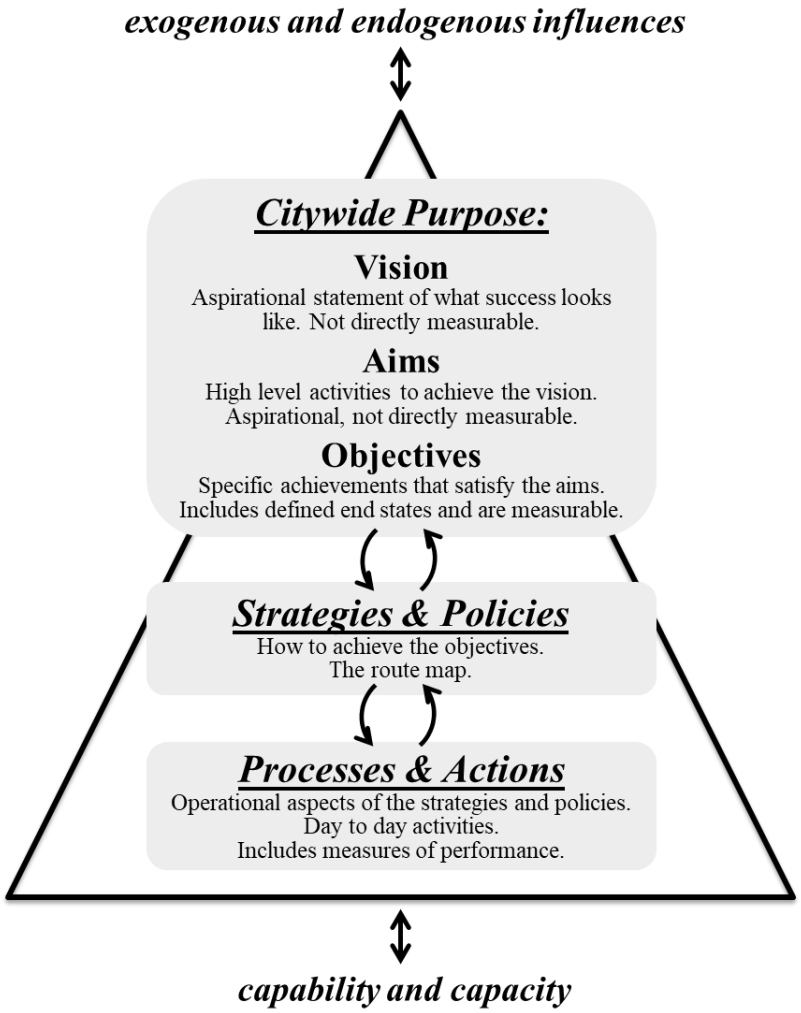

Figure 3. Static strategic management framework for a city.

A dynamic strategic management framework for a city

Over time, Strategies & Policies and Processes & Actions will need to be reviewed and revised to accommodate progress towards the Citywide Purpose and to changing contexts. Rates of change within cities vary. For example, some engineered infrastructures, such as housing stock, roads, and rail can be in place for more than 100 years; others, such as high-speed fibre optics, have decadal lifespans; whilst some social infrastructures, such as community groups, might disband after only a few years.

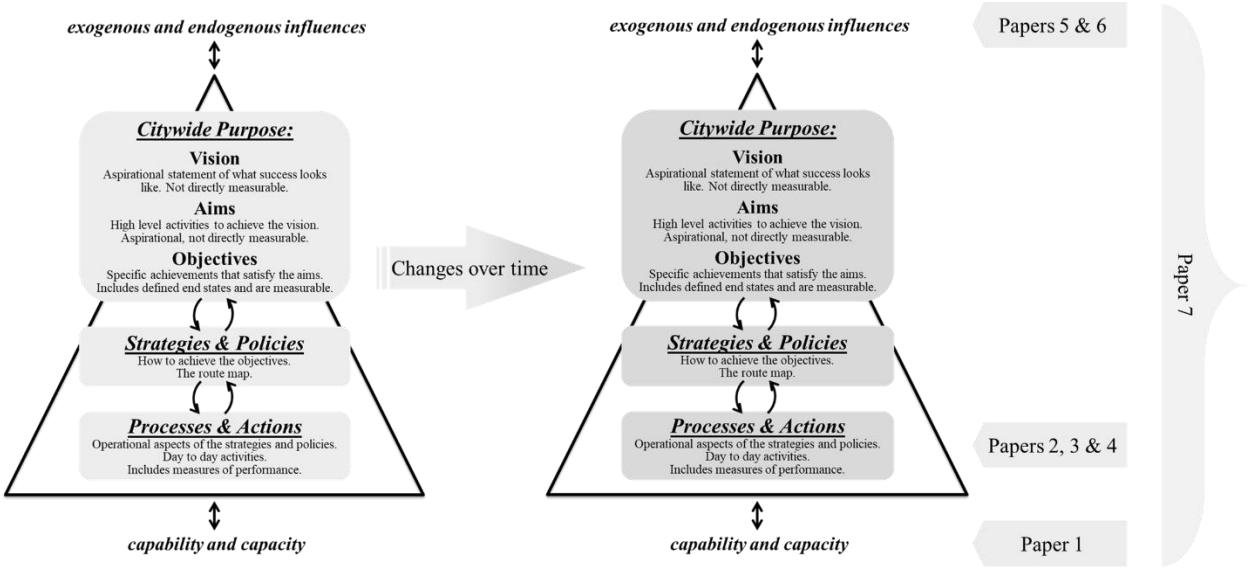

Figure 4. Dynamic strategic management framework for a city.
To the right I have indicated where the papers within this thesis fit within the framework.

The resulting dynamic strategic management framework (Figure 4) can be applied to any city by analysing its Visions, Aims, Objectives, Strategies & Policies, and Processes & Actions (both formal and informal) to populate the framework and then, via datasets and models, exploring performance both before and after interventions. While this process is conceptually straightforward, the implementation of change relies upon a fit to the context, exogenous and endogenous influences, and the city's capacity and capability. It faces many barriers, such as the ever-changing and dynamic nature of cities, resistance to individual and societal behaviour change, political will to enact change in a climate of short-term electoral cycles, inflexible systems and processes, professional inertia, the capability and capacity to effect changes and the perceived risks associated with doing things differently. Nevertheless it has the potential to make explicit the opportunities and consequences of action or inaction.

This conceptual framework is used to address the objectives of this study, which are as follows.

- To conduct a critical review of (1) existing urban performance measurement and assessment methods relevant to sustainability and liveability (Papers 1-3), and (2) existing urban challenge identification methods relevant to city services and systems (Paper 5) to explore the methods and capture the dimensions of their analyses.
- To measure and assess the performance of, and to diagnose the challenges of, the city of Birmingham, UK, and to refine the framework accordingly (Papers 3-6)
- To develop a decision-making process that incorporates urban performance measurement, assessment and diagnostics that can be used by UK urban design decision-makers and policymakers to guide the development of, and assess the potential impacts of, policies and practices (Paper 7).

PAPER SUMMARIES

This thesis is based upon seven papers that have been reproduced with permission (see Appendix A). The papers contribute (primarily, but not exclusively) to two research initiatives: Liveable Cities and Urban Living Birmingham. Liveable Cities was a five year, £6m, Engineering and Physical Sciences Research Council (EPSRC) funded programme grant that began in 2012 and finished in 2017 (grant no. EP/J017698/1). Urban Living Birmingham was a two year, £400k, Urban Living Partnership funded research project that began in 2016 and finished in 2018 (grant no. EP/P002021/1). Papers 1-4 and 7 contribute to the Liveable Cities research programme. Papers 5 and 6 contribute to the Urban Living Birmingham research project. Papers 1 and 7 build upon a series of research projects leading up to and including Liveable Cities, all of which are acknowledged in the papers.

Please note that I use the plural 'we' as the papers were written with the support of co-authors.

The papers presented herein describe the design, application and interpretation of a decision-making process (the 'Liveable Cities Method', Paper 7) that incorporates a bespoke city performance measurement and assessment method (UK City $LIFE_1$: UK City Liveable-sustainability Indicator Framework Edition 1, Paper 3) and a bespoke Urban Diagnostic Method (Paper 5).

Collectively, the papers triangulate information from three strands of analysis, as follows. The data management plan is available in Appendix B.

1. Reviews of the sustainability and liveability measurement and assessment literature, and the city diagnostic literature.

2. Critical assessments of the design and application of a bespoke city performance measurement and assessment method (UK City LIFE$_1$), and a bespoke urban challenges diagnostic method (Urban Diagnostic Method), to the city of Birmingham, UK.
3. Critical reflection upon the relevance of UK City LIFE$_1$ and the Urban Diagnostic Method for urban design decision-making and policymaking.

Paper 1

Note on terminology. This paper uses the term 'assessment method' to describe the guidelines, measurement methods, and assessment methods for improving urban design.

Paper 1 focuses on the use and usefulness of sustainability assessment methods in the UK. It is particularly concerned with whether they constrain or encourage creativity and innovation in urban design. We were motivated by a perceived undercurrent of opinion within the urban design industry that sustainability assessment methods were constraining creative freedom. We conducted semi-structured interviews with urban design professionals. The interview questions are available in Appendix C, the interviewee-validated interview summaries in Appendix D, and ethics information in Appendix E. Although the number of interviewees was small (nine), we were surprised at the small number of sustainability assessment methods they identified (32 in total). We had expected more given the mushrooming of such methods in recent decades (see Paper 3).

A parallel motivation was to identify those sustainability assessment methods that are part of a UK urban designer's toolkit. This study provided a starting point for my

literature review on sustainability- and liveability-related assessment methods. It also provided valuable insights into the differentiating features of the methods.

We also wanted to gauge the traction that sustainability assessment methods have with urban design professionals. Up to this point, we did not know whether, in practice in the UK, these methods are seen as cosmopolitan aids or parochial dead weights. Beyond this, we were looking to understand the impacts sustainability assessment methods are having on the urban design professions. Ultimately, I wanted to ensure that when designing a measurement method for liveable sustainability I incorporated the positives and avoided the negatives of existing methods and that I did so in such a way as to be useful to practitioners. In the end, I did not achieve this. The measurement method I designed (UK City LIFE$_{1,}$ see Appendix F) has 346 indicators, making it cumbersome to say the least! This was a trade-off that I knowingly made when I discovered that existing sustainability and liveability assessment methods are neither holistic nor comprehensive and I refocussed upon these characteristics over usability (see Paper 3 for more on this).

My colleague, Dr Christopher Boyko, and I interviewed nine urban design professionals between the 31st of August and the 17th of September 2013. Interviews lasted approximately one hour and were guided by a set of seven questions. The interviews revealed that there is perceived value in using assessment methods to engage with complex issues such as sustainability, and, importantly, that this has the potential to *improve* urban design. We also discovered that although existing tools focus upon the technical aspects of achieving sustainability, the interviewees had ultimate faith in their own technical competencies and assessment methods should tap into these.

Another useful learning was that sustainability assessment methods are perceived as transient. No sustainability assessment other than Environmental Impact Assessments are mandated in the UK, although some provide discretionary accreditations and kudos (BREEAM (Building Research Establishment Environmental Assessment Method) and the Global Liveability Ranking are respective examples). This creates a fluid and forgettable ecosystem of sustainability and liveability assessment methods. I had no reason to believe anything I created would be any different and this realisation meant that I felt justified in prioritising rigour and completeness over usability.

Although it is not possible to generalise from this study, given the small sample size, it provides useful insights into how urban assessment methods can be designed, and these were used to shape UK City $LIFE_1$.

Paper 2

Note on terminology. This paper uses the term 'assessment method' to describe measurement, assessment, and appraisal methods and their associated urban design, planning, analysis, and evaluation tools, rating systems, and models.

Paper 2 defends the structure of UK City $LIFE_1$ (its Lens Framework). It sets out best practice guidance for indicator-based assessment methods and undertakes a review of urban assessment methods, narrowing the focus to sustainability and liveability in the UK. It was provoked by the busy (and potentially confusing and ineffective) urban assessment method landscape. It makes the case for developing a bespoke method for the assessment of the sustainability and liveability of UK cities, secure in the knowledge that any new method will likely get lost in the sea of other assessment methods, but that the

process of understanding what comprises a comprehensive method will have positive implications for urban design decision-making and policymaking.

Repetti and Desthieux (2006) advocate the need for urban assessment methods to establish causal chains. Overall, urban assessment methods group indicators into themes, such as energy, waste, and water. Although useful for getting an overview on any given theme, thematic categorisation does not encourage a systems approach nor does it provide guidance on the desired direction of travel. It may seem obvious that to improve sustainability and liveability a city should increase its recycling rates, but it is much less obvious as to whether it should increase or decrease its housing stock (and how). This study hypothesised that it is possible to design a holistic, comprehensive, and interlinked urban assessment method in which grey areas like this can be addressed.

One way of doing this is to provide the wider context, and this is one reason UK City LIFE$_1$ includes so many indicators. Another way of doing this is to link the indicators to higher-level ambitions. Guided by my conceptual framework, literature review, and CH2M Hill's sustainable city framework (CH2M Hill, 2011), we designed a Lens Framework to do just that and applied it using a thought experiment based upon the real-world extension of Birmingham's light rail network.

The lenses (society, environment, economy, and governance) ensure the breadth of sustainability and liveability is covered. The arising goals and their arising actions provide the desired directions for the city's performance at increased levels of granularity. Indicators measure the status of each action. In the end, however, it was not possible to avoid completely thematic categorisations, not least because they are so well embedded in how we understand cities that they facilitate engagement with the indicator set (see Paper 4). Both options are offered within UK City LIFE$_1$.

By drawing in liveability alongside sustainability, this study made visible the people in cities and ensured that UK City $LIFE_1$ incorporates subjective as well as objective measures of performance. Focusing upon the UK means that UK City $LIFE_1$ is relevant to the UK's environmental, social, economic, and governance ecosystems and, it is hoped, has traction with decision-makers and policymakers.

The paper concludes with a discussion about how the Lens Framework can be used to aid decision-making. It does so from the perspective of an intervention (the extension of the city-centre light rail system in Birmingham), rather than from a thematic perspective. In taking this perspective, the Lens Framework becomes manageable and usable. Causal chains and interdependencies are embedded, enabling the full implications – and possibilities – of an intervention to be made evident.

This study stops short of presenting the indicators level of the Lens Framework, which are published in Paper 3.

Paper 3

Note on terminology. This paper uses the term 'measurement and assessment method', making the distinction between methods that measure performance and those that include an assessment component. Examples of the former are footprinting, indicators, and material flows. Examples of the latter are scenarios, multi-criteria analysis, and computer modelling. UK City $LIFE_1$ is positioned as a measurement and assessment method.

Paper 3 fully describes the first edition of UK City LIFE, UK City $LIFE_1$, and applies it to the city of Birmingham, UK. The accuracy and efficacy of urban measurement and assessment methods is unknown (Kitchin *et al*., 2015), so rather than focusing upon the data, we focus upon the *process* of designing and applying UK City

$LIFE_1$. We were inspired by a paucity of studies that take this approach, with the valuable lessons to be learnt being rarely captured.

This paper crystallises the previous foci of sustainability and liveability into one on liveable sustainability, where sustainability's long-term, large-scale priorities meet liveability's short-term, small-scale priorities (Gough, 2015). We also discuss the value of missing data (for more on this, see the conclusions to this thesis). UK City $LIFE_1$ is unique in that it includes indicators for which data are not available. In doing so, it reminds decision-makers and policymakers of what they do not know and highlights where further information is needed if a well-informed decision is to be made.

This study draws its evidence from a review of the measurement and assessment method literature, the application process, and critical reflection. The process of gathering the data is described in Paper 4. The study seeks to discover whether it is possible to measure, holistically and comprehensively, a UK city's liveable sustainability. If so, can arising challenges and gaps be overcome and can the outcomes be interpreted by UK urban design decision-makers and policymakers.

We take a reflexive approach to the critique, bringing together best practice guidance on designing, applying, and interpreting urban measurement and assessment methods and describing how they shape UK City $LIFE_1$, crystallising them into design parameters. Perhaps one of the more interesting, and recurring, themes is the difficulty in asserting 'good' performance (also touched upon in Papers 1 and 2). Defining good performance for all of the individual indicators proved impossible and so we chose an umbrella definition, "moving towards sustainability without compromising the liveability of those who live in, work in and visit the city" (p. 83). The Lens Framework, then, provides the detail.

The political boundary of the UK City of Birmingham was selected as the geographical boundary. There were a number of reasons for this, including the excellent relationship between the University of Birmingham and Birmingham City Council, it allowed us to build upon our previous work, and Birmingham is data rich comparative to other UK cities outside of London.

I have already commented upon decisions made about the design of UK City $LIFE_1$ that compromise its usefulness to decision-makers and policymakers (namely, the large number of indicators). When applying UK City $LIFE_1$ to Birmingham we became aware of a systemic barrier. The Lens Framework encourages outcome-focussed, cross-silo thinking. For example, the action 'ensuring an enabling physical environment that maximises individual capabilities in the context of carbon reduction and resource security' requires consideration of urban form, transport, emergency services provision, and social services provision, amongst other things. Yet these responsibilities lie with discrete Local Authority departments that do not necessarily collaborate. In order for the Lens Framework to be effective for local government, Local Authorities need to overcome departmental divides.

UK City $LIFE_1$'s extensive indicator set presents challenges when it comes to interpretation. Some form of visual interpretation would clearly be useful. However, it is not possible to define a common unit of measurement for the indicators, so it is not possible to present them on the same chart or graph. Two avenues for visual communication of the indicators were pursued: (1) circular plots and (2) cube plots.

Circular plots are useful communicators of flows and have been successfully used to illustrate global migration (Abel and Sander, 2014). I applied this visualisation technique to Birmingham's material and energy flows (component parts of UK City

LIFE$_1$). By linking plots, a more complete picture of resource flows is achievable. Figure 5 shows the links between Birmingham's food, waste, and energy flows using informed, estimated values to demonstrate the concept (see Appendix G). Food waste from households and eating out that is not composted is drawn into the city's municipal waste stream, which feeds the city's electricity from waste plant, which, alongside electricity from the National Grid, forms part of Birmingham's energy supply (electricity + natural gas + petroleum oil + manufactured fuels) for transport, domestic and non-domestic consumption. However, I was not able to use circular plots to provide an overview of city performance.

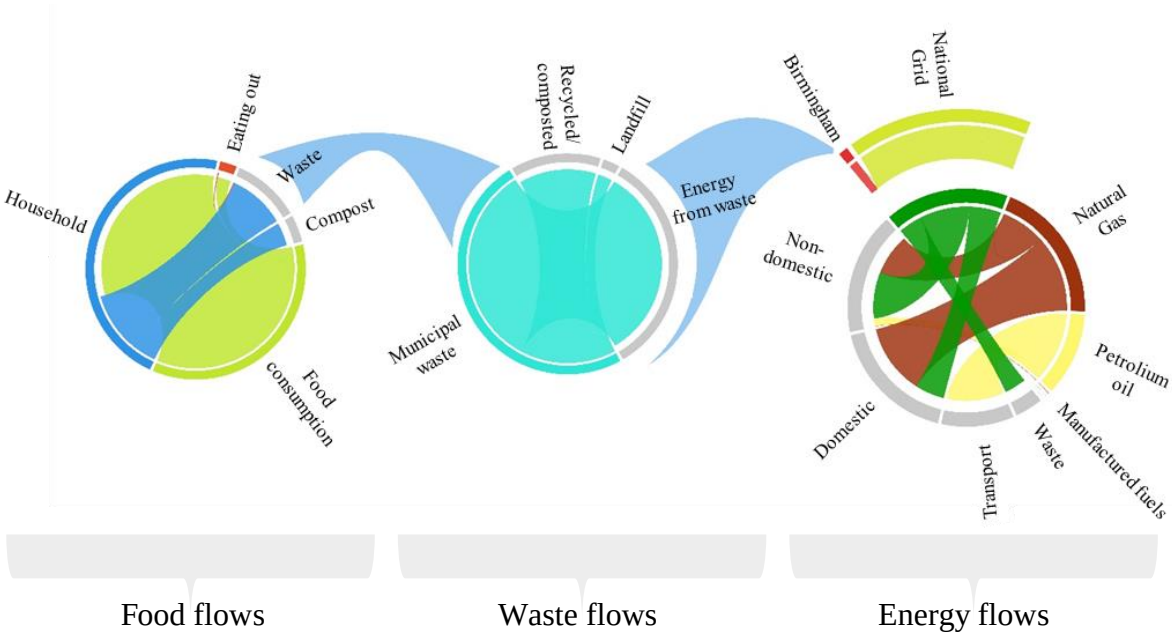

Figure 5. Birmingham's food, waste, and energy flows.

The cube plot published as part of this paper provides such an overview with a highly simplified version of UK City LIFE$_1$'s indicators. The calculations for the cube plot are found in the paper's supplementary information (Appendix H). Personally, I was

pleased we had found a way to provide an overview of the indicator set. I was also concerned about the degree of simplification this required. In the end, I realised that different levels of granularity are required at different points in the decision-making and policymaking processes, making both the simplicity of the cube plot and the complexity of the indicator set useful.

This paper describes the first edition of UK City LIFE, which had 346 indicators. The current edition of UK City LIFE, edition 2, has 345 indicators. The Lens Framework allows for duplicates and a beta version of UK City LIFE contained a large number of duplicates. As UK City $LIFE_1$ developed, however, it became obvious that including duplicates overly complicated interpretation and all but one, noise, was removed. Applying UK City $LIFE_1$ to Birmingham highlighted that having one duplicate indicator was also confusing and so I removed it, leaving each indicator aligned to the action to which it most directly relates.

Paper 4

Note on terminology. This paper uses the term ‘measurement and assessment method’ in the same way as Paper 3.

Paper 4 is the UK City $LIFE_1$ Birmingham dataset, which is available in Appendix F. It explains its specification, value, and data collection parameters and includes a link to the online location of the freely available dataset. Although it was not mandated by the funding body, at the time of publication EPSRC advised that all research data should be made open access. In the spirit of this, we made the Birmingham data for UK City $LIFE_1$ available to freely download and use. This data article includes a hyperlink to Paper 3, providing the user with the full context for the urban measurement and assessment method

and its application to Birmingham. The data spreadsheet is stored in the University of Birmingham's online data depository. The depository allows for up-to-date editions of UK City LIFE to be made available by linking them to the original and, indeed, I have uploaded the Birmingham data for UK City $LIFE_2$.

There are clear benefits to making data freely available for others to use and share, and these underpin a global trend towards open data. From a researcher's perspective, these benefits include the potential for increased impact from, and replicability of, the research. Personally, I found the process of tidying up the dataset and annotating it for other users gave me confidence in the work and its robustness as an urban measurement and assessment method. It also made sharing UK City $LIFE_{1\&2}$ straightforward, as I did not need to worry about reviewing the content or adding explanatory notes, because I'd done all of this work already. My co-authors approved what I had done, of course, but their primary contributions lay in shaping UK City $LIFE_1$ and contributing some of the data, not in preparing the dataset for publication.

It is worth commenting here upon the lack of longitudinal, cross-sectional and real time data in UK City $LIFE_{1\&2}$. At first glance, these three data types appear to be very similar as they all gather the same data (i.e., data for the same indicator, from the same sensor, or from the same survey question) at different points in time. Longitudinal and cross-sectional data differ in their sampling (Payne and Payne, 2004), of course, but the real differentiator is the frequency of data collection. Real time data are collected, and sometimes analysed, live and immediately (Kitchin, 2014), whereas longitudinal and cross-sectional data collection occur less frequently (Payne and Payne, 2004). For longitudinal and cross sectional datasets, I selected for inclusion the waves (when the same survey is conducted more than once, each repeated survey is referred to as a wave

(SAGE Publications, 2019)) that coincided as closely as possible with the preferred date for data (2011). However, this is not possible with real time data. For some real time data it might have been possible to include averages over a year, but averaging has certain disbenefits (such as smoothing out fluctuations and hiding outliers). It also requires data access and big data competency that is beyond most Local Authorities, which is one of the considerations for indicator inclusion (see Paper 3). Averaging is also nonsensical for some data, for example, data tracking people's movements. The outcome is that no real time data were collected for UK City $LIFE_{1\&2}$ unless they had been processed for an annual value by a third party, such as the Office for National Statistics (ONS). In future versions of UK City LIFE, I would like to rectify this.

Paper 5

Paper 5 develops a method for diagnosing urban challenges (the Urban Diagnostic Method) and applies this to Birmingham, UK. The focus upon urban diagnostics was stipulated by the funder, which commissioned five pilot projects, one in each of five UK cities. The call for projects coincided nicely with my realisation that urban assessment and urban diagnostics are sometimes used interchangeably. I see urban assessment and urban diagnostics as highly complementary, but, nonetheless, distinctly different. The Urban Living Partnership call provided me with an opportunity to explore this complementarity.

Originally, the purpose of the study was to apply an urban challenges diagnostic method to the city of Birmingham, UK, and interpret the results with a view to shaping the next phase of the project. However, my literature review of urban diagnostic methods revealed that there are none that are holistic and explorative (i.e., not hypothesis-driven).

This was a surprise and it changed the focus of the study from ‘applying’ to ‘developing and applying’ an urban challenges diagnostic method.

We developed a mixed-methods approach that brought together a data-driven method (Principal Components Analysis (PCA), led by my co-author, Dr Rachel Mulhall) with an information-driven method (evidence mapping, led by me). The inspiration for this was drawn from developing UK City LIFE$_1$, where it had become clear to me that stipulating data compatibility drastically reduces data availability. Doing so for urban diagnostics negatively influences the viability of the outcomes. Many of Birmingham’s datasets are restricted access, but information about them is often freely available in reports and papers. Further research led me to an evidence mapping technique developed by McKinnon *et al.* (2015) that enabled me to develop an understanding of those data translated into reports and papers.

The geographical area of interest is, once again, the city of Birmingham, UK. This allowed us to take advantage of UK City LIFE$_1$’s datasets and build upon our familiarity with the city.

An extensive description of the Urban Diagnostic Method is available in the supplementary material for this paper (Paper 6). We did attempt to publish separately (1) the evidence supporting the need for an urban diagnostic method, (2) the development of the method, and (3) its application to Birmingham, giving each part the care and attention we felt it deserved. We submitted the first two parts to the SAGE journal *Urban Studies* and were advised that, without the third part, they were unable to publish, and, unfortunately, they would not accept an augmented resubmission of the paper. We therefore revised the paper to include all three parts, including as supplementary material a detailed description of parts 2 and 3 (which we deemed essential if others are to recreate

the analysis), and submitted it to the Elsevier journal *Cities*, where it was accepted for publication. The PCA and evidence mapping datasets are freely available from the University of Birmingham's online data depository and are signposted from this paper.

We drew upon medical diagnostics to frame our approach, with its abductive and deductive components. For this study, our focus was upon abductive diagnostics. In meetings with the other Urban Living Partnership pilot projects, I was surprised to discover that we were the only ones to exploit the medical literature.

We developed a conceptual framework for the mixed methods approach that leverages analysis methods (the PCA and evidence mapping) and outputs (challenge maps, network maps and narratives) as mechanisms for drawing together the datasets and evidence documents prior to interpretation. Some data sets and documents fed directly into the outputs without any analysis (a good example of these are the challenge maps, which include raw data).

Our interpretation of the outcomes from the two analysis methods relies heavily upon identifying overlaps and outliers, and it is in the former that we had our breakthrough. The overlaps are nicely clear (energy, economy, connectivity, and health & wellbeing), the PCA links them together and the evidence map provides the broader context. Together, they describe a plexus of connected challenges facing the city – connected in *specific* ways – the implication being that to address successfully these challenges they must be tackled as a plexus.

Our abductive diagnostic approach stops short of providing suggestions as to how urban design decision-makers and policymakers address the city's plexus of challenges. This is where the deductive, hypothesis-driven, diagnostics evident from the literature review come to the fore.

Paper 6

Paper 6 presents the methodologies employed in Paper 5. We had always intended to conduct our diagnosis of Birmingham's challenges using secondary data, as budget and time constraints did not allow for primary data collection. Our initial aim had been to develop a solely quantitative approach; however, my experience in locating existing datasets for UK City LIFE$_1$ had impressed upon me how constraining such an approach can be and so we opted for a mixed methods approach, incorporating quantitative (Principal Components Analysis (PCA)) and qualitative (evidence mapping) analyses. Importantly, the evidence map provided insights from datasets to which we had no direct access.

The mixed methods approach meant that we were not able to bring the diagnostic's outcomes together through a common analysis method. In response to this, we took great care to ensure common parameters were used for evidence gathering for the PCA and evidence mapping. This was done to improve synthesis of the outcomes from the analyses. The resultant evidence-identification framework uses standard data categories, where possible, to improve synergies with secondary data. It also stipulates a timeframe (from 2010), thematic focus (public services and their systems), and geography (the political boundary of the city). Outcomes from this approach include challenge maps, network maps, and narratives. The latter were particularly helpful when synthesising the outcomes.

> "[N]arrative works to create coherence between a variety of different elements that otherwise do not appear to hang together… The fitting together can be thought of as a process of coherence making… [that] is consistent with all the bits of scientific stuff on the table, perhaps reaching for integration or synthesis."
> (Morgan, 2017, p. 2)

Dr Rachel Mulhall led the PCA. Although from a methodological standpoint the PCA is relatively straightforward, it was not without its difficulties. The main challenge was identifying and getting access to the appropriate geocoded datasets. Not all of the 258 datasets identified as relevant to Birmingham's public services are geocoded and, in the end, only 58 variables were included in the PCA. This said, it is the first time datasets for Birmingham have been brought together in this way to inform the delivery of the city's services. The outputs are challenge maps and principal component groupings, of which six were retained as stable. Of these six, five challenge areas for the city were identified, and Rachel and I worked closely together to shape them.

I led the evidence mapping analysis. This required some iteration in order to aid interpretation. I made the biggest changes to the thematic analysis. Whereas McKinnon *et al.* (2015) produced a chart of binary thematic relationships, when I produced the same I found its interpretation difficult. A network map solved this problem and facilitated a level of interpretation simply not possible in chart form (specifically, the disconnected academic medical literature and the disconnect between the policy and academic literatures). I then separated the frequency element and visualised this as a hot and cold spot grid. Four challenge areas for the city were identified from the evidence map.

We then synthesised the challenge areas identified by the two analysis techniques. The high number of commonalities between the two sets enabled us to use the interlinkages identified through the PCA. These interlinkages do not link all the challenge areas together; rather, they link specific challenges to each other: health & wellbeing and connectivity, health & wellbeing and energy, health & wellbeing and economy. The evidence map provides the overarching governance challenge. Without the PCA, the

evidence map could not have linked the city's challenges. Without the evidence map, the PCA would have missed the city's governance challenge.

Paper 7

Paper 7 draws together the previous studies, with the aim of making them relevant to urban design decision-making and policymaking. It argues that achieving successful (i.e., thriving, sustainable, liveable, resilient, prosperous) cities means overcoming current gaps in our understanding of how cities perform (measurement and assessment (Papers 1-4)) and what challenges they face (diagnostics (Papers 5 and 6)), and planning for how they will fare in the future. We propose a decision-making process, the Liveable Cities Method, that incorporates these elements. Underpinning the Liveable Cities Method is our belief that civil engineers should, and must, play a proactive role in shaping cities. On the whole, in the UK, civil engineering takes isolated, narrow, technical, disciplinary approaches to problem solving (e.g., structural, geotechnical, water, chemical, materials) (Jowitt, 2004). The infrastructures designed and built by civil engineers fundamentally shape how cities operate and how they perform and many have long design lives, ensuring they shape cities well into the future (Balmforth, 2015). It is now understood that cities are characterised by complexity and emergence (Batty, 2000), which means that civil engineers need to think holistically, engage with complexity, incorporate systems approaches and understand other domains that interface with their discipline if the infrastructures they design and build are to contribute to creating successful cities. There is a clear need for tools and techniques to aid this change in approach and to working practices (Gaterell, 2013).

The Liveable Cities Method builds upon the Designing Resilient Cities Method (Lombardi *et al*., 2012; Rogers *et al*., 2012), which was developed as part of an EPSRC-funded research project that completed in 2008 (grant no.: EP/F007426/1). Whereas the Designing Resilient Cities Method focused upon pressure testing a given intervention (i.e., something being done in the city, which can range from building a cycle network to a zero carbon policy) for its resilience to future change, the Liveable Cities Method assists the user in identifying what the intervention might be and how it might realise multiple benefits in order to move the city towards a desired future state.

The Liveable Cities Method's nine steps are shown in Figure 6, including where UK City LIFE$_1$ and the Urban Diagnostic Method fit within the process. This process is highly simplified and shows only the critical path and not the many loops and iterations that naturally accompany any decision-making process (Mintzberg and Westley, 2001).

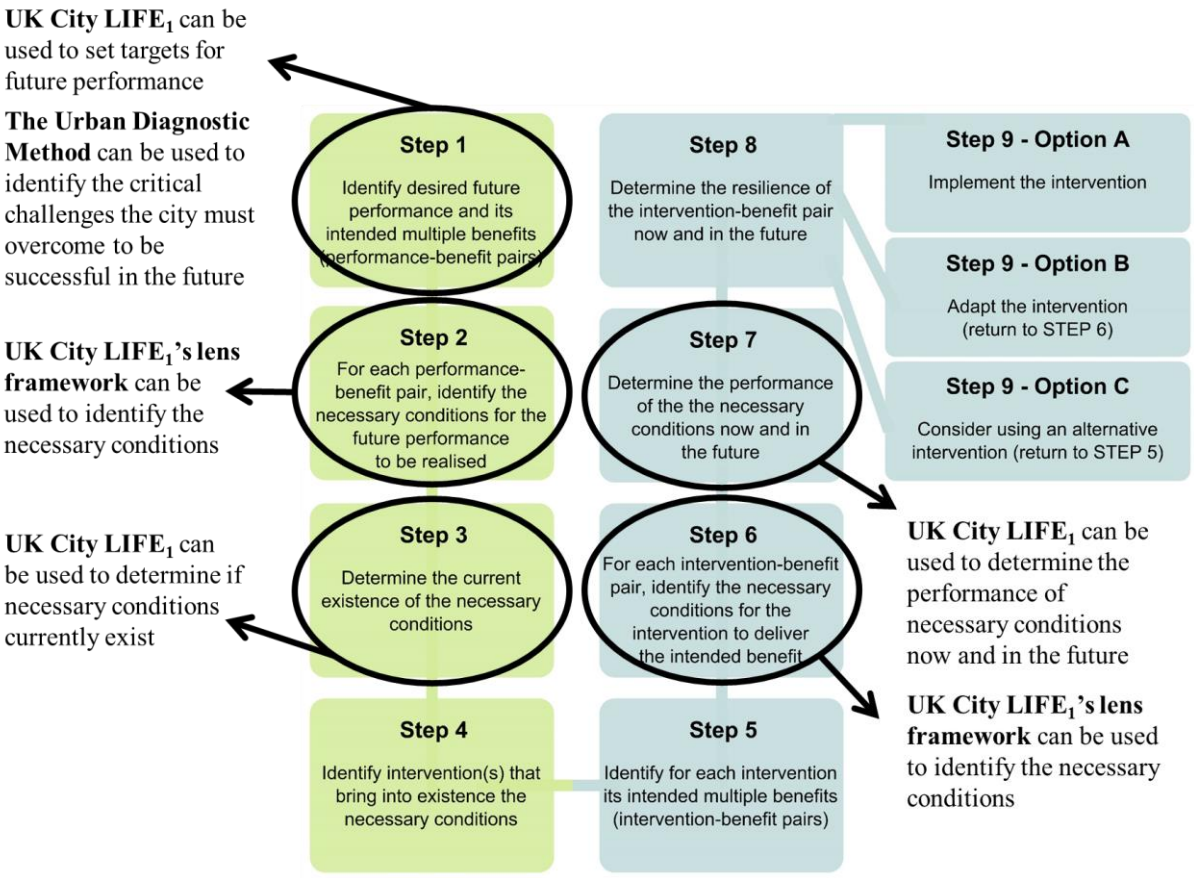

Figure 6. How UK City LIFE$_1$ and the Urban Diagnostic Method fit with the Liveable Cities Method.

For simplicity within this paper, we identify Liveable Cities' Ideal City Model (Ortegon-Sanchez and Tyler, 2015) as the mechanism for establishing a city's desired future performance. However, UK City LIFE$_1$ can also be used. Its lens framework indicates desired directions of travel and it is possible to set future targets for the indicators.

Steps 4, 5, 8, and 9 of the Liveable Cities Method are where the ingenuity, expertise, and experience of the user come into play. These steps are where other tools and methods can be incorporated, such as collaborative and transdisciplinary working

practices, communities of interest engagement, holistic and systems thinking techniques, foresighting, and scenarios methods.

This paper concludes by setting UK City LIFE$_1$, the Urban Diagnostic Method, and the Liveable Cities Method into the context of a portfolio of research on urban sustainability, liveability, and resilience that has been advanced over the last 15 years by the authors of the papers contained within this thesis. This portfolio emphasises the importance of processes alongside technical knowledge in the delivery of successful cities. It seeks to enable engineers in the UK, in particular, and elsewhere, to address the urgent, complex, and wicked problems facing our urbanising world.

CONCLUSIONS

"You think that because you understand 'one' that you must also understand 'two' because one and one make two. But you must also understand 'and'."
(Attributed to Mawlana Jalal-al-Din Rumi)

Local Authorities are less focused upon arriving at an urban theory of everything (despite the benefits this might have for them) and more focussed upon directly addressing the challenges they face. There is a long history of urban design decision-making and policymaking building upon 'best practice' – importing what works elsewhere to address a challenge being faced at home. There are many forums for this (the Covenant of Mayors, for example (Covenant of Mayors Office, 2019)). Understanding what may and may not work in the new context is an art and a science where not all the variables and their interactions are known.

The digital revolution has increased the aspects of cities that are measurable and quantifiable. It is now possible to easily measure many characteristics of urban performance, such as air quality; health and wellbeing; water, energy, food, and transport flows; economic activity; demographics; quality of the urban form; waste and emissions; crime; social cohesion; employment; and, education (all these are measured in UK City $LIFE_1$). However, it does not follow that these aspects are measured completely.

In the context of this thesis, 'missing data' are those data that are excluded from measurement or diagnostic techniques because they are not available. There are a number of reasons this may be the case and we came across all of these in applying UK City $LIFE_1$ and the Urban Diagnostic Method to Birmingham. One obvious reason for excluding data is that they are simply not collected (unless the user does so themselves, of course). An example of data not routinely collected for UK cities are household attitudes towards materials use. Another reason is that data are collected, but not in a form

that is compatible with the measurement technique being used. For example, Geographic Information Systems (GIS) require data are geocoded before they can be visualised and analysed. Access to collected data may be restricted, perhaps for commercial reasons, issues of national safety, or personal identification. In some cases it is possible to gain access to these data, for example, via a confidentiality agreement, payment for the data, or upon completion of specialised data handling courses (as offered by the UK Data Archive, for example (UK Data Archive, 2019)). Finally, data may be available, but the lead-time to obtain them may be prohibitive.

Missing data also include data that are excluded because they are not of sufficient quality. Just because data exist does not mean they are 'good' data. It is up to the user to decide upon the acceptable level of data quality, offsetting data quality against availability; i.e., is it better to include data that are of lesser quality than to omit them altogether? The caveat is that data quality should be explicit and should shape measurement and diagnostic outcomes. "[T]he notions of truth, error and accuracy are still useful regulative ideals that account for the need to reduce uncertainties and correct inconsistent measurement results" (Mitchell *et al*., 2017, p. 4).

If data are omitted from measurement, assessment, and diagnostic techniques, then how does that technique compensate? My reviews of urban measurement, assessment, and diagnostic methods revealed that missing data are effectively forgotten. Outputs and arising analyses focus upon the included data without much mention of the missing data. Conclusions drawn and decisions made based upon these outputs and analyses are, therefore, unknowingly ignorant of certain aspects of urban performance.

Although my reviews didn't uncover how much data were omitted because they were unavailable, they did reveal that included indicators largely reflect those already in

existence and rarely are new indicators created. The impact is that aspects of urban performance and diagnostics are not measured completely (and sometimes not at all). The collective impact is that outcomes risk converging on what is known and shedding increasingly less light on the unknown.

Within UK City LIFE$_1$ and the Urban Diagnostic Method, care was taken to make explicit what was within scope but unknown. For the Urban Diagnostic Method, a hot and cold spot analysis was conducted. For UK City LIFE$_1$, indicators were retained even if it was not possible to obtain data for them. The hot and cold spot analysis revealed that of 210 theme pairings, 79 (38%) had only one connection (see Paper 6). Of UK City LIFE$_1$'s 346 indicators, 92 (27%) have null values (see Papers 3 and 4). The latter are distributed amongst the lens framework as shown in Figure 7.

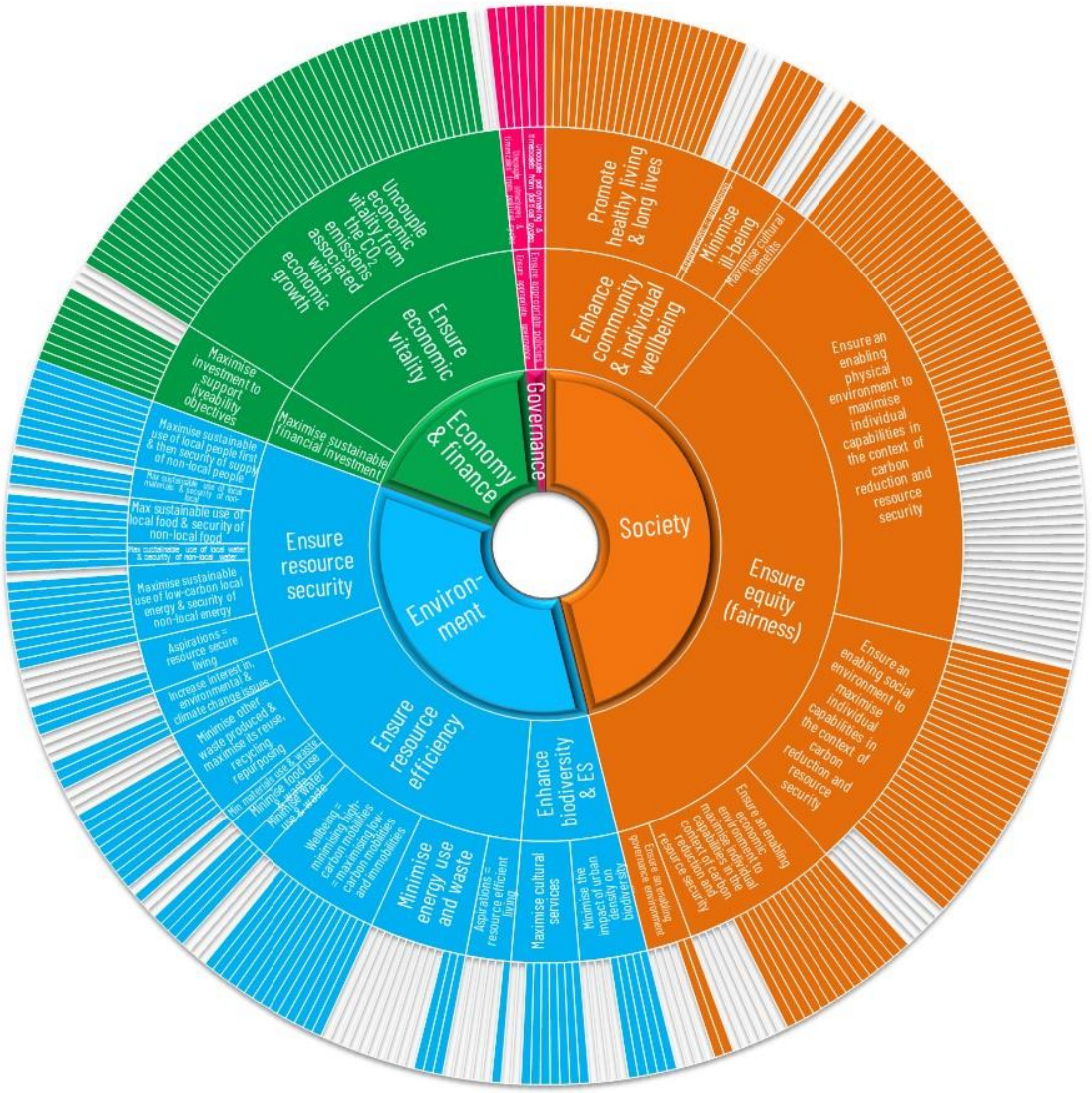

Figure 7: Birmingham's missing data in UK City LIFE$_1$.

Interestingly, it appears that scale influences the type of data that are unobtainable. In a study that is yet to be published, I apply UK City LIFE$_1$ at the neighbourhood scale. This entailed the creation of two surveys, which can be found in Appendix I. Ethical approval was obtained for the surveys from the University of Birmingham Ethics Committee, reference number ERN_15_0341A. One survey was completed by the household, the other by individual members of the household. The surveys were conducted in the Hay Mills neighbourhood of Birmingham, UK, during the summer of

2016. Of the ~350 households in the neighbourhood, 37 households and 46 individuals participated in the study. Initial analysis of the responses show that missing data are different at the neighbourhood and city scales. Broadly speaking, objective data such as energy use and water use are more easily obtainable at the city scale as this scale matches, or can be matched to, the scale at which the raw data are gathered by third parties. Neither energy nor water are measured at the Hay Mills scale or at the sub-Hay Mills scale, although household water metering was being rolled out at the time of the study. I did ask residents for energy use and water use data from their latest utility bills, but these data were inconsistently supplied. In contrast, subjective data are easier to obtain at the neighbourhood scale as they can be gathered as part of the survey and easily answered by respondents. There are a number of national surveys that ask subjective questions and that are disaggregated to the city scale, and these are incorporated into UK City $LIFE_{1\&2}$, but they cannot be disaggregated to the neighbourhood scale. If the neighbourhood scale application of UK City $LIFE_1$ had relied solely upon secondary data sources then it would have been very data poor indeed.

Subjective data relating to people's attitudes are disproportionately missing at the city scale for Birmingham. This raises the question as to whether residents are getting lost in city-scale urban performance and diagnostic assessments. Equally, objective data relating to resources are disproportionately missing at the household scale, raising the question as to whether infrastructure services and resource flows are being lost at the household scale. This may be particularly true for services and resources that are not charged based upon usage.

The key aims of this thesis were to:

1. Describe the global landscapes of urban performance measurement, assessment, and urban challenges diagnostics.
2. Determine how useful they are to urban design decision-making and policymaking in the UK.
3. Build upon them to develop bespoke methods and processes fit for the UK.

I am confident that the papers that form this thesis have addressed each of these aims. Aims 1 and 2 are addressed in Papers 1, 2, and 3 (for urban performance measurement and assessment) and Paper 5 (for urban challenges diagnostics), which simultaneously establish the parameters for the bespoke methods subsequently designed: UK City LIFE$_1$ and the Urban Diagnostic Method. Aim 3 is covered in Papers 3 and 4 (which describe UK City LIFE$_1$), and Papers 5 and 6 (which describe the Urban Diagnostic Method), with their fit to UK urban design decision-making and policymaking (linking to Aim 2) described in Paper 7.

AREAS FOR FUTURE RESEARCH

> "[A] more theoretically self-conscious pooling of data, experiences and investigative results is essential if urban investigations are to progress beyond localism, difference and the celebration of empirical complexity for its own sake."
> (Storper and Scott, 2016, p. 1124)

The above quotation nicely captures an underpinning theme within this thesis, that the science of cities is not yet advanced enough for the development of complete and robust urban performance measurement, assessment, and diagnostics. Shortcomings lie within both urban theory and the applied urban sciences. In both cases, the multiple realisability of cities is a contributing factor, but it is also where the opportunities of understanding lie.

The validity of 'urban' studies is, however, worth questioning. "[N]ot all aspects of life, perhaps not even most aspects, can be understood as being necessarily (that is, 'ontologically') urban phenomena" (Storper and Scott, 2016, pp. 1117-1118). Viewed another way: just because things happen *in* a city does not mean they are happening *because* of the city.

The primary aim of Paper 1 is to understand how urban assessment methods affect urban design creativity. We interviewed a small sample six years ago and since then urban assessment has developed considerably. It would be interesting to revise and update the survey to include the changing urban landscape (for example, incorporating tools that address resilience and smartness) with a larger, more diverse cohort.

Paper 2 suggests adding targets for each UK City $LIFE_1$ indicator and incorporating relative and absolute changes, bearing in mind that liveability and sustainability are, themselves, moving targets. The merits (or not) of this approach are discussed throughout this thesis.

Papers 3 to 6 make the case for, design, and apply urban measurement, assessment, and diagnostic methods. For urban measurement and assessment, incorporating real-time and longitudinal data would provide a step-change to the snapshot of city performance currently achievable in UK City $LIFE_1$. For urban diagnostics, complementing abductive diagnostics with deductive diagnostics would enable robust testing of Birmingham's plexus of critical challenges.

The application of UK City $LIFE_1$ and the Urban Diagnostic Method highlights the scale of missing information for the city of Birmingham. The implications for this have already been discussed within this thesis. Filling in the gaps would enable a better understanding of Birmingham and highlight how missing information affects interpretation.

Papers 3 to 6 make evident the paucity of data and information for the better understanding of governance and finance processes and outcomes. Governance and finance are fundamentally important to achieving a successful city, yet, unfortunately, they garner little interest from the urban sustainability and liveability research communities.

I have already discussed how the design of UK City $LIFE_{1\&2}$ is underpinned by robustness and completeness rather than usability. To make UK City LIFE usable likely means reducing its number of indicators. The best way of achieving this isn't fully clear, but one way forward is to apply UK CITY $LIFE_2$ to 20-30 UK cities (a combination of the Core and Key Cities would suffice) and factor analyse the data. This would highlight the most influential indicators for UK cities and could be used to streamline the existing indicator set.

Wider application of UK City $LIFE_2$ and the Urban Diagnostic Method would allow statistical and other methods to be used to draw conclusions across cities rather than within one city. Application beyond the UK will require reassessment of the included indicators to ensure they fit the national context under investigation. I have been in discussion with the Kumaraguru College of Technology in Coimbatore, India. The engineering department there is interested in applying UK City $LIFE_2$ and the Urban Diagnostic Method to Coimbatore, but, unfortunately, thus far we have been unable to secure funding to undertake this work.

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PAPERS

List of papers

1. Leach J. M., Boyko C. T., Cooper R., Woodeson A., Eyre J. and Rogers C.D.F. (2015) 'Do sustainability measures constrain urban design creativity?', *Proceedings of the ICE: Urban Design and Planning,* 168(1), 30-41. DOI: 10.1680/udap.13.00034.
2. Leach J. M., Braithwaite P. A., Lee S. E., Bouch C. J., Hunt D. V. L. and Rogers C.D.F. (2016) 'Measuring urban sustainability and liveability performance: the City Analysis Methodology (CAM)', *International Journal of Complexity in Applied Science and Technology (IJCAST),* 1(1), 86-106. http://dx.doi.org/10.1504/IJCAST.2016.081296.
3. Leach J. M., Lee S. E., Hunt D. V. L. and Rogers C. D. F. (2017) 'Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK', *Cities*, 71, 80-87. https://doi.org/10.1016/j.cities.2017.06.016.
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5. Leach J. M., Mulhall R. A., Rogers C. D. F. and Bryson J. R. (2019) 'Reading cities: Developing an urban diagnostics approach for identifying integrated urban problems with application to the city of Birmingham, UK', *Cities*, 86, 136-144. https://doi.org/10.1016/j.cities.2018.09.012.
6. Leach J. M., Mulhall R. A., Rogers C. D. F. and Bryson J.R. (2019) 'Analysis methods used when applying the mixed-methods diagnostics approach to Birmingham, UK', *Cities*, supplementary information, S1-45. https://doi.org/10.1016/j.cities.2018.09.012.

7. Leach J. M., Rogers C. D. F., Ortegon-Sanchez A. and Tyler N. (2019) ‘The Liveable Cities Method: Establishing the case for transformative change for a UK metro’, *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*, Ahead of print. https://doi.org/10.1680/jensu.18.00028.

Author contributions

Joanne Leach was the lead author on all publications and in each case undertook at least 60% of the data collection, analysis and manuscript preparation (typically more). Statements of author contributions for each paper and co-author statements of my contributions are found in Appendix J.

Paper 1. Do sustainability measures constrain urban design creativity?

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Abstract

Planners, architects, urban designers and other built environment professionals engage with a myriad of checkboxes, guidelines, requirements and specifications, all of which potentially compromise creativity and innovation in urban design. Approaches that measure performance are accused of belying the nature of places as messy, plural, organic, accidental and emotive; trying to find a formula that works may tick boxes, but it risks creating soulless spaces, oppressing innovation and incorporation of inappropriate design elements. This paper argues that sustainability assessment methods do have something to contribute to creativity and innovation in urban design precisely because they encourage engagement with challenging and often complex societal priorities. Through interviews with built environment professionals and a critical examination of sustainability assessment methods, the authors suggest that such methods can promote creativity and innovation if they engage competently with sustainability, work at a scale that allows for both breadth and depth (typically greater than the building scale) and

incorporate in their design a set of eight key characteristics designed to promote creativity and innovation.

1. Introduction

In 2005, Urban Task Force, the UK body charged with setting out a vision for the renaissance of cities, stated that, "the majority of new developments remain poorly designed, with public realm and buildings of a very low quality" and that "too many housing projects … often lack the core social and commercial institutions that sustain urban life and any sense of place or beauty" (Urban Task Force, 2005, p. 5). They believed that design quality was not considered a priority by the public sector, nor was design culture properly embedded in procurement and management processes. Since this time, government and local authorities have attempted to bring design quality to the foreground within urban design, planning and sustainability (e.g. ODPM, 2005). What has often happened, however, is that the arising guidelines and assessment methods, which aim to improve design quality, rigidly and restrictively quantify or objectify urban design into a series of tick boxes, indicators and normative requirements for the sake of efficiency, thus negatively impacting the quality of urban design by constraining creativity and innovation (Kelbaugh, 2002).

Rather than view guidelines, assessment methods and their ilk as hindering creativity and innovation in urban design, this paper suggests that, if properly embraced, such approaches actually may promote these attributes by facilitating opportunities to engage directly with complex issues, such as sustainability, resilience and liveability. Furthermore, there are opportunities for guidelines, assessment methods and specifications to enhance creativity and innovation by incorporating characteristics that

promote these attributes. In this paper the authors investigate the following research questions: Do sustainability assessment methods encourage or hinder creativity and innovation in urban design? How can they encourage creativity and innovation?

The methodology used in conducting the research is first outlined in the following section. In Section 3, the authors summarise urban design – it is here that the tension between fostering creativity and innovation, and the requirement to follow established procedures, is first highlighted. The fourth section introduces sustainability assessment methods and establishes their relationship with urban design. In Sections 5 and 6, eight key characteristics that promote creativity and innovation are derived, and their presence or absence in a selection of 32 sustainability assessment methods is assessed. Section 7 then draws together and summarises the above content, and the paper concludes with the formulation of a principle for promoting and enhancing creativity and innovation in sustainability assessment methods.

2. Methodology

The authors conducted eight interviews with nine UK built environment professionals (two were interviewed together): two architects, two design and engineering consultants, four sustainable development consultants and one urban designer. Two of the nine interviewees have multiple professional roles, although for the purpose of this paper the interviewees' primary current roles were used. This group was selected because urban design is informed by a breadth of professions, rather than solely by urban designers (Lombardi *et al.*, 2011). Interviews were typically an hour in duration and (with two exceptions) both lead authors were present. Semi-structured interviews were employed,

comprising seven questions plus supplementary questions when necessary (e.g. to clarify issues), as listed below.

a) What does urban design mean to you?
b) What promotes innovation and creativity in urban design?
c) What techniques or methods do you use to encourage innovative and creative urban design, both yourself and in others?
d) Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?
e) What is your experience of sustainability assessment methods?
f) Do sustainability assessment methods promote or hinder creativity and innovation in urban design? Specifically which ones… good and bad… and why?
g) Are there any urban design assessment methods in addition to those mentioned in this interview that you wish us to note?

Immediately following each interview a summary was compiled and validated by the interviewee. The summaries were analysed for information related to the study's two primary constructs: (a) characteristics of creativity and innovation, and (b) engagement with complex issues (i.e. sustainability). A content analysis of the summaries was conducted to identify additional themes.

In this way, the built environment professionals determined which sustainability assessment methods were to be examined, as well as which relevant characteristics to investigate. It should be noted that the interviewees were not asked to define concepts, such as 'good', 'quality' or 'sustainability' during interviews; rather, they focused on

barriers to creativity and innovation in relation to addressing dimensions of sustainability to achieve their own notions of ‘good’ and ‘quality’.

3. Defining urban design

From its beginnings in the 1950s as a confluence of architecture, landscape architecture and town planning (Frey, 1999; Schurch, 1999; Krieger, 2008; Mumford and Sarkis, 2008), urban design has grown and matured into something more than just designing places that look good (see Cuthbert (2010) for a discussion about who established urban design and when it was established, and Frey (1999) for a discussion of how urban design should not be a discipline in its own right). Dimensions of urban design include relationships between people and between people and places (DETR and CABE, 2000; Mumford and Sarkis, 2008); the spirit of place (Norberg-Schulz, 1979); satisfying practical and emotional needs (Mumford and Sarkis, 2008); ordering the future, but not necessarily creating utopian futures (Kreditor, 1990); the dynamic features of space and time (Lynch, 1981; DETR and CABE, 2000; Mumford and Sarkis, 2008); how the physical parts of the built environment create networks of spaces and activities, which, in turn, have social roles (CABE and DETR, 2001); creating places that all citizens enjoy and with which they identify (Buchanan, 1988; Lai, 1988); the integration of humans and nature (Colman, 1988; Ellin, 2013); and the response to urban change and development (Barnett, 1982; Rowley, 1994). These dimensions help in understanding what comprises urban design: it is ‘the art and process of designing, creating, making and managing spaces and places for people’ (Boyko *et al*., 2005; cf. Marshall (2009) and Cuthbert (2011) for a discussion about the lack of a broadly accepted definition).

Two themes emerge from these ideas and from within the urban design literature, both of which were supported by the interviews. First, that urban design is an art (Floyd, 1978; Norberg-Schulz, 1979; Lynch, 1981; Cowan, 2000; CABE and DETR, 2001; Biddulph, 2012; Moughtin *et al.*, 2003). The 'design' part of urban design suggests a link with the arts and humanities (Biddulph, 2012), especially the notions of creativity and innovation (see Section 5 for definitions of these terms), which stem from synthesis and imagination. All nine interviewees acknowledged that urban designers must creatively apply their skill, ability, knowledge, craft, science and imagination, and may involve innovation and taking risks: "Creativity seeps through the cracks, innovation breaks through" (design and engineering consultant 1, 5 September 2013). All the interviewees also acknowledged the limitations that working in urban design can place upon designers. For example, one interviewee suggested that compliance is perceived to be more important in the current linear UK planning system, allowing for innovation neither to seep nor break through (design and engineering consultant 2, 17 September 2013).

The second theme is that urban design is a process (Barnett, 1982; Gosling, 1984; Toon, 1988; Webber, 1988; Madanipour, 1997; Frey, 1999; DETR and CABE, 2000; CABE and DETR, 2001; see also Brown, 1971, 1990). Process is the framework, rules and guidelines that allow for the 'orchestration of the city's physical parts' (Frey, 1999, p. 16). Outlining a process for urban design, whether it is for policy or practice, means that the generic 'rules' will be known by decision makers and stakeholders. All the interviewees recognised the value of following an urban design process to ensure more desirable outcomes. Doing so could result in a more open and transparent way for understanding how decisions are made, for allowing creativity to be part of the process and for acknowledging the political context under which decisions are made (Biddulph,

2012). The challenge is to undertake a process that does not stifle creativity and innovation.

4. Urban design and sustainability assessment methods

Recent decades have seen growing influence of the principles of sustainable development upon urban designers, urban design, the built environment and users of the built environment. The Brundtland Commission (WCED, 1987), the 1992 Earth Summit in Rio and the establishment of Agenda 21 and in 1996 of UK Local Agenda 21 placed urban sustainability as a high priority for all levels of UK government as well as for the private and academic sectors. Good urban design became an integral part of building and maintaining sustainable communities, ensuring that the government's social, environmental and economic objectives were intimately tied with how places were designed and developed (ODPM, 2003, 2005). All but one of the interviewees reflected this thinking. However, when asked whether or not 'doing' sustainability, de facto, leads to good urban design, the interviewees were split: half said that urban designers would have engaged with sustainability if not pushed by external factors, such as legislation. The other half felt that the emphasis on adhering to sustainability standards seems to have allowed urban designers to address previously unconsidered issues.

Sustainability assessment methods, such as Breeam and Code for Sustainable Homes, are used to improve the sustainability of designed buildings and spaces up to and sometimes beyond legislative requirements (Barlow, 2011; DCLG, 2014). Although the interviewees acknowledged this, they believed it was difficult for urban designers to know what methods are available to them at what stages of the urban design process. In addition, questions arose about whether these methods stifled creativity and innovation

due to their tick-box approach and normative aspects. Eight of the nine interviewees agreed with this statement: these methods contribute primarily to the technical aspects of sustainability, not to creativity. However, they also recognised that these methods provide a way for urban designers to engage with sustainability, a complex and fast-moving issue, providing information that could form the basis for creativity and innovation.

While scholars have identified more than 700 different sustainability assessment methods (see Deakin *et al.*, 2002; McCreadie, 2006; Poveda and Lipsett, 2011; Gil and Duarte, 2013), over half the interviewees failed to directly reference specific methods until prompted by the interviewers (with an average of four methods mentioned per interviewee). Methods were often discussed as a seemingly homogeneous group. In all the interviews, aspects of assessment methods that were not attributed to specific methods were offered. These fell into two areas: method design and function, and method operation.

4.1 Method design and function

Positive comments focused on the ability of sustainability assessment methods to prompt thinking on issues that might not otherwise have been considered (e.g. elucidating and prioritising aspects of urban design that influence sustainability, breaking down silos). One interviewee expressed a desire for methods that assess the value and quality of design, not just their impact on sustainability (sustainable development consultant 4, 10 September 2013).

Although interviewees were split as to whether methods should consider sustainability holistically, a sub-section of those who favoured the holistic approach wanted greater emphasis on social equity and social justice. This finding speaks to their

perception that urban design can be used to exclude sectors of society, restricting access to scarce resources and reinforcing outdated social norms. The interviewees' comments also suggest that the current suite of available methods could be used as part of a larger, creative process for including a greater number and diversity of voices in urban design.

Interviewees' negative comments highlighted that methods can be too detailed and scientific. In some cases, then, the methods become overly prescriptive and assume a solution without the opportunity for built environment professionals and other stakeholders to engage with the bigger 'urban design' picture, thus hindering creativity and innovation.

4.2 Method operation

Comments focused on the possibility of making the evidence gathering process less onerous and more transparent, the need for transparency throughout decision making, the importance of allowing time for designs to evolve and the benefits of greater time spent on co-production and co-design (stakeholder input was seen as desirable even if it did not necessarily lead to a better outcome). The latter comment raises the possibility of bringing creativity and innovation into urban design through interesting, fun and ongoing collaboration with a variety of people.

In addition, three interviewees thought that assessment methods should fit naturally within existing urban design stages, phases and activities (even though the literature reflects that these are not standardised; see Boyko *et al*. (2005)).

5. Characteristics that promote creativity and innovation

Sawyer (2012) refers to creativity as comprising a little 'c' and a big 'c'. The little 'c', or individualist approach to creativity, concerns 'a new mental combination that is expressed in the world' (p. 7). The big 'c', or sociocultural approach to creativity, is about 'the generation of a product that is judged to be novel and also to be appropriate, useful, or valuable by a suitably knowledgeable social group' (p. 8). Thus, creativity is not only about generating something unique; it also has to possess utility for people. Furthermore, an understanding of how to make something useful to people is important, which refers directly to innovation: it is a multi-stage process whereby ideas are transformed into new or improved products, services or processes so that the ideas advance, compete or differentiate themselves successfully (Baregheh *et al*., 2009).

To promote creativity and innovation in urban design a number of characteristics need to exist. These characteristics are not specific to urban design, but may be found in, and adopted from, other professions and disciplines, such as design, design management and business (see Cooper and Press, 1995; Perks *et al.*, 2005; Cooper *et al.*, 2011). According to Amabile *et al.* (1996), and Bruno-Faria and Alencar (1997), creativity and innovation may be encouraged by the following.

a. Organisations that promote creativity. They may do this by
    i. fostering risk-taking and idea generation from the lowest to the highest levels of that organisation
    ii. promoting fair and supportive evaluations (i.e. are not critical)
    iii. rewarding and recognising creativity
    iv. allowing for collaborative idea flow across organisational levels and using participative management and decision-making practices.

b. Supervisors, project managers and leaders that promote creativity. They may do this by
    i. clarifying goals
    ii. interacting openly with people in the lower levels of an organisation
    iii. supporting a team's work and ideas.
c. Work groups that promote creativity. They may do this by
    i. having a diversity in team members' backgrounds
    ii. supporting mutual openness to ideas
    iii. fostering constructive challenging of ideas
    iv. possessing a shared commitment to a project.
d. Freedom in day-to-day conduct of work and a sense of ownership and control over work and ideas.
e. Resources to accomplish work (e.g. funds, materials, facilities).
f. Pressures that promote challenges (e.g. time pressures that foster working hard on challenging tasks and important projects).

The interviewees echoed many of the above characteristics – particularly around appropriate skills, a clear starting point, visionary leaders and a good team – and added some new ones, as follows.

g. Understanding the uniqueness of each design context, including constraints.
h. Knowing that inspiration may come from elsewhere (e.g. a development in another country).
i. Community involvement.

j. A committed and enthusiastic client (e.g. a local authority).

Summarising the above characteristics and thinking more broadly about designing and developing urban environments, eight key characteristics that promote creativity and innovation in urban design emerge, as listed below.

- risk-taking in idea generation (from (a), (f) and (g))
- visionary leadership (from (b))
- team understanding and commitment (from (b), (c) and (j))
- clear, and ideally visionary, brief and strategy (from (b))
- access to relevant information and appropriate and sufficient resources (from (e) and (h))
- ownership of ideas (from (d))
- good communication skills, including visualisation and diplomatic skills (from (a), (b) and (c))
- working well with stakeholders outside the design team (from (i) and (j)).

6. Presence of creativity and innovation characteristics in sustainability assessment methods

No attempt was made during the interviews to define or reach a common understanding of what constituted a sustainability assessment method so as not to influence the interviewees' decisions about which methods they wished to discuss. With that in mind, interviewees identified 32 sustainability assessment methods. The most frequently cited methods were Breeam and Breeam Communities, each mentioned by five interviewees.

Design Review Panel was the next most frequently mentioned assessment method, by three interviewees. Casbee, Ceequal, Green Star, Leed, Leed Neighbourhood Development, Passivhaus and SKA Rating were each mentioned by two interviewees, with all other assessment methods being mentioned by only one interviewee.

Of the ten assessment methods mentioned more than once, half were not discussed in detail: Casbee, Ceequal, Green Star, Passivhaus and SKA Rating. Of the remaining five, only Design Review Panel and Leed Neighbourhood Development were put forward as supporting creativity and innovation in urban design (see Table 1).

Table 1. Sustainability assessment methods identified by the interviewees.

Sustainability assessment method	**Number of interviewees who mentioned the method**	**Aspects of the method that promote creativity and innovation, identified by interviewees**	**Aspects of the method that hinder creativity and innovation, identified by interviewees**
Operational scale of method: National			
NPPF	1	• Allows for flexibility	
Operational scale of method: Urban, Neighbourhood and Building			
Arup SPeAR	1	• Holistically considers sustainability • Considers interrelationships • Identifies strengths and weaknesses • Assesses impacts of change • Makes users think • Covers change over time • Does not provide an award	• Not publically available
BEQUEST	1		• No value framework • Technocratic

CASBEE	2		
CEEQUAL	2		
Design Review Panel	3	• Engages with outside experts • Understanding of criteria against which design will be tested • Pressure tests design • Addresses design quality • Stands up to scrutiny	
GSAS: Global Sustainability Assessment System	1		
Parametric design	1	• Removes burden of time-consuming design elements • Provides performance data	
Urban/ Building Futures Game	1	• In its original form as the Urban Futures Game, the outcome was not prescribed	• In its current form as the Building Futures Game, the outcome is prescribed as built form
Designing Resilient Cities Tool (formerly known as the Urban Futures Tool)	1		• Requires intellectual capacity for users to engage with it
Whole Life Costing	1		
Operational scale of method: Neighbourhood and Building			
Building for Life	1		
Enplanner	1	• Provides some data • Determines compliance with local planning	
Sustainability Checklist	1	• Addresses compliance • Provides clues to what compliance looks like	• Misused as a rote checklist

Operational scale of method: Neighbourhood			
BREEAM Communities (2012 revision)	5	• Can work at the urban design scale • Prompts thinking	• Does not holistically consider sustainability • Lacks breadth • Lacks robustness • Self-referential • No quality assessment • Too specific and prescriptive in places
European Common Indicators of Local Environmental Sustainability	1		• Too tedious
Future Communities	1		
LEED Neighbour-hood Development	2	• Prompts thinking	• Does not holistically consider sustainability • Lacks breadth • Lacks robustness
Planning for Real	1	• Encourages community involvement	• Cannot work when starting from a blank sheet
Operational scale of method: Building			
BREEAM	5	• Increases cross-disciplinary working • Can shape developments if used early in the design process • Addresses compliance • Provides clues to what compliance looks like • Common • Marketable • Provides benchmarks • Popular, recognised and valued in the UK	• Misuse can lead to perverse outcomes • Justifies poor designs • Does not holistically consider sustainability • Lacks breadth • Lacks robustness • No value framework • Technocratic • Divorced from the development process • Used too late in the design process • Credit system is too rigid • Credit system is too onerous

BREEAM New Construction	1		
Building Information Modelling (BIM)	1		
Code for Sustainable Homes	1		
Defence Related Environmental Assessment Method (DREAM)	1		
Design Quality Indicator (DQI)	1		
Green Star	2		
LEED	2	• Popular, recognised and valued in the UK	• Not fit for the UK market • Does not holistically consider sustainability
LEED Building Design	1	• Common • Marketable • Provides benchmarks	
LEED Construction	1	• Common • Marketable • Provides benchmarks	
Passivhaus	2		
Sefaira	1	• Provides performance data	
SKA Rating	2		

Table 2 shows which of the eight characteristics of creativity and innovation identified in Section 5 are incorporated within the sustainability assessment methods identified by the interviewees. Some interesting points to note can be drawn from this. Of the four methods that display all eight characteristics – Design Review Panel, Future

Communities, Planning for Real, Urban/Building Futures Game – all operate at a scale above the building level. Aside from the Design Review Panel, Leed Neighbourhood was the only other method promoted by more than one interviewee as having a positive effect upon creativity and innovation. It incorporates three of the characteristics. The most commonly mentioned sustainability assessment methods – Breeam and Breeam Communities – contain one and four characteristics, respectively. The interviewees who mentioned Breeam Communities thought it somewhat hindered creativity and innovation with regard to its prescriptive elements, but it was its lack of robustness at assessing sustainability that prompted the majority of the criticism.

Table 2. Creativity and innovation characteristics incorporated within the sustainability assessment methods identified by the interviewees.

		Creativity and innovation characteristics incorporated within the method:							
Assessment method	**No. of interviewees mentioning method**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Eight characteristics									
Design review panel	3	✓	✓	✓	✓	✓	✓	✓	✓
Future Communities	1	✓	✓	✓	✓	✓	✓	✓	✓
Planning for Real	1	✓	✓	✓	✓	✓	✓	✓	✓
Urban/ Building Futures Game	1	✓	✓	✓	✓	✓	✓	✓	✓
Seven characteristics									
Six Characteristics									
CEEQUAL	2			✓	✓	✓	✓	✓	✓
Design Quality Indicator (DQI)	1			✓	✓	✓	✓	✓	✓
Five characteristics									
Arup SPeAR	1			✓	✓	✓	✓	✓	
Designing Resilient Cities Tool	1	✓			✓	✓	✓	✓	
Four characteristics									

BREEAM Communities	5			✓	✓	✓			✓
Building for Life	1			✓	✓	✓			✓
Three characteristics									
LEED Neighbour-hood Development	2			✓	✓	✓			
Sustain-ability Checklist	1			✓	✓	✓			
Two characteristics									
Building Information Modelling (BIM)	1					✓		✓	
GSAS	1				✓	✓			
NPPF	1	✓							✓
Para-metric design	1					✓		✓	
Sefaira	1					✓		✓	
SKA Rating	2					✓		✓	
One characteristic									
BEQUEST	1					✓			
BREEAM	5					✓			
BREEAM New Construction	1					✓			
CASBEE	2					✓			
Code for Sustain-able Homes	1					✓			
Defence Related Environmental Assessment Method (DREAM)	1					✓			
Enplanner	1					✓			
European Common Indicators	1						✓		
Green Star	2					✓			
LEED	2					✓			
LEED Building Design	1					✓			
LEED Construction	1					✓			
Passivhaus	2					✓			
Whole Life Costing	1					✓			

7. Discussion

It was apparent from the interviews that an instinctive reaction to rules and regulations – in this case, sustainability assessment methods – is that they stifle creativity and innovation. Interviewees felt that this can be the case particularly if those using or applying them do not properly embrace them and instead resort to ticking boxes and checklists. The danger with rules, regulations and directives is that the designer establishes what is needed to conform, works out the most effective way to achieve this (e.g. practically, with regard to cost) and then proceeds with implementation without properly reflecting on the process of urban design and looking behind or beyond the immediate requirements and normative elements. The interviewees also acknowledged the converse of this argument: rules, regulations, targets or other directives promote deeper thinking on complex issues and that the process of designing can be enhanced by such methods.

Half of the interviewees picked up on the tensions between the ability of assessment methods to engender thinking about complicated issues – providing guiding principles, providing information, possibly providing benchmarks and ideas of what success looks like – with being too prescriptive and driving out creativity and innovation. Interestingly, none of the interviewees suggested sustainability assessment methods should be scrapped, although this may have been because of their perceived value in promoting the sustainability agenda rather than because of any positive impact they have on creativity and innovation in urban design.

There was broad recognition (by eight of the nine interviewees) of the role sustainability assessment methods have in elucidating sustainability issues, providing guidance and benchmarks, thus providing a platform from which urban designers can be

creative and innovative. It was in the discussion of specific assessment methods that negative impacts on creativity and innovation prevailed, thus suggesting that those methods currently being applied in practice should be improved upon so they not only positively affect urban sustainability, but also creativity and innovation in urban design.

From the first interview, it became apparent that the use of sustainability assessment methods is inherently complicated and that their efficacy cannot be captured by simple uptake figures (if they existed, which they do not). Interviewees spoke about the difference between the use of an assessment method as it was designed to be used and its use in practice; in some cases the difference was marked. There also was a strong sense that methods are only as good as the person or team using them. This being the case, design teams and their organisations need the capability and capacity to engage with sustainability (and sustainability assessment methods) as well as to be creative and innovative.

The interviewees gave a sense that there was not much perceived difference between many of the sustainability assessment methods currently being applied in practice. Methods such as Breeam, Leed, Casbee and Green Star were discussed in some interviews as if they were almost identical. This may be because there genuinely is little difference between methods. Likewise, built environment professionals may not have a detailed understanding of the plethora of methods on the market and their general or specific use within sustainability, planning and urban design.

Much of what has been discerned from these practitioner views resonates strongly with the experience of the Designing Resilient Cities research team, of which the authors were a part. Designing Resilient Cities was a multi-disciplinary research programme that sought to provide an answer to whether design interventions in cities would likely be

resilient in the far future (see Lombardi *et al.*, 2012; Rogers *et al*., 2012). The Designing Resilient Cities tool (formerly known as the Urban Futures tool), a primary output from the research programme, was identified by one of those interviewed for this paper. The tool operates across scales (urban, neighbourhood and building) and contributes to five of the eight characteristics of creativity and innovation (see Table 2).

When trialling the tool with a wide range of different practitioner groups (e.g. architects, town planners, engineers), it became apparent that one of its most important features is forcing designers to question their design thinking. Moreover it does not attempt to impose anything, dictate or limit design solutions, or remove responsibility from the designer. In these ways, the tool does not stifle creativity or innovation; rather, it encourages thinking about alternative approaches by raising 'what if?' questions. These ideas were supported by the interviewees, who largely agreed that currently adopted sustainability assessment methods should raise open-ended questions alongside providing guidelines, performance parameters and benchmarks. It is argued that it is for this reason that the Design Review Panel was most positively viewed by the interviewees.

8. Conclusion

The insights from nine interviews with UK built environment professionals on the relationship between sustainability assessment methods and creativity and innovation in urban design are revealing, and confirm many of the core findings within urban sustainability research. Interviewees named 32 methods as well as characteristics that promote or hinder creativity and innovation in urban design. The methods were assessed for the presence of eight 'key' characteristics that promote creativity and innovation. From the analysis, it has been possible to establish that sustainability assessment methods

do impact creativity and innovation in urban design, and that many current methods are described more negatively than positively in terms of their impact upon creativity and innovation.

There also was broad recognition of the value that sustainability assessment methods have in elucidating sustainability issues and in providing guidance on how they might be addressed. This, in turn, provides a platform from which urban designers can be creative and innovative, both at specific points in the urban design process and throughout the process. Based on the above findings, the authors propose the following principle: a sustainability assessment method will promote creativity and innovation in urban design if it engages competently with sustainability, works at a scale that allows for breadth and depth (typically greater than the building scale), and incorporates a set of eight key characteristics designed to promote creativity and innovation. This principle should guide any new sustainability assessment methods under development.

The findings also suggest that the people creating sustainability assessment methods should think more broadly about those who will use their methods and for what purpose(s). At the moment, many methods appear to be designed to work within a more deterministic, normative, empirical and scientific framework. They either fail to understand or ignore the creative and innovative aspects of urban design and the designers who use them (and who work in a more ‘designerly’ way) (Cross, 1982). Perhaps, when sustainability is more embedded in society, sustainability assessment will naturally encourage creative processes as well as creative and sustainable design solutions.

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Paper 2. Measuring urban sustainability and liveability performance: the City Analysis Methodology

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Abstract

The rise in the influence of sustainability principles has resulted in an almost overwhelming number of methods for defining, measuring and assessing sustainability and liveability. For such assessments to be accurate they must have a clearly defined 'sustainability and liveability space', be designed for the context in which the measurements are to be taken, evidence a clear causal chain and make explicit interdependencies. The degree to which current methods meet these criteria is varied. This paper introduces the City Analysis Methodology (CAM), an innovative urban analysis framework for holistically measuring the performance of UK cities with regard to sustainability and liveability. It demonstrates the need for, and defines the parameters for, interventions that enhance rather than compromise wellbeing and provides a model for other countries to leverage the sustainability and liveability of their cities. The paper concludes with an application of the CAM to the design of city infrastructure.

1. Introduction

The world is facing considerable challenges around urban sustainability and resilience, and it is widely accepted that there is an imperative to act quickly if serious environmental, social and economic consequences are to be avoided in the future (UK National Ecosystem Assessment, 2011; UN, 2012; WWF, 2014). In our increasingly urban world, cities have an important role to play in achieving sustainability (Rosenzweig *et al.*, 2010; SustainAbility, 2012; UN-HABITAT, 2012; United Nations, Department of Economic and Social Affairs, Population Division, 2014). On the demand-side, the ecological footprint of many cities vastly outstrips their geographic footprint, yet their resource efficiency is greater than many suburban or rural communities. On the supply side, cities are almost entirely dependent upon their hinterlands (and beyond) to supply basic goods and services such as food, water and energy, and to dispose of waste (Folke *et al.*, 1997; Calcott and Bull, 2007; WWF, 2014). Arguments vary as to the influence cities have in creating a more sustainable world, ranging from very little to the only truly effective enabler from the single city perspective, this latter view supporting the idea of cities collectively being the engines of change (Vliet, 2002; Portney, 2013). This paper does not attempt to address this question directly, preferring to acknowledge both the combined influence of cities upon sustainability in the context of rising populations and growing urbanisation and the merit in improving the sustainability of one single city.

Liveability is almost inextricably linked to the sustainability of cities. In fact, Portney (2013) maintains that, as concepts, liveability and sustainability are practically indistinguishable. In practice, however, a sustainable city is not de-facto liveable and a liveable city is not de-facto sustainable. However, it is important to acknowledge that despite, or perhaps because of, extensive writings and reflections on sustainability and

liveability, their meanings remain nebulous and open to a myriad of interpretations. This paper proposes that liveability and sustainability can, and should, be inextricably intertwined, incorporating societal and planetary wellbeing within the context of low-carbon living and resource security.

The professionals who shape our cities are educated, trained and practice according to theories and experience derived largely through a single discipline, such as architecture, civil engineering or planning (Frey, 1999; Cooper *et al.*, 2009; Lombardi *et al.*, 2012). This entrenchment in a disciplinary silo, perpetuated by professional qualifications and language, facilitates the analysis, design, and implementation of solutions to the complex challenges that cities pose for sustainability and liveability – but only according to the discipline that has driven the analysis. Such limited perspectives will fail to deliver full potential without an overarching framework to address these challenges that also demonstrates the need for, and defines the parameters for, solutions that embrace all relevant disciplinary perspectives (Rogers *et al.*, 2012). The sustainability debate has established that three pillars embrace the core aspects across which the balance should be drawn: economy, society and the environment (Connelly, 2007). Added to this, we know that without social acceptance solutions can be doomed to failure (Assefa and Frostell, 2007; Vallance *et al.*, 2011). A deep understanding of the relationship between wellbeing and behaviour, as it relates to sustainability and city living, is therefore imperative if solutions are to be successful.

Accordingly, Liveable Cities, a five-year, multi-university and highly multi-disciplinary research programme combining around 50 academic researchers with a similar number of practitioner project partners, was established in 2012 to identify and test radical interventions that will lead to sustainable and liveable cities of the future. The

specific focus of this programme concerns pathways to low-carbon, resource-secure cities in which societal wellbeing is prioritised, while changes in population, urbanisation, demography, climate, security of energy/other resources, and a plethora of historical legacies, provide the context. The programme focuses upon UK cities, with implications for cities worldwide (see: http://www.liveablecities.org.uk).

This paper introduces the City Analysis Methodology (CAM), which forms a core element of the Liveable Cities programme. The CAM is an urban analysis framework for holistically measuring the performance of a city, demonstrating the need for, and defining the parameters for, the design of city interventions. In order for cities to move towards increased sustainability and liveability, it is important first to understand how cities function and how well they perform. This provides a baseline against which to identify and prioritise aspects that would benefit from change and assess the impact of any proposed interventions. Gaps in performance can then be identified, barriers to achieving a sustainable and liveable future elucidated, and robust interventions designed and assessed. Section 2 of this paper describes how to make operational the measuring of city performance. It begins by describing the rise in prominence of the principles of sustainability and liveability and the concomitant desire to measure them, resulting in an abundance of methods and measures. Section 2.1 discusses the varied definitions of sustainability and liveability and defines a measurable 'sustainability and liveability space' for the CAM. In Section 2.2 a framework for measuring city performance derived from the management literature is proposed (the lens framework), and in Section 2.3 the lens framework is applied to the CAM's sustainability and liveability space to form the CAM itself. The discussion section illustrates how the CAM can be used to elucidate causal chains and interdependencies, to design interventions and to assess their impact,

with a particular focus upon infrastructure. The paper concludes with a description of future developments for the CAM and applicability to UK cities. It is intended for the CAM to become a methodology, usable by those seeking to create a more sustainable and liveable urban future, and to this end it is being tested by the Liveable Cities team in the UK case study cities of Birmingham, Southampton and Lancaster to explore its robustness in different city contexts.

2. Measuring city performance: operationalising the concept

Recent decades have seen a rise in the influence of sustainable development principles. In 1987, the Brundtland Commission published *Our Common Future,* providing an enduring definition of sustainability and the basis for the Rio de Janeiro Earth Summit in June 1992 (WCED, 1987). The Earth Summit gave rise to Agenda 21, the principles to guide countries towards economic development, including the promotion of sustainable development and a mandate for the United Nations to establish a set of sustainable development indicators (UN, 1993). In 1996 in the UK, Local Agenda 21 was made compulsory via the LA21 policy initiative, placing urban sustainability as a high priority for all levels of UK Government as well as for the private and academic sectors.

As the influence of the principles of sustainability has increased, so has the desire to quantify and measure sustainability itself (Wong, 2006). The result is an abundance of sustainability assessment methods (Bell and Morse, 2008). For example, a UK research programme (Sustainable Urban Environment Metrics, Models and Toolkits for Whole Life Sustainable Urban Development, SUE MoT) identified more than 600 sustainability assessment methods (McCreadie, 2006), these being categorised as: urban planning tools, design tools, rating systems, life cycle analysis tools and infrastructure. Urban planning

tools and rating systems (for buildings) were found to be the most developed. As part of the Building Environmental Quality Evaluation for Sustainability Through Time (BEQUEST) project, Deakin *et al.* (2002) identified more than 100 assessment methods related to sustainable urban development. Gil and Duarte (2013) reviewed tools for evaluating the sustainability of urban design, identifying 35 tools that met their criteria of being at the neighbourhood scale, which assessed sustainability holistically and which were relevant to the early stages of the urban design process. Poveda *et al.* (2011) pointed to the continued growth in the number of sustainability assessment methods, reiterated the concomitant need for a useful classification system, and identified 12 categories of the most commonly used sustainability assessment methodologies, models, approaches and appraisals. Looking across the methods reveals a multitude of definitions, forms and purposes. It is perhaps not surprising, therefore, that urban designers struggle to be knowledgeable about more than a handful of them (Leach *et al.*, 2015).

Moreover, whichever assessment method, or combination of methods, is used, the aspirations of citizens, society more generally and those leading cities need to be accounted for. This is a further core element of the Liveable Cities research programme, with individual citizen aspirations (Joffe and Elsey, 2014) and societal aspirations being surveyed, while a separate evidence-gathering exercise from those who lead, or are leading thinking in, cities (Rogers *et al.*, 2014) is bringing clarity to the preferred direction of travel. This has been taken forward in policy terms by a UK Government led Foresight Future of Cities project, which explored policy options for the UK's city systems and the UK's system of cities looking forward to 2040 and 2065 (http://www.gov.uk/government/collections/future-of-cities).

For sustainability (and liveability) measurement to be accurate it must have a clearly defined space (Connelly, 2007), be designed for the context in which the measurements are to be taken (Bell and Morse, 2008), evidence a clear causal chain and make explicit interdependencies (Repetti and Desthieux, 2006). The degree to which current methods meet these criteria is varied.

2.1. Defining the sustainability and liveability space

Common to all sustainability assessment methods is the concept of sustainability, but this does not mean that the definition of sustainability is the same across the methods. One reason for this is that our understanding of sustainability changes over time (Connelly, 2007; Portney, 2013). Another reason is the contested nature of the term (Bell and Morse, 2008). There is no one, agreed, operational definition of sustainability (Kidd, 1992; Connelly, 2007; Bell and Morse, 2008). The linkage between the environment, society and economy can be seen as a political one not inherent in the concepts themselves. The result is that sustainability assessment methods acknowledge the three-pillar conceptualisation of sustainability and then define an operational space between those pillars that they seek to assess. Each definition is underpinned by a unique set of priorities that when in conflict are resolved in different ways, all under the umbrella of sustainability (Connelly, 2007).

More recently, sustainability assessment is being subsumed into big data, open data and smart city discourses. Information communication technologies (ICT) hold the promise of being able to collect large amounts of data, including real-time data, that will greatly improve our understanding of how cities function. These data are increasingly being brought together either publically, such as on city dashboards available via local

authority websites, or privately, such as in data analytics centres (Kitchin, 2014). This emancipation of data is leading to the identification of linkages, interdependencies and points of leverage amongst a much wider set of data and priorities (beyond those traditionally seen as in the domain of sustainability) that up to now have remained elusive and opaque.

Dictionary and thesaurus definitions of liveability indicate that liveability is about being suitable for (usually) human living (Swannell, 1986, p. 316; Manser *et al.*, 2013, p. 605; Merriam-Webster, 2013; The Free Dictionary by Farlex, 2013). These definitions suggest a basic level of suitability, tolerability and functionality that is at increasing odds with the use of the word when applied to cities. In relation to cities, liveability describes the surpassing of basic living conditions to meet aspirations. This is reflected in the annual rankings of liveable cities by (separately) the Economist's Intelligence Unit, Mercer, and Monocle (Ministry of Foreign Affairs, Denmark, 2013; Parakatil, 2013; The Economist Intelligence Unit, 2013).

Taking cognisance of these arguments, the CAM defines a 'sustainability and liveability space' within which the performance of a city can be measured, so that baseline performance can be established and the effects of interventions assessed. The space chosen is relevant to urban development and regeneration, and the policies and priorities of UK cities set within their national context. A structured approach adapted from the management literature is adopted to allow for deconstruction and operationalisation.

A review of the academic and practitioner literature on urban development and regeneration as it relates to sustainability and liveability gave rise to three themes:

1. performance
    a. wellbeing (including community and individual wellbeing)

   b. resource use (including scarcity, security and efficiency)
   c. greenhouse gas emissions (including CO_2 emissions)
2. context
   a. built and natural environment
   b. governance and policy
   c. economy and finance
   d. society (including behaviour, social norms and practices)
3. drivers of change
   a. technology and innovation
   b. changing populations (including population growth and aging populations)
   c. peak resources (including energy and food, and competition for resources)
   d. climate change
   e. global urbanisation.

The three items grouped under ‘performance’ underpin the CAM: wellbeing, resources and emissions. These three aspects of performance define the sustainability and liveability space measured by the CAM. The four items grouped under ‘context’ constitute the context within which the city performs: the city’s physical environment, governance structures, economy and social environment. They are included in the CAM as they enable the interpretation of city performance. The five items grouped under ‘drivers of change’ come into play when designing interventions that will lead to sustainable and liveable cities of the future, and as such fall outside the CAM, but not outside the Liveable Cities research programme.

The application and interpretation of sustainability (and liveability) can only be done in context (Bell and Morse, 2008). The CAM takes the UK as its context, and thus translation of its operation and outcomes to other national contexts requires due consideration. The following describes the CAM's sustainability and liveability space as it relates to the UK.

2.1.1 Wellbeing

In 2010 the UK's Prime Minister recognised the need to supplement economic measures of progress by commissioning the Office for National Statistics (ONS) to develop measures of 'national wellbeing and progress' (House of Commons Environmental Audit Committee, 2012, p. 5). This is one of two recent wellbeing initiatives in the UK, the other being the sustainable development indicators produced by Defra (2013). The Defra indicators measure intergenerational wellbeing (wellbeing across generations) whilst the ONS initiative measures wellbeing within one generation. This two-pronged approach has been criticised by the House of Commons Environmental Audit Committee (2012) as confusing for the public and policymakers. To avoid this confusion the CAM measures both current and intergenerational wellbeing.

The *National Health Service Act 1946* (*National Health Service Act 1946*) sets out the provision for physical and mental health in the UK as part of a nationalised system. Until recently the NHS sat apart from the services delivered by local councils. This changed with the *Health and Social Care Act 2012* (*Health and Social Care Act 2012*), which made health the responsibility of local councils. The importance of wellbeing gained prominence in the UK with a Foresight report commissioned by the Government Office for Science on Mental Capital and Wellbeing (Foresight Mental Capital and

Wellbeing Project, 2008). This was followed by Marmot *et al.* (2010), which explored the impacts of social factors on physical and mental wellbeing. Collectively, they reflect that many of the factors that promote wellbeing are, in fact, within the purview of local councils, such as transport, education, housing and planning (Aked *et al.*, 2010). The CAM reflects this thinking and also acknowledges that liveable cities are those that support individual and community wellbeing (Newman, 1999).

2.1.2 Resources

In the UK securing the supply of resources is recognised as a national priority and it forms the second underpinning priority for the CAM. 2012 saw the publication of the Resource Security Action Plan (BIS and Defra, 2012). This report recognises that the UK operates within a global system where resource supplies are subject to increasing demand, physical and geopolitical risks. In addition, many of the UK's resources are imported, although it does have indigenous sources of construction and some industrial materials and some capacity to increase local production. This exposes the UK, and UK businesses, to vulnerabilities.

Resource security (ensuring security of supply) must incorporate resource efficiency (efficient use of resources) (Dobbs *et al.*, 2011). For the supply of resources to be truly secure it must be secure over time. As all resources are finite their security over time can only be ensured if their current use does not exceed their ability to regenerate or recycle (acknowledging that some resources cannot regenerate or recycle). Furthermore, the efficiency of resource use must equal or exceed the resource's regeneration/recycle rate if diminished availability is to be avoided in the future. However, it should be noted

that this relationship does not necessarily hold in reverse: the efficient use of resources can be achieved with resources that do not have a secure supply chain.

The interactions between resource use, CO_2 emissions (see below) and wellbeing gave rise to six categories of resources fundamental to UK city processes and incorporated into the CAM: energy, waste, water, food, carbon-intensive materials and people (in particular, daily commuting and annual migration). Seven carbon-intensive materials were identified: steel; aluminium; cement; plastic; paper (Allwood *et al.*, 2011); glass (of particular relevance to the case study city of Birmingham, UK); and sand, gravel and aggregates (construction materials such as these being heavy, bulky and carbon-intensive to transport). The CAM utilises material and energy flow analyses (MEFA) to more fully understand a city's resource security and efficiency (Hunt *et al.*, 2014; Lee *et al.*, 2014).

2.1.3 Emissions

The *Climate Change Act 2008* (*Climate Change Act 2008*, p. 1) saw passing into law the UK's commitment "to ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline". Achievement of this target is the third underpinning priority for the CAM. Figures for CO_2 emissions for the UK and for UK cities are available, but this measure alone reveals little about how the emissions came about, from where and by whom. If the purpose is to implement interventions to reduce anthropogenic CO_2 emissions, it is more useful to consider the activities that contribute to the emissions. These activities can be technological, such as emissions from an industrial process, or behavioural, such as choosing to drive a car with an internal combustion engine or one powered by electricity. The combination of the types of technologies and how they are used gives rise to anthropogenic CO_2 emissions (Hunt *et al.*, 2013). The CAM uses the

MEFAs previously described as a basis for calculating CO_2 emissions, attributing CO_2 emissions to each element of a flow to build a picture of the city's emissions related to its resource use (Hunt *et al.*, 2014; Lee *et al.*, 2014).

2.2 Designing the lens framework

A lens framework has been established based upon the three pillars of sustainability plus governance. This reflects the UK Government's approach to sustainability as well as drawing in the four contextual priorities identified in the literature review (built and natural environment, governance and policy, economy and finance, and society).

In *Securing the Future* (Defra, 2005, p. 16) the UK Government set out its five pillars of sustainable development. Whilst all UK policies must be underpinned by all five pillars, they do not have to be equally prioritised. Within the pillars, the government recognises the interconnectedness of the three core pillars of sustainability: economic, social and environmental. The five pillars are:

1. living within environmental limits: respecting the limits of the planet's environment, resources and biodiversity – to improve our environment and ensure that the natural resources needed for life are unimpaired and remain so for future generations
2. ensuring a strong, healthy and just society: meeting the diverse needs of all people in existing and future communities, promoting personal wellbeing, social cohesion and inclusion, and creating equal opportunity for all
3. achieving a sustainable economy: building a strong, stable and sustainable economy which provides prosperity and opportunities for all, and in which

environmental and social costs fall on those who impose them (polluter pays), and efficient resource use is incentivised

4. promoting good governance: actively promoting effective, participative systems of governance in all levels of society – engaging people's creativity, energy, and diversity
5. using sound science responsibility: ensuring policy is developed and implemented on the basis of strong scientific evidence, whilst taking into account scientific uncertainty (through the precautionary principle) as well as public attitudes and values.

Whilst the five pillars themselves have remained unchanged since 2005, what has changed is their relative emphasis. In 2005 the Government stated that "We want to achieve our goals of living within environmental limits and a just society, and we will do it by means of a sustainable economy, good governance, and sound science" (Defra, 2005, p. 17). By 2011 there had been a change in emphasis towards economic growth: "The government has initiated a series of growth reviews to put the UK on a path to a strong, sustainable and balanced growth. Our long term economic growth relies on protecting and enhancing the environmental resources that underpin it, and paying due regard to social needs" (House of Commons Environmental Audit Committee, 2011, p. 12). It is not the purpose of this paper to explore the underpinning reasons for this, but certainly the recent financial crisis has played its part, thus emphasising the role of context in shaping visions and the need for new business models that capture social and environmental value alongside economic value. Coupled with the Government's localism policy, the effect has been an emphasis upon leveraging market forces, bringing with it

the concomitant need for financial return and relaxing of sustainability criteria (Tallon, 2013).

Effective urban assessment methods should establish causal chains and interdependencies both between systems and between measures (Repetti and Desthieux, 2006). There is no 'industry standard' method for achieving this within the sustainability and liveability assessment literature (nor, indeed, within the wider urban management literature) (Repetti and Desthieux, 2006). However, there is within the organisational management literature. The classic strategic planning hierarchy is a structured approach to deconstructing and making operational vision statements by linking them to business objectives, strategic goals, success factors, action plans, and finally performance measures (Bititci *et al.*, 1997; Bordum, 2010). CH2M HILL used this structure to create their sustainable city framework (CH2M HILL, 2011).

The lens framework draws upon the strategic planning hierarchy and CH2M HILL's Sustainable City Network, adapting them to the UK urban context and the CAM's sustainability space. The result links the CAM's four lenses to a set of goals, which have arising actions and measures (see Figure 1). The lens framework is designed to enhance (rather than compromise) wellbeing, resource security and low-carbon living and to make clear the pathways to impact: each lens has associated goals that are delivered via actions, the impacts of which are measured. In practice, tensions between priorities are inevitable, but by using the lens framework to assess the impact of interventions trade-offs will be made explicit.

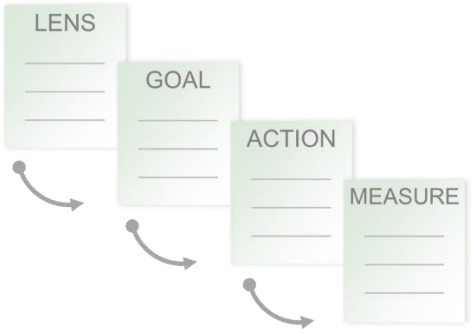

Figure 1. Lens framework.

2.3 The CAM

Each level of the lens framework was informed by the literature review and UK government priorities, initiatives and policies. In addition, a series of consultation meetings was held with the members of the Liveable Cities academic team who have expertise in wellbeing, urban design, engineering, planning, architecture, social sciences, mobilities, aspirations, energy, water, transport, governance and policy, economics and financing, business models, biodiversity, ecosystem services, urban geography, density and decision-making. The result is a theoretical framework for analysing city performance. Future work includes testing the framework with practitioners and on three UK cities: Birmingham, Lancaster and Southampton.

The first level of the lens framework is the four lenses previously described: society, environment, economy and finance, and governance and policy. Goals form the second level of the framework. Goals disaggregate the lenses into a small number of desired outcomes. Goals are not specific enough to set policies or measure performance. Associated actions are therefore required to provide enhanced detail and desired directions of travel. These actions form the third level of the framework, as illustrated in the following examples.

1. Lens: society
    - goal: enhance community and individual wellbeing
        a. action: promote healthy living and healthy long lives
        b. action: increase the match between city dweller aspirations and wellbeing
        c. action: minimise ill-being
        d. action: maximise social and cultural benefit
    - goal: ensure equity (fairness)
        a. action: ensure an enabling physical environment to maximise individual capabilities in the context of carbon reduction and resource security
        b. action: ensure an enabling social environment to maximise individual capabilities in the context of carbon reduction and resource security
        c. action: ensure an enabling economic environment to maximise individual capabilities in the context of carbon reduction and resource security
2. Lens: environment
    - goal: enhance biodiversity and ecosystem services
        a. action: minimise the impact of urban density on biodiversity
        b. action: maximise cultural services (health benefits, recreation, opportunities for outdoor learning)
    - goal: ensure resource efficiency
        a. action: minimise energy use and waste (including heat and CO_2 emissions) and maximise energy efficiency

b. action: increase the match between wellbeing and minimising high-carbon mobilities while maximising low-carbon mobilities and immobilities of people and objects
c. action: minimise potable and non-potable water use and waste (including leakage) and maximise water efficiency
d. action: minimise food use and waste and maximise food efficiency
e. action: minimise carbon-intensive materials use and waste and maximise their efficiency
f. action: minimise other waste produced and maximise its reuse, recycling, repurposing
g. action: increase awareness of, and interest in, environmental and climate change issues

- goal: ensure resource security
    a. action: increase the match between people's aspirations for cities and resource secure cities
    b. action: increase the match between city dwellers' aspirations and resource secure living
    c. action: maximise sustainable use of low-carbon local energy first and then maximise the security of supply of non-local energy
    d. action: maximise sustainable use of local water first and then maximise the security of supply of non-local water
    e. action: maximise sustainable use of local food first and then maximise the security of supply of non-local food

f. action: maximise sustainable use of local carbon-intensive materials first and then maximise the security of supply of non-local carbon-intensive materials

g. action: maximise sustainable use of local people first (e.g., utilising the local workforce and leveraging local skills) and then maximise the security of supply of non-local people

3. Lens: economy and finance

- goal: maximise sustainable financial investment
    a. action: maximise investment portfolio structuring designed to support investment with environmental objectives
- goal: ensure economic vitality
    a. action: uncouple economic vitality from the CO_2 emissions associated with economic growth

4. Lens: governance and policy

- goal: ensure appropriate governance
    a. action: selection of appropriate governance mechanisms, styles and structures to promote liveability
    b. action: uncouple governance structures and timescales from political cycles and ‘colour’ of governing bodies
- goal: ensure appropriate policies
    a. action: selection and implementation of appropriate policy mechanisms to promote liveability
    b. action: uncouple policy-making and policy timescales from political cycles and ‘colour’ of governing bodies.

Achievement of actions is assessed by measuring city performance. The CAM consists of a set of metrics and indicators designed to measure the performance of a city. Metrics can be thought of as those aspects of city performance being measured; e.g., age of usual resident population. Indicators can be thought of as the presentation of the metrics, e.g., mean age of the usual resident population. One metric can be associated with multiple indicators. For example, the metric 'age of usual resident population' is associated with 'mean age of usual resident population', 'median age of usual resident population', 'percentage of the usual resident population that are children', and 'percentage of the usual resident population that are senior citizens'.

Indicators fall into two broad types: contextual and performance. A contextual indicator does not have merit on its own, but provides valuable information for the interpretation of other indicators (for example, number of inhabitants). A performance indicator speaks on its own to the issues being addressed (for example, healthy life expectancy), an adaptation that complements those presented elsewhere (UN, 1993; adapted from Mant, 2001; Bell and Morse, 2008). Indicators frequently give rise to statistics, as they do for Eurostat, the statistical office of the European Union (see http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home). They are not, however, constrained to numerical representation, as statistics are. Indicators can be qualitative in nature as well as quantitative (Bell and Morse, 2008). Both types of data and both types of indicators are included in the CAM.

A review of the sustainability and liveability measurement literature reveals a number of desirable properties for the CAM's indicators, with two useful additions (numbers 15 and 16):

1. be simple, elegant and effective (Harger and Meyer, 1996; Hardi and Zdan, 1997; UN, 2001b ; Repetti and Desthieux, 2006).
2. holistically address sustainability – and liveability (Harger and Meyer, 1996; Maclaren, 1996; Hardi and Zdan, 1997; UN, 2001a)
3. be measurable, where possible in a standardised way (Harger and Meyer, 1996; Hardi and Zdan, 1997)
4. overlap as little as possible (Harger and Meyer, 1996)
5. be sensitive to change (Harger and Meyer, 1996)
6. be conceptually sound (Bossel, 2001; UN, 2001a)
7. do not compromise underlying complexity (Bossel, 2001; UN, 2001b; Repetti and Desthieux, 2006)
8. be easy to understand, clear and unambiguous (UN, 2001a)
9. be relevant and easy to use in decision-making (Hardi and Zdan, 1997; UN, 2001b)
10. primarily use existing data or data that are easy to obtain in a reasonable timescale and at reasonable cost (UN, 2001a)
11. measure and calibrate progress toward agreed goals in agreed timeframes (Harger and Meyer, 1996; Hardi and Zdan, 1997; UN, 2001a; House of Commons Environmental Audit Committee, 2012)
12. assess trends, incorporating relative and absolute changes (Harger and Meyer, 1996; Hardi and Zdan, 1997)
13. have clear boundaries – noting that varying boundaries to suit the question is beneficial, but requires the context is appropriately set (Bossel, 2001; Bell and Morse, 2008)

14. are organised in a useful way (Hardi and Zdan, 1997; Bossel, 2001)
15. incorporate subjective and objective measures
16. consider all aspects of an issue: consumption and production, demand and supply.

A number of mechanisms have been used to identify the CAM metrics and indicators. This included a top-down approach using the lens framework to identify a causal chain as described above. As this work progressed it was important to allow bottom-up and middle-out associations to be made. Therefore, the metrics and indicators were disassociated from the lens framework, 21 themes were identified and complementary metrics within these themes researched and added where appropriate. Their interpretation is dependent upon the context within which the city performs: its built and natural environment, governance and policies, economy and finance, and society. In order to identify the best contextual measures for the UK a systematic review of the measures gathered by the UK's ONS was conducted.

Currently the CAM contains 231 metrics giving rise to 288 indicators, although this may change as UK city performance data are gathered and analysed. The resultant set of metrics and indicators, along with their associated actions, goals and lenses comprise the CAM.

3 Discussions

Infrastructure systems provide the structures and mechanisms through which cities function at their most basic: supplying energy and water, removing waste, etc. Infrastructure systems also provide the structures and mechanisms though which cities function at their most sophisticated: ICT, integrated public transport, low-carbon energy,

re-use and recycling, sustainable communities, etc. Thus infrastructure is crucial in achieving urban sustainability and liveability. The lens framework, on which the CAM is based, elucidates causal chains and interdependencies both between systems and between indicators. This aids decision-makers in understanding the implications of their decisions not only on the desired indicators, but on the system of which the measure is a part and on other systems. For example, the city of Birmingham in the UK is currently extending its light rail (metro) system into the heart of the city. One of the aims is to increase the number of people who take public transport and to reduce the number of people who access the city by private car. Within the CAM the direct impacts of this intervention are measured using the indicators associated with the action: increase the match between wellbeing and minimising high-carbon mobilities while maximising low-carbon mobilities and immobilities of people and objects. Ascending a level (to that of goals) in the CAM hierarchy shows that this intervention affects the greater goal of resource efficiency, which is perhaps obvious. Less obvious is the link between extending the metro and minimising carbon-intensive materials (an action that sits in the same family of actions as increasing the match between wellbeing and minimising high-carbon mobilities...). Reducing car use reduces the demand for cars and with fewer cars manufactured, less steel and aluminium are used in the automotive industry. The goal of ensuring resource efficiency sits within the environment lens alongside enhancing biodiversity and ecosystem services. Enhancing biodiversity and ecosystem services has the related action of maximising cultural services (including health benefits, recreation and opportunities for outdoor learning). With fewer cars in Birmingham, fewer roads and car parks are required and more space can be given over to recreational facilities with concomitant health benefits. In addition, fewer cars mean less pollution, which is also

good for health. Health benefits can be measured using the CAM by ascending to the highest level (that of the lens) and drilling down through the goal of enhancing community and individual wellbeing to the action of promoting healthy living and healthy long lives to the associated performance indicators. Figure 2 visually represents these interdependencies.

By navigating the CAM in this way, users are able to decide which relationships apply to a given intervention and context, what the areas of priority are and where performance needs to be measured. In an ideal world with no restrictions upon resources, capacities or capabilities, and no changing context, the full CAM would be used to measure performance before and after any type of intervention. In the real world this simply is not possible and so the CAM elucidates potential interactions and provides related measures of performance.

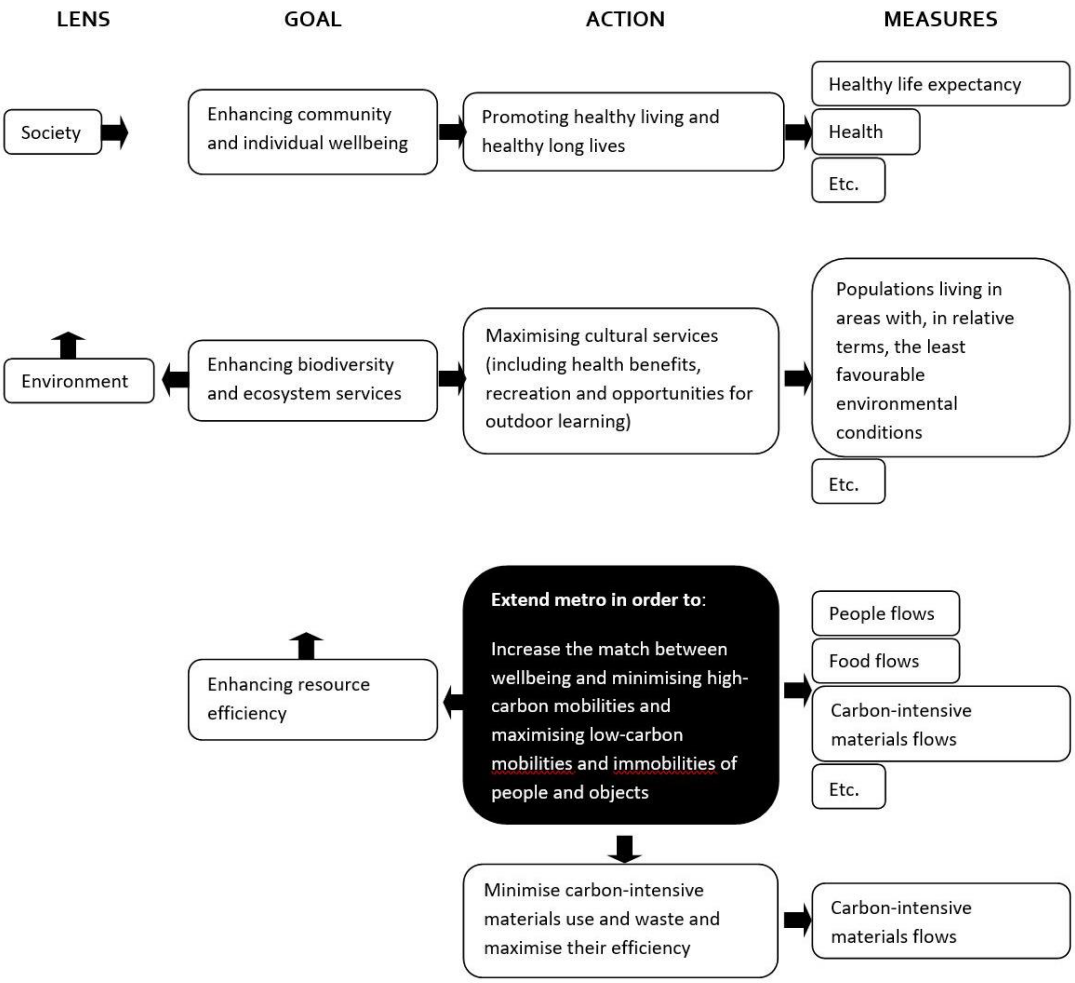

Figure 2. Using the lens framework to identify interdependencies.

Although knowing the impacts of implementing interventions has value, ameliorating unforeseen or unintended negative impacts once an intervention is in place can be difficult, time consuming and costly (Lombardi *et al.*, 2011). Being aware of negative impacts prior to implementation allows for interventions to be redesigned to minimise negative impacts and maximise positive impacts. To this end the CAM can be used to theoretically assess impacts before implementation. For this, users should consult as many disciplines as possible to ensure different perspectives are considered and a more robust outcome results (Lombardi *et al.*, 2011), and a structured approach to identifying

the full range of potential intended benefits of the intervention, and whether the conditions are in place for those benefits to be delivered now and in the future, should be followed (such as the designing resilient cities methodology; see Lombardi *et al.* (2012)). In addition, citizens should be empowered within this process to create and deliver their city's narrative – an embellished city vision that incorporates the city's history, current context and future vision (Rogers *et al.*, 2014).

The CAM described herein is a tool to measure the impacts of change. It does not measure progress towards sustainability or liveability (acknowledging that these are not an end state as such, but a direction of travel). To do this two additional aspects will be introduced to the CAM:

1. setting targets and timescales
2. incorporating relative and absolute changes.

Performance indicators must have targets in order to be meaningful and the targets must have a temporal aspect to them (Harger and Meyer, 1996; Hardi and Zdan, 1997; UN 2001; House of Commons Environmental Audit Committee, 2012). At its most basic level, a target describes a desired end point and deadline for achieving it. A more nuanced and insightful target acknowledges that not all targets can be achieved using a linear approach and thus incorporates magnitude and speed of change (Leach *et al.*, 2014). Relative changes in performance are important, but should not be at the exclusion of absolute changes. In some cases, for example, there is a threshold in the economic viability of securing a resource, a tipping point in a natural system, or a point in time where a resource will have been exploited.

Lastly, it is important to reiterate that the CAM is built upon international academic and practitioner literature and practice refined specifically for the UK. Transferability of the framework to other national contexts will require adjustment to the CAM. The results may be variable as different countries have different levels of sustainability and liveability embedded into legislature and guidance – that is they have a different context, reinforcing the observation that what might be effective in moving one city towards a more sustainable and liveable state might not be effective in another city.

4. Conclusions

This paper describes the process followed to design and populate a framework for measuring city performance: the CAM. The CAM is used to measure 'as is' city performance. It describes a specified, UK sustainability and liveability space that prioritises wellbeing, resource security and CO_2 emissions. It is part of a five-year programme of research, the Liveable Cities programme, set up to identify and test radical interventions that will lead to more sustainable and liveable cities of the future. The CAM provides a baseline of city performance against which to identify and prioritise aspects that would benefit from change and then to assess the impact of any proposed interventions (measuring performance before and after interventions). This allows gaps in performance to be identified, barriers to achieving a more sustainable and liveable future elucidated, and robust interventions to be designed and assessed. The challenge is in attributing changes to implemented interventions in complex city systems where it is impossible to hold all other variables constant. In this respect, by applying the CAM in full before and after an intervention it may only be possible to identify that a significant,

broadly positive or negative, change in city performance has occurred – there being changes in several of the CAM's indicators relative to the baseline. This is because other aspects of city performance might well have altered, i.e., the context in which the intervention has been implemented has changed. This means that further work is required to unpick how much can be attributed to the implemented intervention. Nevertheless, what the CAM does offer, once the baseline performance of a city has been established, is the opportunity to hypothesise how an intervention would impact the many indicators. This enables a refinement of the analysis, embedded in the Designing Resilient Cities methodology (Lombardi *et al*., 2012), to be undertaken: identifying and then embellishing all of the potential intended benefits from the intervention, establishing the conditions necessary for those benefits to be delivered, determining whether those conditions are in place (now and in the future), and predicting the consequences (or impacts) of the intervention. As such, it adds a powerful 'enabler' to the suite of tools aimed at practitioners, city leaders and policy-makers who seek to meet the aspirations of their citizens while making their cities more sustainable, resilient and liveable.

Data availability

The underpinning data for this publication are currently available from the lead author and will be made available in an open access data depository six months after the completion of the Liveable Cities research programme (November 2017), as future papers will draw upon these data.

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Paper 3. Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK.

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Abstract

Despite the attention sustainability-related urban measurement and assessment methods have received it is still not well understood how accurate (or not) the various methods are; their limitations in holistic city performance assessment; or, how they can be effectively used to better the design of the urban environment, city services and policies. Necessarily, urban measurement and assessment methods focus upon what is known. However, reflecting upon the unknowns and their impacts has the potential to deliver crucial insights into the assessment of city performance and governance. To this end, this study applies and critiques the city performance measurement and assessment method UK City $LIFE_1$ in order to explore the challenges of, and prospects for, filling these gaps. UK City $LIFE_1$ is designed to measure 'livable sustainability' at the city scale for the purpose of aiding UK policy makers and urban design decisionmakers. Results suggest that definitional uncertainties, the availability and viability of data, and the design of the method introduce inaccuracy, uncertainty and bias into data interpretation. This, combined with the complexity of city systems and the nascent 'science of cities', prevents causal effects from being fully described, potentially rendering decision-makers impotent. However, the language of 'realizing the multiple benefits of interventions' and 'coupling

and uncoupling relationships' alongside making the unknown explicit has the potential to empower decisionmakers in the face of absent and disconnected data and interpretational challenges.

1. Introduction

Cities are now the dominant form for human habitation (United Nations, Department of Economic and Social Affairs, Population Division, 2014), the dominant depleters of planetary resources (Bai, 2007) and the dominant producers of CO_2 emissions (Nordbo *et al.*, 2012). As such, cities have become the simultaneous saviors and destroyers of human coexistence with the planet. As centers of innovation and culture (Atheyetal., 2007; Vojnovic, 2014), cities are the means by which humans can live sustainable lifestyles, balancing environmental, economic and social priorities, taking advantage of economies of scale and their concomitant efficiencies (Dodman, 2009; Klopp and Petretta, 2017). As wielders of large demand footprints (Folke *et al.*, 1997), cities are the means by which humans can live unsustainable lifestyles, ignorant of food, energy and waste processes (amongst others) with the potential to compromise a healthy, sustained and livable future.

Addressing the capacity and capability of cities to effectively deliver sustainability—and livability—has been the subject of much recent academic and practitioner effort (Wong, 2006; Bell and Morse, 2008; Gough, 2015; Kitchin *et al.*, 2015; Leach *et al.*, 2016; Lynch and Mosbah, 2017). These efforts draw upon an increasing pool of methods for urban measurement and assessment such as, material flow analysis, indicators, scenarios, footprinting, life cycle assessment, multi-criteria analysis and

computer modelling (Astleithner and Hamedinger, 2003; Ness *et al.*, 2007; Mayer, 2008; Pires *et al.*, 2014; Kitchin *et al.*, 2015; Leach *et al.*, 2015).

Despite the attention urban measurement and assessment has received and the sophistication of the available methods it is still not well understood how accurate (or not) the various methods are; their limitations in holistic city performance assessment; or, how they can be effectively used to better the design of the urban environment, city services and policies (Kitchin *et al.*, 2015; *Leach et al.*, 2016). In part this is because of definitional challenges, with neither sustainability nor livability having agreed definitions (Kidd, 1992; Connelly, 2007; Bell and Morse, 2008; Tanguay *et al.*, 2010; Vojnovic, 2014; Gough, 2015; Leach *et al.*, 2016) and that our understanding of these concepts isn't fixed, but changes over time and contexts (Astleithner and Hamedinger, 2003; Connelly, 2007; Portney, 2013). It is also because our understanding of how cities operate and how they are best governed is incomplete (Batty, 2012; Vojnovic, 2014). In truth, there is no 'one' way a city behaves. For example, cities change along multiple temporal scales: centuries, decades, political cycles, yearly seasons, day to night, hour to hour. They also change along multiple geographic scales: city quarters, neighborhoods, streets and households. Urban measurement and assessment methods are one attempt at developing this understanding: they capture what is known about a city and assess its value (e.g., via benchmarking against the performance of other cities or extrapolating performance into the future).

Necessarily, urban measurement and assessment methods focus upon what is known. However, reflecting upon the unknowns and their impacts has the potential to deliver crucial insights into the assessment of city performance and governance. Many critiques of urban measurement and assessment methods exist (see for examples Morse

(2004); Ghosh (2006); Pinfield (2007); Mayer (2008); Lyytimäki *et al.* (2011); Mori and Christodoulou (2012); Pires *et al.* (2014); Dawodu *et al.* (2017); Klopp and Petretta (2017); Lynch and Mosbah (2017)). What are less common are critiques that cover design as well as application and interpretation. Yet it is inevitably the case that in understanding the complete process of designing, applying and interpreting a method, a richer picture emerges of the (unavoidably) compromised view of the city afforded by the method. Such insights can be used to improve measurement and assessment methods, inform decision-making and influence governance practices.

Within this context, this paper describes the design, application and interpretation of UK City LIFE$_1$ (UK City Livable-sustainability Indicator Framework Edition 1) – a city performance measurement and assessment method that is designed for the comprehensive and holistic measurement of livable sustainability (the delivery of livability alongside sustainability (Gough, 2015)), to the city of Birmingham, UK, for the purpose of addressing the study's three primary research questions: (1) Is it possible, in practice, to holistically and at the city scale measure a UK city's livable sustainability? (2) What challenges and gaps arise and can these be overcome? and (3) How can the outcomes be interpreted to aid local authority decision-making in the UK?

The study triangulates information from three strands of analysis, described in the subsequent sections of this paper: a review of the sustainability and livability measurement and assessment literature (Section 2), a critical assessment of the design and application of UK City LIFE$_1$ to the city of Birmingham, UK (Section 3) and a critical reflection upon the interpretation of UK City LIFE$_1$, taken with UK local authorities, urban design decisionmakers and urban professionals (Section 4). Section 5 discusses the outcomes and sets out the conclusions of the study.

This research was conducted as part of the development of the Livable Cities' decision-making method, a decision-support tool designed to assist urban design professionals in thinking holistically, complexly and long-term when making interventions in an urban environment, which can range from the delivery of city services to urban regeneration to policy formulation. The work forms part of the Livable Cities Program Grant.

2. A review of the sustainability and livability measurement and assessment literature

Current city performance measurement and assessment methods are many and vary in criteria, measurement methodology, robustness, transparency and applicability to specific urban contexts, with no single method dominating (Kitchin *et al.*, 2015; Leach *et al.*, 2016). This presents a challenge to policymakers and others wishing to use these methods to inform policy (Mayer, 2008).

City performance data for urban design decision-making and policymaking are almost universally expressed in the form of indicators (Kitchin *et al.*, 2015). As such, this paper will focus upon indicator based city performance measurement and assessment methods. Indicators provide information about the object of the data or are used as a representation of an associated factor (Business Dictionary, 2016; Oxford Dictionaries, 2016). For example, GDP (gross domestic product) and employment rate are both indicators of economic performance. Used wisely, indicators can effectively measure city performance (Bell and Morse, 2008; Kitchin *et al.*, 2015) whilst guarding against the tendency for them to compromise creativity (Leach *et al.*, 2015). This section describes the principles, challenges and gaps for the design, application and interpretation of indicator-based urban sustainability and livability performance measurement and

assessment suggested by the literature. An exploratory literature survey was undertaken to collect and analyze written sources that contributed to understanding the principles, challenges and gaps. Literature from 1992 to 2017 were considered to coincide with the Rio Earth Summit and the establishment of Agenda 21 (the local implementation strategy for global sustainability and climate change mitigation), which gave rise to a proliferation of sustainability- and livability-focused measurement and assessment methods (Kitchin *et al.*, 2015).

2.1. Designing urban measurement and assessment methods: a review of the literature

The criteria for designing successful indicator-based measurement and assessment methods are diverse and contested (Mayer, 2008). Inevitably, indicator choice is, at some stage in the process, based upon arbitrary decisions (Niemeijer and de Groot, 2008). This said, there are principles that should be followed where possible and these are described here.

Consideration should be given to how interpretation is influenced by the conceptualization and measurement of the performance criteria (Marans and Stimson, 2011). In order for performance data to be useful, a determination of what constitutes 'good' performance must be made. Who does this, and how, materially influences the conclusions drawn (Kitchin *et al.*, 2015; Mackenzie, 2008). As such, the transparency of this information is crucial for policymaking (Kitchin *et al.*, 2015).

Performance measurement should be accompanied by a performance assessment framework that allows for the accurate and clear interpretation of the data (Mayer, 2008). The framework should have a clearly defined area of focus (e.g., livable sustainability), be designed for the context in which the measurements are to be taken (e.g., cities in the

UK), evidence a clear causal chain, make explicit interdependencies and extend across disciplinary and professional siloes (e.g., architecture, engineering, planning and governance) (Leach *et al.*, 2016).

Selecting or designing a performance assessment framework and indicators useful for policymaking requires careful consideration. Any given framework should be holistic with minimal overlap, be simple (without compromising any underlying complexity), include subjective and objective perspectives as well as quantitative and qualitative data, be usefully organized and be relevant to decision-making (Leach *et al.*, 2016). The individual indicators should be simple, elegant, effective, sensitive to change, measurable and verifiable (preferably in a standardized way), conceptually sound, understandable, unambiguous, objective (value-free) and draw upon data that either exist or are relatively easy to obtain (Kitchin *et al.*, 2015; Leach *et al.*, 2016).

Perhaps most importantly, however, is designing a city performance measurement and assessment method that is fit for purpose. This requires a clear understanding of the intended use of the outcomes and the best-fit mechanism for achieving this. Parris and Kates (2003) identify four purposes for sustainability assessments: (1) decision making and management, (2) advocacy, (3) participation and consensus building and (4) research and analysis. Kitchin *et al.* (2015) identify two broad mechanisms for achieving these purposes: (1) indicators for description and providing context; and, (2) indicators for diagnostics, determining performance and progress towards targets.

2.2. Applying urban measurement and assessment methods: a review of the literature

The application of urban measurement and assessment methods is carried out by various stakeholders for various reasons. These include academic initiatives, such as Biophilic

Cities, the Designing Resilient Cities Method and SuBSelec (Tanguay *et al.*, 2010; Lombardi *et al.*, 2012; The Biophilic Cities Project, no date); public-sector initiatives such as the many bespoke city dashboards that exist and the Urban Audit (Gough, 2015; Kitchin *et al.*, 2015; European Commission, no date); third/other sector initiatives, such as the Urban Sustainable Development Goals, ICLEI's Local Authorities Self-Assessment of Local Agenda 21 (LASALA) tool and the City Biodiversity Index (Convention on Biological Diversity, 2013; ICLEI, no date; United Nations, no date); and, private sector initiatives, such as 100 Resilient Cities, Arcadis' Sustainable Cities Index and the Economist's Global Livability Ranking, (S, C and D, 2014; Arcadis, 2015; Rockefeller Foundation, no date).

The motivations for these initiatives vary. As generalizations, academic and public-sector initiatives seek to add to the knowledge base through the creation of new knowledge in order to increase understanding and inform decisions. Third and other sector initiatives usually have philanthropic goals. Private-sector initiatives are used to enhance the organization's offering. Motivations must be understood in order to put the arising outcomes into context. For example, if a measurement and assessment method has been designed to enhance a private organization's economic offering, this may have affected the balance of the method, skewing it towards the organization's strengths and away from its weaknesses.

The choice of urban measurement and assessment method is important. Different results can be obtained from the same data if different methods of assessment are used (Mayer, 2008). Bespoke methods benefit from being designed to be fit for purpose (e.g., specific geographic or thematic contexts). The tradeoff is that understanding issues that go beyond the chosen geographic boundary (such as sustainability, which operates

beyond the city scale at regional, national and global scales) or theme (e.g., water, which is closely tied to energy and water) is compromised making meaningful benchmarking impossible to achieve. A challenge for any sustainability-related urban measurement and assessment method is to generate holistic understanding within and outwith the city.

It is also important to be cognizant of the capacity and capabilities of those applying the method. For example, in the UK there are particular challenges faced by the public sector in applying, interpreting and maintaining a city performance measurement regime. In recent years the capability and capacity of Local Authorities to undertake these (and many other) tasks has been severely compromised by austerity and concomitant budget cuts (Lowndes, 2013; The Economist, 2017). Without appropriate resources, UK Local Authorities will struggle to decide what data to collect and to acquire the specialized knowledge and skills for their collection and analysis.

For any initiative, data availability and viability are a potential problem. Kitchin *et al.* (2015) describe a number of potential data pitfalls. Do those applying the method have access to the necessary data? That is, do the data exist and are they made available? How current are the data to which they have access? Are the data in a form that is usable? Are they unbiased, reliable, accurate and at an appropriate scale? No matter how advanced the urban measurement and assessment method may be, if the data it uses are compromised in some way then so will be the data interpretation.

2.3. Interpreting urban measurement and assessment methods: a review of the literature

Some issues related to the interpretation of urban measurements have already been discussed. These include how interpretation is affected by the choice of measurement

method (its fit for purpose), its performance criteria, how it defines its subject area (e.g., sustainability, livability), and who carries out the application and interpretation.

Kitchin *et al.* (2015) describe a number of interpretational considerations. The authors make the argument that on the surface the data arising from urban measurement and assessment methods can appear to represent an 'absolute truth', but in fact many factors influence their ability to do this – and that the very existence of an absolute truth is a myth. They go on to say that data themselves cannot be separated from their contexts and the ideas that gave rise to them; they are not the manifestation of a static situation that can only be measured on one way, if the situation can be directly measured at all; and, data are generated from normative, value-laden processes. As such, it is the responsibility of interpreters of the data to fully understand the measurement data and assessment frameworks being used and to account for biases and unknowns.

Much of what has been written thus far in this paper relates to interpretation for the purpose of accurately describing and understanding an urban situation in as much detail as possible. The dashboards described by Kitchin *et al.* (2015) are one manifestation of this approach. Batty (2016) presents an alternative, or perhaps an evolution: understanding an urban situation in as little detail as necessary. What Batty advocates is urban theory building: "… abstract[ing] from an agreed reality, throwing away that which appears irrelevant to the purpose in hand and only keeping what appears to be essential to good explanation" (Batty, 2016, p. 797). One unifying theory of cities is unlikely to be achievable given the individual and collective complexities of cities, but theories of aspects of cities are achievable and can be combined and made manifest via urban measurement and assessment methods.

3. A critical assessment of the process of designing and applying UK City LIFE$_1$ to the city of Birmingham, UK

This section describes the processes of designing and applying UK City LIFE$_1$ to the city of Birmingham, UK, for the purpose of addressing two of the study's three research questions: (1) is it possible, in practice, to holistically and at the city scale measure a UK city's livable sustainability? and (2) what challenges and gaps arise and can these be overcome? The arising dataset, including all data sources and dates, are published in Leach *et al.* (2017).

Gough (2015) defines livable sustainability as the delivery of livability alongside sustainability: "…sustainable outcomes result over time through a series of livability outcomes. Together, the conceptual linkages between livability and sustainability reveal tensions, but also complementarities that can assist with the other's implementation" (Gough, 2015, p. 147). Livable sustainability arises from an inherent tension in measuring the sustainability performance of cities: that of scale. Sustainability is a long-term challenge with greatest relevance at global, national, regional, mega city and city region scales (Banai, 2012; Lynch and Mosbah, 2017). Livability makes sustainability relevant at the city and sub-city scales (Lynch and Mosbah, 2017). It achieves this largely by ignoring sustainability's long-term viewpoint, giving rise to the criticism that short-term interventions risk derailing long-term sustainability (Gough, 2015). In short, livable sustainability attempts to combine the long-term views of sustainability with the short-term impetus of livability (Gough, 2015).

UK City LIFE$_1$ has been developed by the authors as part of the Livable Cities research program (see www.livablecities.org.uk), which is devising interventions, and their means of implementation, to transform engineering to deliver societal and planetary

wellbeing. A cornerstone of the program's methodology is determining how UK cities are currently performing with regard to livable sustainability. This gave rise to the following research question: does there exist an effective way of assessing the livable sustainability performance of UK cities? A comprehensive review of existing livable sustainability-related measurement and assessment methods was undertaken and the results tested against the literature to determine their suitability for measuring UK urban livable sustainability. As none proved to be suitable, primarily due to the lack of comprehensive coverage or applicability to the UK context, a bespoke city analysis methodology was designed: one that applied the best available knowledge via effective indicators delivering comprehensive coverage within a city performance assessment framework. The city analysis methodology draws together a collective knowledge on city assessment that has been developing over recent decades with the most effective ways of assessing the livable sustainability performance of UK cities. UK City LIFE$_1$ is the embodiment of the outcome and, we contend, makes a unique contribution. Moreover, it enables a critique of the processes of its design, application and interpretation in a way that would not be possible if a pre-existing method had been chosen.

At the start of the design process the intended purpose and mechanism for UK City LIFE$_1$ were determined. It was imperative that these were returned to throughout the design, application and interpretation process in order to avoid scope creep.

- Purpose: decision-making and management, specifically aiding UK local authority decisionmakers. This focus led to compromises being made that might otherwise have been overcome. For example, data that are available to researchers but not local authorities were excluded, although the indicator was retained to make explicit what is missing. The purpose being to prompt

consideration by local authorities to collect these data or by data services to allow local authorities access to the data.

- Mechanism: indicators for description and providing content, which could be used as a baseline from which to backcast from a desired future scenario to elucidate barriers to its realization (as part of the Livable Cities research program).

In addition, an early assessment was made as to what constitutes ‘good’ performance. The performance being measured was scoped (i.e., livable sustainability) and initially it was assumed that there was a common understanding of what good performance entails. It quickly became apparent that this was not the case. A number of discussions, workshops and focus groups were organized between the authors, with the wider Livable Cities' academic team and with practitioner experts in order to converge upon a common understanding. At one point it seemed reasonable to deconstruct the problem by determining parameters of good performance for each of the method's indicators. However, this quickly proved impossible because for many of the indicators the literature does not support the allocation of absolute values and it is not possible to quantify the interactions between all the indicators. Instead, it was decided to set out an overriding principle of good performance: moving towards sustainability without compromising the livability of those who live in, work in and visit the city.

Following the literature review of existing sustainability-related measurement and assessment methods and consultation with practitioner experts it was decided that an indicator-based approach to measuring city performance was appropriate. This gave rise to an immediate tension between the usable number of indicators and the ambition to

comprehensively and holistically measure livable sustainability at the city scale. The literature advocates a limited number of indicators for any given method (Hardi and Zdan, 1997; Tanguay *et al.*, 2010), a view which was supported by practitioner experts, but this was determined to be insufficient to provide an in-depth understanding of city performance. Instead, an assessment framework was devised to assist with interpreting the indicators.

The framework incorporates an 'intelligent reductionist' approach to urban policymaking. It comprises four tiers (see Figure 1), derived from the classic strategic planning hierarchy (Leach *et al.*, 2014). The following summary is taken from a full description of the framework available in (Leach *et al.*, 2016). The least granular of the four tiers is that of the 'lens'. There are four lenses, aligned to the four commonly accepted pillars of sustainability: society, environment, economy and governance. This ensures a holistic approach. 'Goals' constitute the second tier, where each pillar of sustainability is broken-down into a set of desired outcomes, for example to 'enhance community and individual wellbeing'. 'Actions' form the third tier and break-down each goal into 'actionable activities' that, crucially, can be measured. An action connected to 'enhancing community and individual wellbeing' is to 'promote healthy living and healthy long lives'. Indicators form the fourth and final tier of the framework with groups of indicators aligned to individual actions. Aligned to 'promoting healthy living and healthy long lives' are the indicators 'healthy life expectancy', 'satisfaction with health' and 'avoidable mortality' to name only a few. In this way a causal chain and linkages (established from the literature) between indicators are mapped.

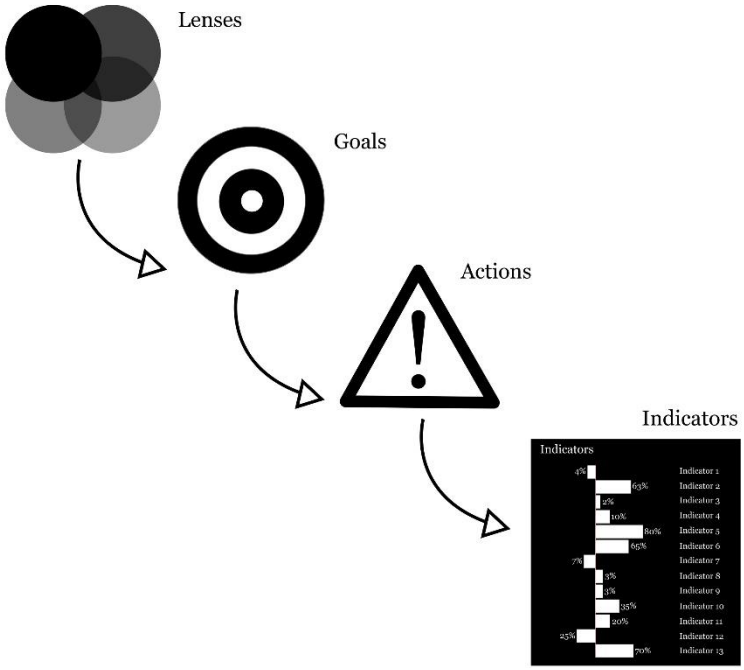

Figure 1. UK City $LIFE_1$ lens framework, derived from (Leach *et al.*, 2016).

In principle, the chosen framework complied with the best practice principles for such a framework and described in Subsection 2.1. The framework has a clearly defined area of focus (livable sustainability), is designed for the context in which the measurements are to be taken (UK cities), and evidences a clear causal chain and makes explicit interdependencies (via the four tier structure). In addition, it attempts to be holistic (extending across disciplinary and professional siloes) with minimal overlap, be simple (without compromising any underlying complexity), include subjective and objective perspectives as well as quantitative and qualitative data, be usefully organized and be relevant to decision-making. However, as the indicators were incorporated into the framework compromises had to be made.

The framework retained its holistic design, but data for approximately one third of the indicators either did not exist, were proprietary or were not viable at the city scale (e.g., the sample sizes were too small to be meaningful). The authors decided to retain

indicators that had null values so it is evident what is not included. The authors also made some compromises on data viability to ensure some data representation was made where possible.

Aligning indicators to actions meant that overlap between indicators was minimized but created another problem: some actions shared indicators in order to provide the fullest picture of the action in question. Sharing indicators was trialed, but proved to be too confusing for users. A stripped-back interpretation of the actions was developed to eradicate indicator sharing but this inevitably compromised some of the underlying complexity.

Subjective and objective indicators were explicitly included and existing indicators were preferenced as this meant data were more likely to exist. Even so, many subjective indicators simply did not exist and in these cases the authors created the indicator in order not to lose the desired subjective element. For example, to ensure a subjective perspective on food the following indicator was included despite there not being data collected for it: percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of food they use at home.

The framework was designed to incorporate quantitative and qualitative data types, but because the authors preferenced existing indicators over creating new ones, and because quantitative measures are dominant in indicator assessments (Kitchin *et al.*, 2015) UK City LIFE$_1$ is predominantly quantitative.

The assessment framework was designed to be usefully organized for local authority decision making. However, in the Birmingham application the cross-disciplinary approach (meaning it also crossed departmental siloes at the Council) and the time needed to engage with the framework proved difficult to overcome. It might be

argued that governance challenges faced by Birmingham City Council (Kerslake, 2014) and its ongoing restructuring exacerbated the problem.

The authors selected 346 indicators based upon their relevance to livable sustainability and the criteria presented in Subsection 2.1. The specifics of the selection process are beyond the scope of this paper, but briefly this entailed a thorough examination and cross-referencing of the livability and sustainability literature and existing livability- and sustainability-related assessment methods and their indicators to identify rigorous indicators, whether they existed or not, that comprehensively measured livable sustainability at the city scale and were relevant to the UK context. Despite these efforts, compromises had to be made during application of the indicators to the city of Birmingham.

As expected, data availability proved to be a defining challenge in applying UK City LIFE$_1$ to Birmingham. As previously discussed, during the design phase some data were known not to be available – such as where new indicators were created. During the application phase further data gaps were discovered. Various reasons existed for the unavailability of data. The most common was that data existed at the national, regional or neighborhood scales, but not the city scale and the existing data could not be disaggregated or aggregated. Some of these data are available through special license access from the UK Data Service, but this option is unavailable to local authorities and so was not pursued. In a small number of cases it was possible for the Livable Cities team to collect missing data using primary data collection techniques (e.g., surveys). These are restricted to those indicators whose data are collected by other organizations but not made available – imperfectly filling the data gap. For Birmingham, 92 of 346 total indicators are null (27%).

Using indicators that already exist over creating new indicators helped ensure that the indicators were measurable and verifiable in a standardized way. This strategy also increased the likelihood of data being collected for the indicator by third-party sources. Data were collected for 2011 as a first preference (given the prevalence of Census data, with the last UK Census conducted in 2011). Data for the least recent year after 2011 were selected as a second preference, with data for the most recent year prior to 2011 being the third preference. The disadvantage with this approach is that the Census data reflects a past and fixed point in time. Despite efforts to collect data for 2011 in order to provide as complete a snapshot in time as possible, inevitably this was not possible and data for different indicators are taken from different years.

Perhaps the most defining trade off that arose from the application of UK City $LIFE_1$ to Birmingham was that between data rigor and providing enough information for decision-making. Subsection 2.2 describes a number of data availability and viability issues, such as determining how biased, reliable and accurate the data are. Ideally, each data point would be assessed for compliance with all the criteria, but in reality this simply is not possible. Some compliance issues take preference, such as whether the data are in a usable format, because continuing without knowing this would prevent the data from being used at all. In many cases the information is not easily available and tracking it down would unrealistically delay performance measurement. As a panacea to this, by selecting data from trusted sources (such as the Office for National Statistics in the UK) the occurrences of noncompliance can be minimized. In the end, a decision must be taken as to whether any compliance failure is severe enough to exclude the data – and in doing so potentially compromise interpretation of the dataset.

4. A critical reflection of the process of interpreting UK City LIFE$_1$

The data collected from Birmingham was interpreted through the UK City LIFE$_1$ framework in collaboration with local authorities, urban design decisionmakers and urban professionals as part of an iterative process that included a series of workshops and meetings. This process sought to address the last of the study's three research questions: (3) how can the outcomes be interpreted to aid local authority decisionmaking in the UK?

It was apparent from the outset that the large number of indicators would require grouping and consolidation in order to be used effectively. The UK City LIFE$_1$ framework provides one such grouping, that of the four tiers. This arrangement allows for potential unintended consequences to be made explicit and for the determination of multiple benefits to be realized – these being two sides of the same coin – see Leach *et al.* (2016) for an illustration. The underpinning linkages were established from the literature, but it is fair to say that the science of cities is still being developed and some of the linkages are more certain than others. Being able to determine potential multiple benefits and unintended consequences arising from decisions had traction with those consulted, but there was a nervousness about the large amount of information contained within the framework. Birmingham viewed through each of the four UK City LIFE$_1$ lenses showed, not unsurprisingly, a complex picture. The large number of indicators allowed for performance highlights to be robustly identified and for a considerable degree of depth of understanding; however, a simplification was encouraged by those consulted for the purpose of revealing “the bigger picture”.

A second, thematic grouping of indicators was undertaken that aligned more closely with how other indicator sets are grouped and with user expectations (e.g., transport, water, energy, governance, wellbeing, health, etc.). Although this grouping was

well received and allowed for easy interpretation of the themes, it had the disadvantage of reinforcing disciplinary and departmental siloes and did not provide an overarching picture of performance.

The task of distilling and communicating an overall picture of Birmingham's livable sustainability performance was challenging. The nature of the data contained within UK City LIFE$_1$ is such that it is not possible to conduct statistical tests upon them. This is partly because of the use of different sources and data types (i.e., objective, subjective, quantitative, qualitative) meaning that the data have different sample sizes and cohorts and cannot be analyzed together. Some of the data are available at the scale of the lower super output area (LSOA), but not all, making statistical analyses impossible when applied to a single city (i.e., there are not enough data points). Conducting statistical analyses beyond the existing descriptive statistics is therefore impossible and another way forward had to be found.

Visualizations of the data offer an opportunity to summarize the data in meaningful ways (Kitchin *et al.*, 2015). In the first instance, a force diagram was used to illustrate desirable and undesirable relationships. Livable sustainability brings together wellbeing, resources (security and efficiency) and carbon emissions (as a proxy for damage to the planet). Their desired relationships can be expressed as follows and visualized in Figure 2. This was well-received by those consulted and it was clear it could be used to inform decisions, but it was too abstracted from the data to provide detailed guidance.

- Uncoupling carbon emissions and wellbeing
- Uncoupling carbon emissions and resource security
- Uncoupling carbon emissions and resource efficiency

- Coupling wellbeing and resource efficiency
- Coupling wellbeing and resource security
- Coupling resource efficiency and resource security

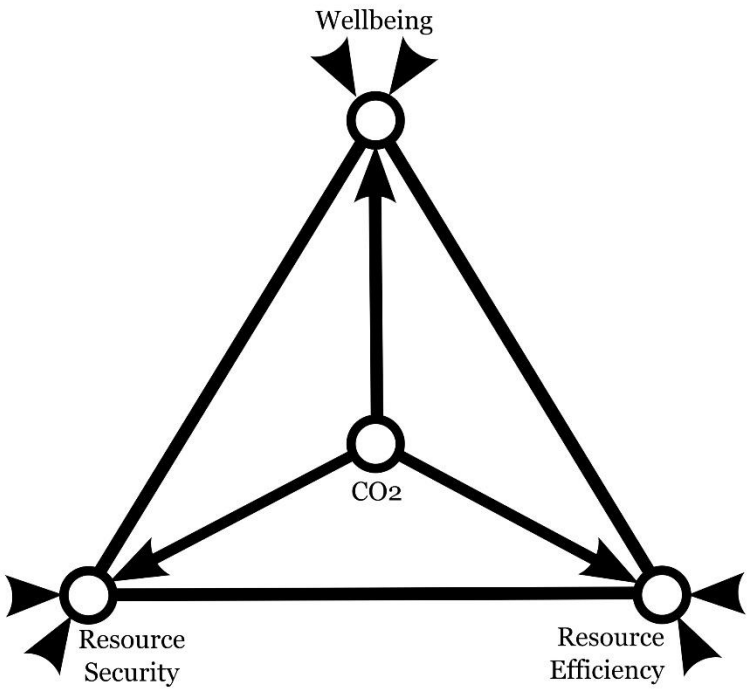

Figure 2. Force diagram of desirable livable sustainability performance relationships.

An attempt was made to determine the degree of the relationships described in Figure 2 using a mathematical approach, which can be found in the supplementary information (Appendix A: Calculations for Birmingham's Livability Scores and Coupling Measures). Scores (termed 'coupling scores') were calculated for each of the four elements of livable sustainability: wellbeing, resource security, resource efficiency and carbon emissions. This involved a drastic distillation of the full indicator set into a representative (if crudely so) and manageable subset. These scores were then used to create 'coupling measures' that determined the distance between the four elements of

livable sustainability and that mirrored the relationships visualized in Figure 2. The outcomes could then be visualized in a 3D space and Venn diagram combination, effectively locating a city's performance in a 3D ‘livable sustainability space’ (inspired by Graedel *et al.'s* (2012) paper: Methodology of Metal Criticality Determination). Figure 3 illustrates Birmingham's performance within this livable sustainability space. Each plane of the box represents the degree of uncoupling and the Venn diagram represents the degree of coupling. The desired (most livable sustainable) position is the nearest, top most corner of the box with all three spheres completely overlapping.

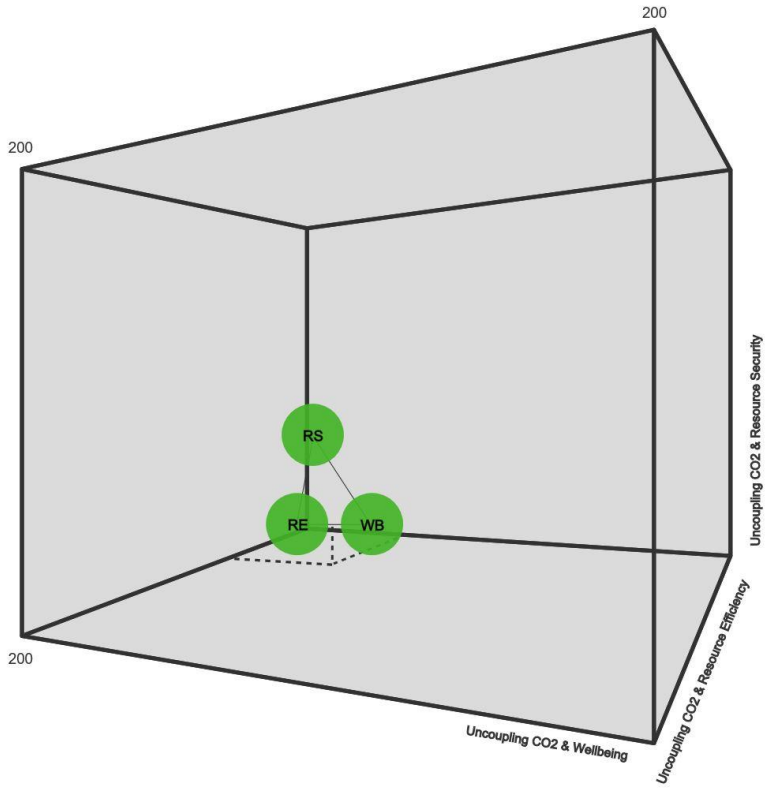

Figure 3. Birmingham's performance expressed as relationships within a ‘livable sustainability space’.

This visualization of Birmingham's livable sustainability is a compromise between the detailed and in-depth picture of Birmingham afforded by UK City LIFE$_1$ and the force diagram. The tradeoffs with visualizing and simplifying the dataset, however,

are not to be ignored. A visualization can make disorder appear organized (Kitchin *et al.*, 2015) and although efforts were made to ensure that the subset of indicators used for the livable sustainability space calculations are as representative as possible, it is the case that such simplifications can lead to poor decision-making (Keeney, 1992). However, it is also the case that simplifications can discard the irrelevant and focus decisionmakers upon the essential (Batty, 2016). The key is using the appropriate degree of detail for the decision in question, and this perspective was reinforced by those consulted. This led to the authors recommending that the headline view presented in the 'livable sustainability space' is used to inform strategic decisions, complemented with the detailed view presented by UK City LIFE$_1$ as operational decisions are made.

5. Discussion and conclusions

This paper describes the design, application and interpretation of UK City LIFE$_1$ to the city of Birmingham, UK, in order to address the study's three research questions: (1) Is it possible, in practice, to holistically and at the city scale measure a UK city's livable sustainability? (2) What challenges and gaps arise and can these be overcome? and (3) How can the outcomes be interpreted to aid local authority decisionmaking in the UK? To achieve this, the study triangulated information from three strands of analysis: (1) a review of the livable sustainability-related measurement and assessment literature, (2) a critical assessment of the design and application of UK City LIFE$_1$ to the city of Birmingham, UK, and (3) a critical reflection upon the interpretation of UK City LIFE$_1$, taken with local authorities, urban design decisionmakers and urban professionals.

It is not possible to comprehensively measure something that does not have clear definitional boundaries (Bell and Morse, 2008), and so the contested definitions of

livability, sustainability and livable sustainability are a barrier to their measurement. In practice, this is a barrier that must be overcome if we are not to discard the valuable insights afforded by their measurement. Developing clear definitions is one way forward, but one that has proven difficult to achieve despite decades of effort (Portney, 2013), resulting in their being no agreed way of measuring these concepts and thus multiple methods for doing so have arisen (Tanguay *et al.*, 2010; Mori and Christodoulou, 2012). This has fragmented efforts to address the challenges and opportunities afforded by livability and sustainability and has stymied useful comparisons across geographic and thematic contexts. To overcome this difficulty, urban measurement and assessment methods can clearly define their area of focus – essentially manufacturing the needed boundaries – and within this set out to holistically measure performance.

In practice, there are a number of barriers to achieving holistic measurement. Many of these are obvious and are related to the data used to populate the indicators: availability, viability, scale, reliability, format, bias, accuracy and causality. Data challenges are not easy to overcome: in some cases they are impossible to overcome. Missing data (either because the indicator has a null value or because the indicator was excluded altogether) skews the emphasis of the urban measurement and assessment method. This, in turn, skews the emphasis of arising interpretations and decisions.

Data challenges risk obscuring the impacts of less obvious barriers: defining purpose and operational mechanisms, defining ‘good’ performance and developing a robust assessment framework. Together, these elements impact upon how the data can be interpreted and used for decision-making. Beyond the scope of this paper, there are additional considerations with regard to using indicator-based urban measurement and assessment methods for decision-making. Kitchin *et al.* (2015) provides a comprehensive

summary and worth mentioning is the misconception that a measurement and assessment method provides information about a ‘one true’ external reality, that the data themselves are objective and independent from the situation they are describing, that the very act of measurement is not a normative one and that those interpreting the data do so in rational and objective ways.

All of this introduces inaccuracy, uncertainty and bias into any given urban measurement and assessment method and potentially renders decisionmakers impotent. However, in the case of UK City LIFE$_1$ the language of ‘realizing the multiple benefits of interventions’ and ‘coupling and uncoupling relationships’ alongside making the unknown explicit (i.e., including null value indicators) had the potential to empower decisionmakers in the face of absent and disconnected data and interpretational challenges.

The livable sustainability space visualization gives urban decisionmakers and policymakers the city's ‘big picture’ performance, identifying areas of concern and of success. UK City LIFE$_1$ provides the detailed information to elucidate the reasons for the ‘big picture’ performance and to inform operational activities. Together they provide the evidence needed for policymakers to commission targeted studies to uncover the underpinning reasons. In the UK, this latter aspiration – for policymakers to commission targeted studies – is at serious risk. UK city councils currently face a perfect storm of constrained budgets, reduced staff capacity and capability and increased responsibilities on the national and world stages to engage with strategic agendas (such as sustainability). Birmingham appears to be acutely suffering and council capacity was repeatedly raised as a barrier during the consultation exercises carried out as part of this study. To paraphrase one member of the Council: Birmingham simply doesn't have the money or

the staff to commission its own studies. And yet at the same time there was recognition that it is crucial to have an evidence-base for policymaking and urban decision-making.

Reduced council capacity can leave councils reactive to (rather than proactive about) strategic agendas, potentially leading to inefficient policymaking and use of resources. A number of organizations offer cities bespoke solutions to addressing strategic challenges. These include 100 Resilient Cities (100 Resilient Cities, 2016); Arup's City Resilience Framework and Smart Cities initiative (Arup, 2016); IBM's Smarter Cities (IBM, no date); Siemens Intelligent Infrastructure (Siemens AG, 2016); and, CH2M HILL Cities (CH2M HILL, 2015). When considering such offerings, councils should satisfy themselves that the arising performance measurements and assessments meet the good practice criteria described herein. In addition, councils must take cognizance of vested interests. Organizations may be predisposed to promote their in-house approaches and solutions even if another approach or solution would be better suited.

Arising from the Birmingham case study, a potentially transformative step in delivering a city's aspirations has been identified. This is based upon a two-tier model where one tier provides detailed measurements of city performance and elucidates multiple benefits and the other tier provides an overview that couples desirable, and uncouples desirable from detrimental, measures of city performance. This model – UK City $LIFE_1$ and the livable sustainability space – founded on measurements and the identification of key relationships, could be translated to any UK city and even any global city with consideration paid to its national context. This new model not only provides an overarching picture of a city's livable sustainability, but by synthesizing the outputs with backcasting techniques, which make explicit potential barriers to achieving a desired future performance, it can provide the necessary evidence base to engender bold and

assured policymaking and, crucially, make explicit how cities can advance towards their common goals of sustainability and livability. As one member of Birmingham's council explained: we must change how we think about making decisions so that we do so in an evidence-based way – this is very different to how things are currently done.

Data

UK City LIFE[1], including all data sources and dates, has been published in Leach *et al.*, (2017).

Calculations for the livable sustainability space have been published in the supplementary information (Appendix A: Calculations for Birmingham's Livability Scores and Coupling Measures).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.cities.2017.06.016.

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Paper 4. Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions.

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Abstract

This data article presents the UK City LIFE$_1$ data set for the city of Birmingham, UK. UK City LIFE$_1$ is a new, comprehensive and holistic method for measuring the livable sustainability performance of UK cities. The Birmingham data set comprises 346 indicators structured simultaneously (1) within a four-tier, outcome-based framework in order to aid in their interpretation (e.g., promote healthy living and healthy long lives, minimize energy use, uncouple economic vitality from CO_2 emissions) and (2) thematically in order to complement government and disciplinary siloes (e.g., health, energy, economy, climate change). Birmingham data for the indicators are presented within an Excel spreadsheet with their type, units, geographic area, year, source, link to secondary data files, data collection method, data availability and any relevant calculations and notes. This paper provides a detailed description of UK city LIFE$_1$ in order to enable comparable data sets to be produced for other UK cities. The Birmingham data set is made publically available at http://epapers.bham.ac.uk/3040/ to facilitate this and to enable further analyses. The UK City LIFE$_1$ Birmingham data set has been used to

understand what is known and what is not known about the livable sustainability performance of the city and to inform how Birmingham City Council can take action now to improve its understanding and its performance into the future (see "Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK" (Leach *et al.*, 2017).

Specifications table

Subject area	*Urban studies and sustainability*
More specific subject area	*Data analytics for understanding urban livable sustainability*
Type of data	*Spreadsheet*
How data was acquired	*Secondary data were downloaded from various sources (specified in the spreadsheet). Primary data were obtained via various surveys (specified in the spreadsheet).*
Data format	*Raw, Filtered, Analyzed*
Experimental factors	*Indicators were selected from multiple sources based upon their relevance to UK urban livable sustainability: human and societal wellbeing, resource security and efficiency, and carbon emissions.*
Experimental features	*Indicators were classified by outcome and theme for the purpose of aiding data interpretation.*
Data source location	*Within the political boundary of the city of Birmingham, UK*
Data accessibility	*The UK City LIFE$_1$ Birmingham data set is free and publically available to download from http://epapers.bham.ac.uk/3040/*
Related research article	Leach JM, Lee SE, Hunt DVL, Rogers CDF. Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK. Cities. 2017 71:80-87.

Value of the data

- This data set captures the livable sustainability performance of the city of Birmingham, UK. The format and information contained within the spreadsheet are designed to enable others to collect livable sustainability data for other UK cities and make possible comparisons across cities. Should data for enough UK cities be collected then statistical analyses across the cities would become possible

(e.g., factor analysis), providing unique insights into the interconnected nature of the indicators and how UK cities perform.

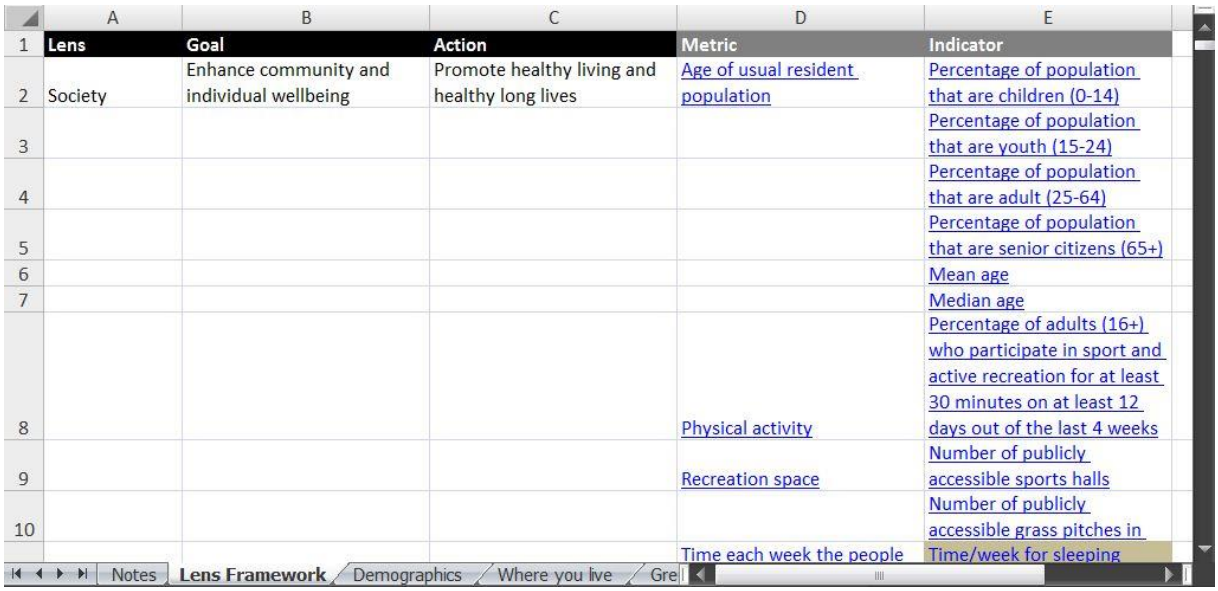
- The data set describes Birmingham, UK's livable sustainability performance as a snapshot (i.e., it does not include longitudinal data). Therefore, there is an opportunity to augment the data set by incorporating longitudinal data.
- The data set is not constrained by data type or scale, requiring only that the data be representative of the entire city of Birmingham. This limits statistical analyses, but creates opportunities for other forms of analyses and in particular for innovative data visualization.
- Expanded analyses of the data are possible through comparison with sub-city-scale areas of Birmingham (e.g., neighborhoods), subject to the collection of neighborhood-scale data.
- The UK city $LIFE_1$ format can be tailored to other urban contexts, such as cities outwith the UK.

Data

The UK City $LIFE_1$ (UK City Livable-sustainability Indicator Framework Edition 1) Birmingham data set presents the livable sustainability performance of the city of Birmingham, UK presented in a multi-tab spreadsheet containing 346 indicators.

The indicators are organized in two ways. The first is within a four-tier, outcome-focused framework ('Lens Framework'). The framework links the least granular of desired outcomes (the four lenses of sustainability: society, environment, economy and governance) to related goals (e.g., enhancing community and individual wellbeing, enhancing biodiversity and ecosystem services) and actions (e.g., promoting healthy living and healthy long lives, minimizing the impact of urban density on biodiversity),

finally to the granularity of metrics and indicators (e.g., healthy life expectancy, quality of waterways) (Leach *et al.*, 2016). The Lens Framework can be found on the second tab of the spreadsheet (see Figure 1). The metrics and indicators are hyperlinked to their full descriptions, which are contained within the spreadsheet's tabs.

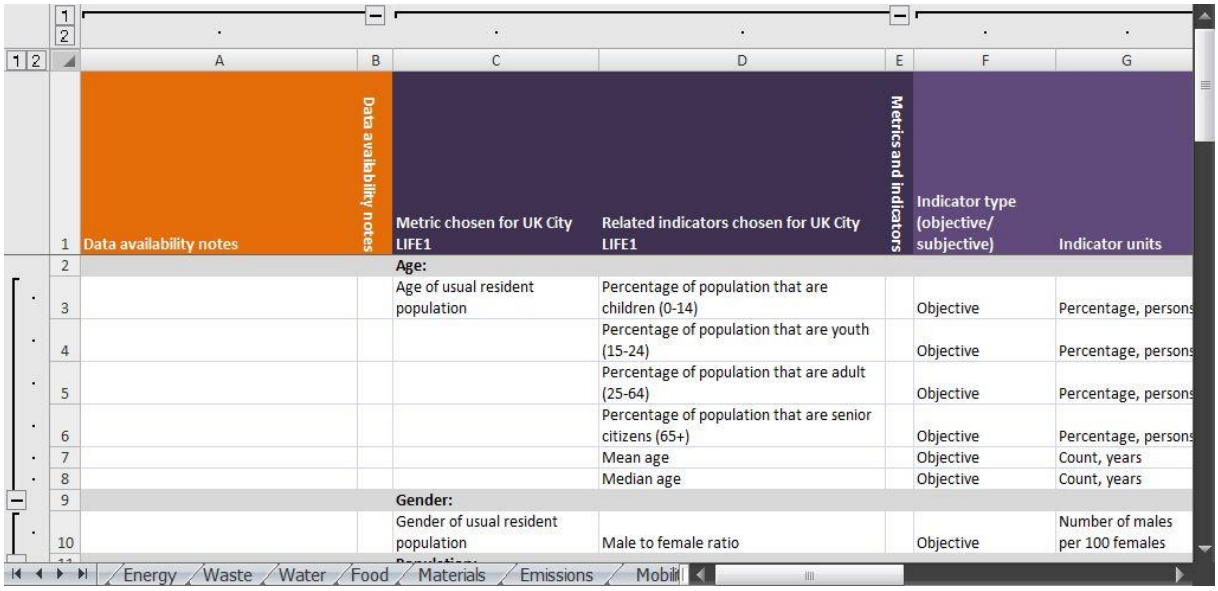


	A	B	C	D	E
1	**Lens**	**Goal**	**Action**	**Metric**	**Indicator**
2	Society	Enhance community and individual wellbeing	Promote healthy living and healthy long lives	Age of usual resident population	Percentage of population that are children (0-14)
3					Percentage of population that are youth (15-24)
4					Percentage of population that are adult (25-64)
5					Percentage of population that are senior citizens (65+)
6					Mean age
7					Median age
8				Physical activity	Percentage of adults (16+) who participate in sport and active recreation for at least 30 minutes on at least 12 days out of the last 4 weeks
9				Recreation space	Number of publicly accessible sports halls
10					Number of publicly accessible grass pitches in
				Time each week the people	Time/week for sleeping

Notes | Lens Framework | Demographics | Where you live | Gre

Figure 1. 'Lens Framework' spreadsheet tab (excerpt).

The second way the indicators are organized is by theme. The themes have been selected to complement government and disciplinary siloes (e.g., health, energy, economy, climate change). Tabs three to 24 within the spreadsheet contain the indicators that correspond with the themes (see Figure 2). Birmingham data for the indicators are presented on each tab, are grouped by metric and include indicator type, units, geographic area, year, source, link to secondary data files, data collection method, data availability and any relevant calculations and notes.



	A	B	C	D	E	F	G
1	Data availability notes	Data availability notes	Metric chosen for UK City LIFE1	Related indicators chosen for UK City LIFE1	Metrics and indicators	Indicator type (objective/ subjective)	Indicator units
2			**Age:**				
3			Age of usual resident population	Percentage of population that are children (0-14)		Objective	Percentage, persons
4				Percentage of population that are youth (15-24)		Objective	Percentage, persons
5				Percentage of population that are adult (25-64)		Objective	Percentage, persons
6				Percentage of population that are senior citizens (65+)		Objective	Percentage, persons
7				Mean age		Objective	Count, years
8				Median age		Objective	Count, years
9			**Gender:**				
10			Gender of usual resident population	Male to female ratio		Objective	Number of males per 100 females

Energy | Waste | Water | Food | Materials | Emissions | Mobil

Figure 2. Themed spreadsheet tabs (excerpt).

Experimental Design, Materials and Methods

UK City LIFE$_1$ is a unique and bespoke city performance measurement and assessment method designed to provide a comprehensive and holistic account of a UK city's livable sustainability. It includes subjective and objective measures and is not restricted by data type (e.g., quantitative, qualitative, categorical, index, etc.). UK City LIFE$_1$ has been used to measure the livable sustainability performance of Birmingham, UK and the arising data set is freely and publically available at http://epapers.bham.ac.uk/3040/. A description and critique of the development of UK City LIFE$_1$ is available from Leach *et al*. (2017).

In order to be included in the UK City LIFE$_1$ Birmingham data set, data were required to be representative of the city of Birmingham, as defined by its political boundary, but did not necessarily have to have sub-city scale components. Data for Birmingham were collected as a first preference for 2011 (given the prevalence of 2011 Census data), as a second preference for the least recent year after 2011, and as a third preference for the most recent year prior to 2011 (Leach *et al*., 2017). The data set does

not contain longitudinal data. The data set is a combination of data from secondary sources and primary sources, with data collection methods and calculations included in the spreadsheet on an indicator-by-indicator basis. Secondary data sources were the preference and sources were selected for their reputation for providing high quality data. In some cases it was deemed necessary for less-robust data to be included as having no data would unnecessarily compromise the balance of the data set. Where no secondary data sources existed or were easily obtainable (e.g., restricted access) and where it was not feasible to conduct primary data collection, indicator values were marked as null. As a result of utilizing data from multiple sources, there are varying cohort sizes, data collection methods and timestamps across the indicators.

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Transparency document. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.dib.2017.10.004.

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Paper 5. Reading cities: Developing an urban diagnostics approach for identifying integrated urban problems with application to the city of Birmingham, UK.

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Abstract

For policymakers, planners, urban design practitioners and city service decision-makers who endeavour to create policies and take decisions to improve the function of cities, developing an understanding of cities, and the particular city in question, is important. However, in the ever-increasing field of urban measurement and analysis, the challenges cities face are frequently presumed: crime and fear of crime, social inequality, environmental degradation, economic deterioration and disjointed governance. Although it may be that many cities share similar problems, it is unwise to assume that cities share the same challenges, to the same degree or in the same combination. And yet, diagnosing the challenges a city faces is often overlooked in preference for improving the understanding of known challenges. To address this oversight, this study evidences the need to diagnose urban challenges, introduces a novel mixed-methods approach for doing so, applies (and critiques) the approach to the city of Birmingham, UK, and proposes a set of principles for the transferability of this new urban diagnostic methodology to other

cities. The paper argues that applying a rigorous, explorative, diagnostic approach to ‘reading cities’ provides confidence that all critical challenges have been identified and, crucially, identifies how they are interdependent, both of which have implications for how policymakers and decision-makers address a particular city's combination of interlinked challenges.

1. Introduction

If urbanisation is “the defining aspect of our time” (Zhang, 2016, p. 214) then the study of cities must surely be one of the defining aspects of academic study. Over time, the study of cities has entered the purview of many academic disciplines. Shaping cities has, however, largely been achieved through planning – acknowledging the contested nature of planning as an academic discipline (Davoudi, 2015), at least for the last century or so (Healey, 2007). Planning itself has evolved. Victorian planners considered cities as consisting of binary relationships between fixity (land uses) and mobility (infrastructure channels) with urban areas being the conceptual centre of their hinterlands (Healey, 2007). By 1990, networks had become an important conceptual device and cities began to be considered in terms of places and flows (Healey, 2007) as social scientists tried to ‘see’ the city as a mix of networks, actors, human effort and organisation (Amin and Thrift, 2017). Today, planners define cities as complex ‘systems of systems’ consisting of ‘webs’, each with “different space-time patterns of nodes and links” (Healey, 2007, p. 8).

The underlying question for the development of all cities is: planning for what purpose? The answer inevitably is determined by politics and actual or perceived private or public sector failure. Today it might be functionality, economic activity, sustainability,

resilience, liveability, smartness, adaptability, flexibility or meeting citizen aspirations. In truth, planning should embrace all these alongside a deep understanding of the context of the city in question (Rogers, 2018). An underlying challenge is determining how the critical problems being experienced by a city are identified (diagnosed). How different cities go about this varies, as does the degree to which strategic problem identification processes are implemented. For example, problem identification may be politically or socially motivated, may focus on well known or fashionable challenges, or may follow funding availability. What appears to be absent is the application of a purely explorative and rigorous diagnostic process – one that is an open rather than a closed process; which does not focus upon a specific problem, issue, or system (Malekpour *et al.*, 2017).

A key challenge is how to 'read' cities. Mark Twain, in his autobiography, noted how river pilots 'read' the Mississippi river (Bryson, Daniels and Warf, 2004, p. 43). According to Twain, river pilots instinctively navigate the river like a book that they read automatically, without knowing how. Policymakers, planners, urban design practitioners, and city service decision-makers may seek to 'see' the city as Amin and Thrift describe it, but they must also learn to 'read' it. This process of 'reading' is often taken for granted and is akin to searching for known problems.

Existing methods for identifying urban problems fall short of an explorative diagnostic approach. This paper develops a new, original, and novel urban diagnostic process intended to 'read' cities. This process is informed by medical diagnostics where abductive and deductive approaches are combined to develop an assessment of a complex system of systems. The study builds upon an extensive body of scholarship examining the challenges faced by cities (described in the literature review) and reveals that explorative urban diagnostics have, surprisingly, been largely overlooked.

This study evidences the need for and describes the design, application and interpretation of an urban challenges diagnostic methodology – a mixed-methods approach to holistically and exploratively identifying a city's challenges through examination of city service-related evidence. This approach is developed from a detailed analysis of the city of Birmingham, UK, but the diagnostics approach can be applied to all cities. The paper focuses on addressing four research questions: (1) What are the current approaches to identifying the challenges facing individual cities and, given these, is there a need to diagnose the challenges of individual cities? (2) Is it possible, in practice, to holistically and exploratively diagnose an individual city's challenges? (3) What methodological problems and gaps arise, and can these be overcome? (4) How can the outcomes be interpreted to aid policymaking and decision-making for addressing urban challenges?

The study synthesises information from several strands of analysis, described in the subsequent sections of this paper, including a review of the urban challenges/problem identification literature; and, a critical assessment of the design, application and interpretation of a new and novel urban challenges diagnostic methodology (taken with UK local authorities, policymakers, urban design decision-makers, urban professionals and academics). The final section explores the study's outcomes and conclusions, including proposing best-practice principles for the transferability of the urban challenges diagnostics methodology to other cities.

2. A review of the urban challenges diagnostic literature

Three literature reviews were undertaken to identify current approaches from across the globe to identifying urban challenges. First, the existence of urban challenges diagnostic

studies was explored. Second, a more general review of studies exploring urban problems was undertaken. Third, a review of diagnostic methods outwith the urban studies literature was undertaken.

First, The Web of Science and Scopus were interrogated for studies that identified themselves as conducting an 'urban diagnostics' analysis. The Web of Science identified 24 studies using topic 'diagnostics' and sub-topic 'urban' within the theme 'urban studies'. Scopus identified 4829 studies using topic 'diagnostics' and sub-topic 'urban' within the themes 'environmental science', 'social sciences', 'decision sciences' and 'engineering'. Of the studies returned, most were deductive, narrow and discipline-specific, focussing on one or a subset of pre-determined urban problems (e.g., deprivation, climate adaptation, transport, governance, ecosystem services; see MacLaran, 1981; Massey, 1996; Rae, 2012; AfDB *et al.*, 2013; McKay *et al.*, 2017; Oberlack, 2017; Ruiz and Seguí-Pons, 2018). Current approaches focus on the identification of spatially concentrated depreciation (Robson *et al*, 2008; Rae, 2012) rather than adopting a focus that highlights the heterogeneity and complexity of intra-urban diversity. Only one study was found to provide a holistic and explorative diagnosis of urban problems: Luque-Martínez and Muñoz-Leiva's (2005) analysis of city benchmarking as a methodological tool through an analysis of Granada. This paper used a breadth of indicators to measure urban performance and then compared this performance to other cities. The variances in performance collectively diagnose a "city's strong and weak points" (Luque-Martínez and Muñoz-Leiva, 2005, p. 415). However, it is worth noting with this method that the choice of comparator city influences the challenges identified and that this study did not develop an intra-urban analysis of place-based differentials.

Next was conducted a review that took semantics into account, acknowledging that studies that conducted urban challenges diagnostics may not have identified themselves using the term ‘diagnostics’. The Web of Science identified 9843 studies using topic ‘urban’ and subtopic ‘problems’ within the themes ‘environmental sciences’, ‘engineering (civil)’, ‘urban studies’, ‘planning and development’, ‘economics’ and ‘area studies’. Scopus identified 82,605 studies using topic ‘urban’ and sub-topic ‘problems’ within the themes ‘social sciences’, ‘environmental science’ and ‘engineering, econometrics, economics and finance’. Of the returned studies, a typology of four approaches to identifying and understanding urban challenges emerged. Importantly, in all four approaches the existence of the urban challenges is taken as given.

1. Studies that describe, investigate and measure urban challenges (see Kitchin *et al*, 2015; Lee and Sissons, 2016; Alivon and Guillain, 2018; Chen *et al.*, 2017; Leach *et al.*, 2017; Nichols and Tosun, 2017; Garau and Pavan, 2018; García-Ayllón, 2018).
2. Studies that focus upon how best to identify and/or address a challenge or set of challenges, either methodologically or via specific interventions (see Bentham, 1985; Wout, 2013; Doussard, 2015; Jeong *et al*, 2015).
3. Studies that assess the efficacy of programmes, policies and technologies designed to address urban challenges (see Stren, 1991; Glass, 2011; Desouza and Bhagwatwar, 2012; Vergara-Erices *et al*, 2015).
4. Studies that focus upon urban characterisations and ethnographies (see Jacobs, 1961; Vernon, 1966; Knox, 1991; Huxley, 2013)

Finally, a critical review of diagnostic methods was undertaken. Since it was apparent from the previous two literature searches that urban challenges diagnostic methods are rare in the urban studies-related academic literature, diagnostic methods from other disciplines were sought.

Although several disciplines promote methods akin to diagnostics (e.g., design, engineering, foresighting; see Ertas and Jones, 1996; Simon, 1996; Ulrich and Eppinger, 2000; INCOSE, 2015; Hunt and Rogers, 2016), upon investigation these were found not to be synonymous. The medical literature proved to be, perhaps obviously, a natural home for diagnostic methods that were complementary to urban studies. Baerheim (2001) proposes two phases to the medical diagnostic process that have clear synergies with urban studies. Phase 1 comprises the abductive and explorative phase where evidence of a patient's symptoms (a city's challenges) are gathered together and a diagnosis is (or diagnoses are) inferred. Phase 2 comprises the deductive phase, where the diagnosis is (or diagnoses are) tested. The results of the diagnostic tests must then be holistically interpreted (Haasenritter *et al.*, 2013). This approach to medical diagnostics provides a useful conceptual framework for exploring the application of a diagnostic approach to understanding cities.

It is somewhat surprising that there is such limited literature on the application of diagnostic approaches to urban areas and that no rigorous, holistic, explorative, urban diagnostic process has been identified. This might be due to the complexity of urban systems, processes and encounters; it might be due to exogenous factors such as economic and political cycles (e.g., the cyclical nature of the political process makes a diagnostic process problematic, as each election results in a different political interpretation of the challenges); or it could be explained by difficulties related to data availability and

methodologies (the former of which varies widely from city to city across the globe). This gap in the literature does not devalue existing approaches to understanding and addressing urban challenges – all are needed to build a rich picture of complex issues. However, determining the malaise of urban areas should not be overlooked and it is this added value that is offered by a holistic and explorative diagnostic approach.

3. A critical assessment of the process of designing, applying and interpreting an urban challenges diagnostic methodology

Having established that no rigorous, holistic, explorative, urban diagnostic process already exists, this section explores the conception, design, application and interpretation of such a process (a detailed description is available in Appendix A). The city of Birmingham, UK, was selected for testing the process as it benefits from extensive study and data availability (building upon the work of Leach *et al.* (2017)), evidences a particularly acute mix of known problems – most notably governance and the economy (Kerslake, 2014) and child social care services (Le Grand *et al*, 2014) – is one of the UK's Core Cities (Core Cities, no date), and it is being governed by a City Council that faces capacity and capability deficits (Kerslake, 2014) and is actively seeking innovative ways to overcome them.

3.1. Design and application of the urban diagnostic process

A mixed-methods framework (Brannen, no date) for evidence gathering that generated an understanding of Birmingham's city-service challenges was designed, acknowledging the need to incorporate numeric datasets as well as narrative-based documents from across a number of secondary sources (Luque-Martínez and Muñoz-Leiva, 2005). The

framework was informed by the literature reviews and inspired by the medical diagnostic process, focussing upon ‘reading the city’ through a quantitative and qualitative abductive diagnostic process, the outcomes from which can then be tested through a deductive process (the subject of future research). It sets out how a diversity of evidence types (datasets and documents) are either transferred directly into outputs or are manipulated (analysed) with the resultant outcomes fed into the outputs (Figure 1). The outputs are then used to infer a diagnosis of a city's challenges that can be tested through a deductive diagnostic phase.

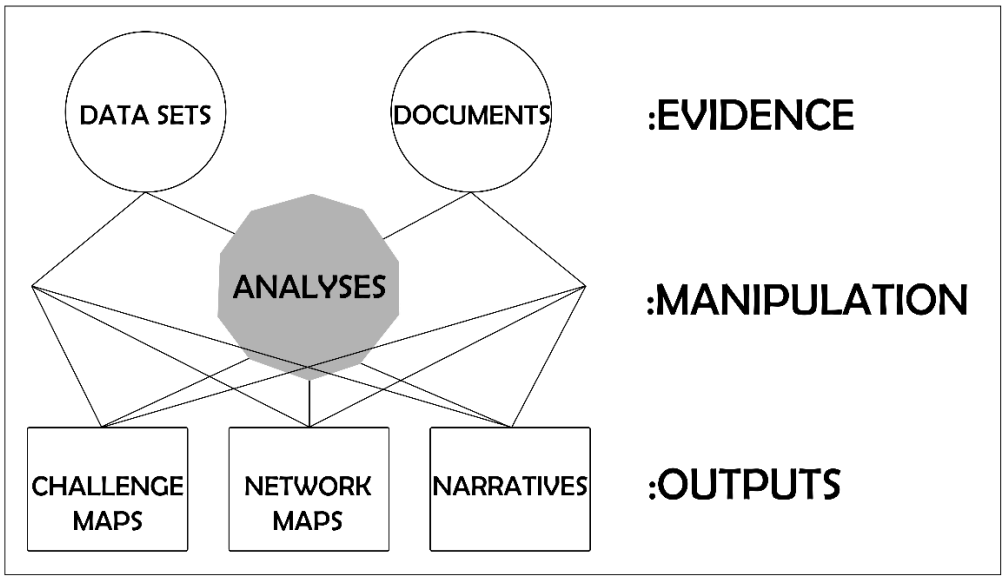

Figure 1. Conceptual framework for a mixed-methods approach to urban diagnostics.

There were three constraints on the development of this diagnostic process. The first constraint was time-related. The purpose of the case study was to identify the challenges that Birmingham currently faces. As such, data and documents that predated 2010 were not considered unless they remained the most relevant for the city's current situation. This facilitated the capture of longitudinal datasets and documents, many of which recur in 5–7 year cycles. It also included the last UK census, conducted in 2011.

This is not to ignore the importance of the past in determining the present (Martin and Sunley, 2006), and historical investigation will inevitably form part of future deductive diagnoses. The second constraint was relevance to urban services and systems. Urban services and systems were defined to include 'soft infrastructure services and systems' such as education, health, governance and ecosystem services, as well as 'hard infrastructure services and systems' such as energy, water, waste, and transport. These were selected because they offered a breadth of understanding whilst at the same time providing a boundary to the enquiry. The third constraint was geographical. The primary geographical focus was the political boundary of the city of Birmingham, including some part thereof; i.e., data and documents did not have to reflect the entire city. Using an existing boundary allowed for multiple datasets and documents with different characteristics to come together via a common geography.

A concerted effort was made to include a breadth of types of evidence so as not to limit the diagnostics. Two main evidence types were included: geocoded datasets and documents. For the purpose of this study, datasets were defined as quantitative, numerical and organised into sets that allowed for statistical analysis. Documents could contain quantitative or qualitative evidence, could be in any form (e.g., numerical, categorical, ordinal, narrative) but were not organised in to sets in such a way as to allow for statistical analysis. Importantly, this enabled evidence from papers and reports to be included even if the underpinning data were not available. Of note is the importance of including objective and subjective evidence (i.e., citizen perceptions and opinions). A framework for identifying the datasets and documents was established, based on 29 categories of city services (e.g., economy and finance, skills and training, income and poverty) devised collaboratively with Birmingham City Council and at two workshops with policymakers,

urban design decision-makers, urban professionals and academics (12 September and 29 November 2016). Each workshop was followed by targeted searches and cross-checking with various information sources (see Appendix A, Table A.1 for the full framework). The evidence base was assessed periodically for thematic and geographical gaps and gluts. The dataset search focussed upon six primary routes of investigation: national datasets, local datasets and surveys, privately held datasets, discussion with Birmingham City Council, identification of thematic datasets at the two workshops, and data from existing policy and project activities across the city. The documents search focussed upon four primary routes of investigation: documents and studies used to create and inform The Birmingham Development Plan (Birmingham City Council, 2013), other documents held by Birmingham City Council, identification of thematic documents at two workshops, and academic studies.

Despite efforts to identify and capture as many datasets and documents as possible, it was not possible to access all existing sources –and accessing city-scale data is not a new or uncommon problem (Knox, 1978; Kitchin *et al.*, 2015; Leach *et al.*, 2017). In some cases, this was because the datasets or documents were proprietary, in other cases appropriate permissions could not be obtained in time, occasionally dataset and document owners could not be located and it cannot be ruled out that some datasets and documents simply may not have been identified as relevant. The datasets and documents that were captured were from various sources with varying geographical boundaries, timestamps and cohorts, gathered using different data collection techniques. This inevitably resulted in analysis and interpretational challenges that had to be overcome if the resultant diagnostics were to have meaning.

The variations in evidence types meant that it was not possible to apply a single analysis method to all the datasets and documents. To compensate for this, and to allow for a breadth of possible interpretational outcomes, a mixed-methods approach was taken. Analysis methods were selected for their appropriateness for conducting a diagnostic assessment, suitability to the gathered evidence, and ability to be interpreted together. In order to avoid predetermining outcomes, explorative approaches were selected (i.e., not hypothesis-directed). Two analysis methods were selected, are summarised below and are fully detailed in Appendix A.

1. A principal components analysis (PCA) of 58 variables arising from the 258 identified datasets was conducted using SPSS for the purpose of identifying the most important variables for characterising the city, and their interactions and geographical attributes.
2. An evidence map of 380 identified documents was conducted for the purpose of determining what is already known about Birmingham, provide pointers to datasets about the city, and to identify common areas of interest and information gaps (McKinnon *et al.*, 2015). The evidence map included:
    - a network analysis of documents using NodeXL (to understand how the city's services/functions are interconnected),
    - a hot & cold spot analysis using NodeXL (to understand how numerous the document themes are), and
    - a geographical bias analysis using Excel (to understand the geographical scales covered by these evidence sources).

Three types of outputs were produced, arising directly from the chosen analysis methods: challenge maps, network maps, and narratives. The challenge maps are geographical representations of the principal components analysis (PCA) that illustrate the datasets on maps of the city (for an example, see Figure 2). Network maps arose from the network analysis and graphically show how the city services/functions (nodes) are connected to each other (links/lines) (for an example, see Figure 3). Narrative outputs arose from all the analyses. The variations in data set and document types and analysis methods meant it was not possible to merge these three output types. Instead, the challenge maps, network maps and narratives were interpreted together to identify and explore Birmingham's critical challenges.

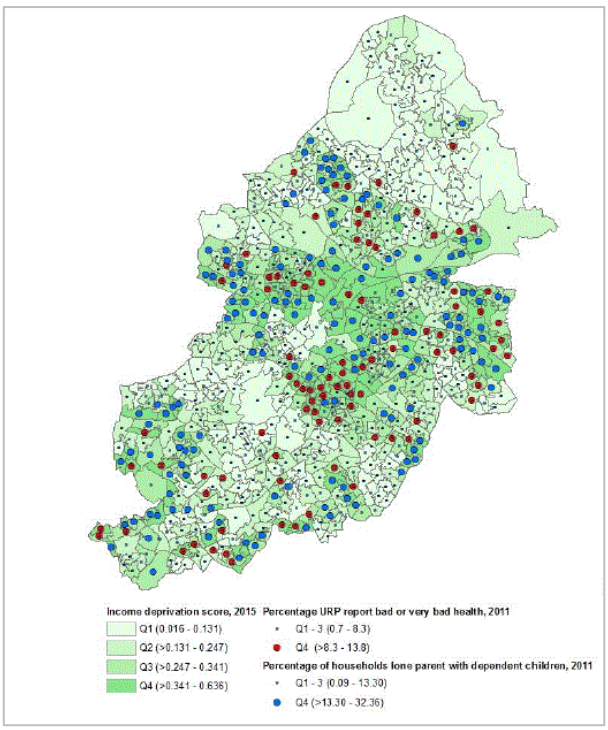

Figure 2. Challenge map example showing income deprivation, health and lone parent households. Source: Contains National Statistics data Crown copyright and database right 2016.

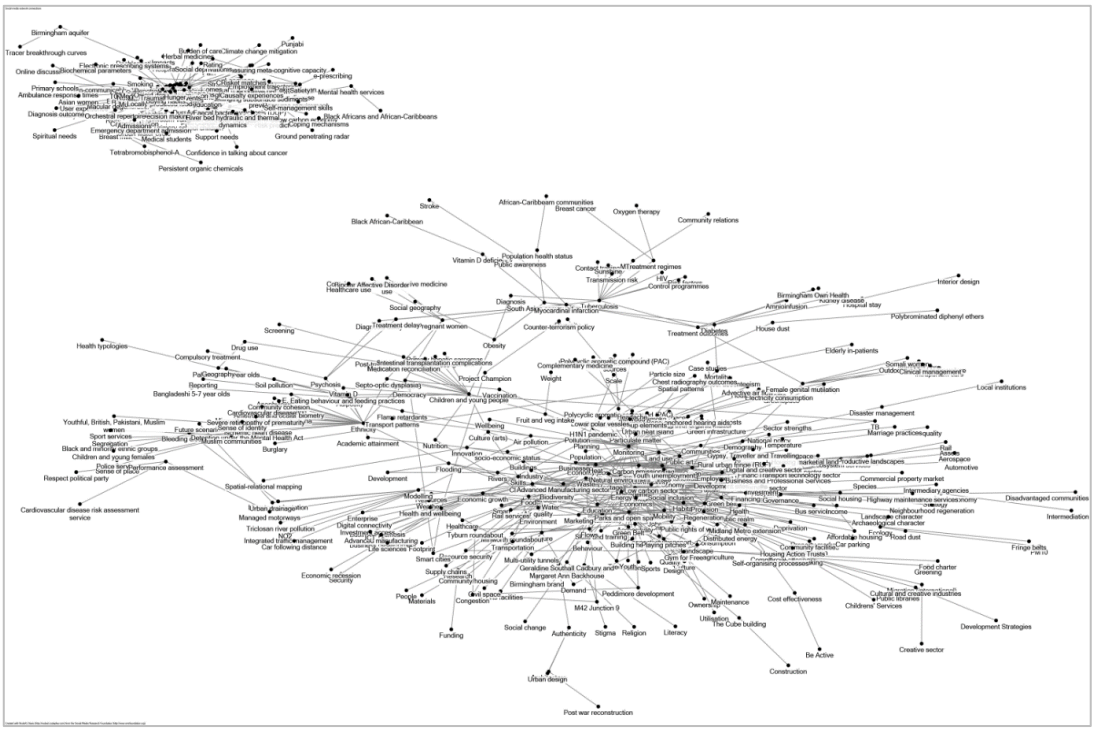

Figure 3. Network map example showing a Harel-Koren Fast Multiscale network visualisation of city service foci.

3.2. Interpretation of the urban diagnostic process

The outcomes from the Birmingham diagnostics were interpreted in collaboration with local authorities, policymakers, urban design decision-makers, urban professionals and academics as part of an iterative process that involved a workshop to scope the city's challenges, followed by an email engagement to unpick the emerging challenges in some detail and then a final workshop to refine and validate the identified challenges and the diagnostics approach. This process sought to address how the outcomes can be interpreted to aid policymaking and decision-making.

In the first instance, the two analysis methods were interpreted in isolation from each other. The Principal Components Analysis identified five areas of potential critical challenges (challenge areas) for Birmingham, summarised in Table 1.

The evidence mapping identified four challenge areas for Birmingham, summarised in Table 2.

Table 1. Results of the Principal Component Analysis (PCA) of Birmingham datasets.

	Challenge area	**Interpretation**
1	There is a significant socio-spatial divide across the city with regard to economic advantage, equity and healthy households	There is a clear spatial divide in the level of economic advantage across Birmingham. The north of the city and parts of the south record higher proportions of resident populations with these characteristics. Counter to this, income deprivation is clustered in the central band across the city. This area also has higher levels of lone parents with dependent children, long term unemployment and the lowest value housing stock.
2	There is a significant socio-spatial divide across the city with regard to healthy living environments and community prosperity	The outer city core has a distinct community group, with higher levels of black and ethnic minority residents and also non-UK born residents. This distinct spatial band around the city core reflects a transition zone that has disadvantaged living conditions, lower quality outdoor environments and lower levels of economic activity.
3	There is a non-spatial relationship between the level of connectivity, associated access to services and levels of life satisfaction	There is a relationship between the level of connectivity, associated access to services and levels of life satisfaction. This suggests a challenge around relative 'distance' and transport networks within the city to support community-based approaches to wellbeing. The interaction extends across the city and shows no clear spatial pattern or hotspot of disadvantage for accessibility.
4	The city core has a distinct sub-profile.	The zone around the immediate city core is disconnected from the regeneration of various parts of the centre. Increased levels of negative liveability suggest the area is not integrated with the prosperity and brand of the city centre.
5	There is a disconnect between the natural and urban form of the city and the resident population characteristics	Of particular interest is that density is not related to socio-demographics, resource use or connectivity within the city.

Table 2. Results of the evidence mapping of Birmingham-related documents.

	Challenge area	**Interpretation**
1	Promoting healthy living and healthy long lives	The network analysis showed a clear disconnect between an extensive, highly specific and narrow academic medical literature and policy literature, which deals with health and wellbeing in little detail. The hot & cold spot analysis showed 'health and wellbeing' in the top two literature hotspots (linking most often with itself and then with demography). At the ward scale health outcomes are variable and clearly health and healthcare do not follow ward boundaries (or ward-level policies). Health and healthcare cut across city services, drawing in the medical health system, green spaces, transport and food, for example. This challenge also touches upon gaps in knowledge, such as Birmingham's food demand profile.
2	Minimizing high-carbon mobilities whilst maximizing connectivity	The hot & cold spot analysis showed 'mobility and transport' as the third and fourth top literature hotspots (linking most often with itself and then with creating an evidence base). Some wards suffer from disproportionately high levels of traffic congestion whilst other wards (notably those further away from the city centre) have poorer access to public transport. Some wards are less connected in non-physical ways. For example, some wards rely more heavily upon working practices that don't lend themselves to working remotely and some wards have higher percentages of older residents who are less likely to use digital services.
3	Reducing environmental risks through the sustainable use of low-carbon energy	The hot & cold spot analysis identified environmental risks associated with carbon emissions, air pollution and flooding as the last of the top five hot spots. Surprisingly energy, the largest contributor to climate change and the resultant environmental risks, was identified as a cold spot. Energy does form part of city-scale and ward-scale policy documents, primarily in relation to reducing carbon emissions, featuring in general terms and it is clear that in recent years (and in particular following the Financial Crisis) reducing carbon emissions and being environmentally friendly has fallen down Birmingham City Council's list of priorities (and economic growth has come up this list, setting the scene for obvious tensions between growing whilst reducing high-carbon energy demands).
4	Developing appropriate governance models to ensure	The link between economic performance and city governance is less evident from the evidence

	economic vitality and establish the city's brand	mapping, but is generally evident in the academic literature and was highlighted repeatedly in the workshops and email engagement. Economic performance (especially in relation to growth) and city governance are, without doubt, two of Birmingham City Council's top priorities. The Kerslake Review captured the city's governance challenges, with an emphasis upon the need for effective leadership and visionary thinking and reflecting an apparent lack of confidence in Birmingham's policymakers to be able to create an economically vibrant city, something that was mirrored at the workshops and in the email engagement. This lack of confidence is, perhaps, reinforced by the city's science-policy gap (revealed by the network analysis), its narrow and disconnected understanding of itself (revealed by the hot & cold spot analysis) and its geographically piecemeal evidence base (revealed by the geographical bias analysis). It also has knock-on effects upon attracting inward investment, new businesses and new residents and establishing the Birmingham brand.

In the second instance, the two analytical methods were interpreted in concert. This included scrutinising them for interconnections and interactions and reducing and refining the identified potential city challenges. Although the challenge areas were identified separately, via different analysis methods, it was obvious that there were considerable thematic overlaps, interconnections, dependencies (i.e., one-way dependency) and interdependencies (i.e., two-way dependency). A comparative analysis revealed that both the PCA and the evidence map had identified four common challenge areas (in all or part) that are specific to Birmingham:

1. Connectivity
2. Economy
3. Energy
4. Health & wellbeing

It then became evident that the PCA statistically linked ‘health & wellbeing’ to ‘connectivity’, ‘health & wellbeing’ to ‘economy’ and ‘health & wellbeing’ to ‘energy’, underscoring the importance of health & wellbeing as a critical challenge area for Birmingham. In addition, the evidence mapping strongly indicated that ‘governance’ is also a critical challenge area for the city and could be established as an overarching challenge. Collectively, these became the ‘Birmingham critical challenges plexus’ (Figure 4).

At the outset of this study it had been expected that the outcomes from the mixed-methods diagnostics would mirror the challenges that were already apparent within the city of Birmingham and might potentially identify additional challenges. Although no new individual challenges were revealed, the mixed-methods approach had the consequence of enabling concurrent interpretation across various analysis methods and this made it possible to identify those challenges that could be considered critical within the city and – importantly – to link them together. This resulted in the identification of an urban plexus of four challenges (all connected by health & wellbeing) and an overarching challenge (governance) giving rise to the implication that interventions (planning, policy or otherwise) should seek to address the plexus as a whole. This is in line with the current conceptualisation of cities as complex systems of systems (Healey, 2007). The implication is that a health and well-being intervention has to be simultaneously an economic, connectivity and energy policy. Siloed policy interventions will produce perverse consequences or result in policy failure.

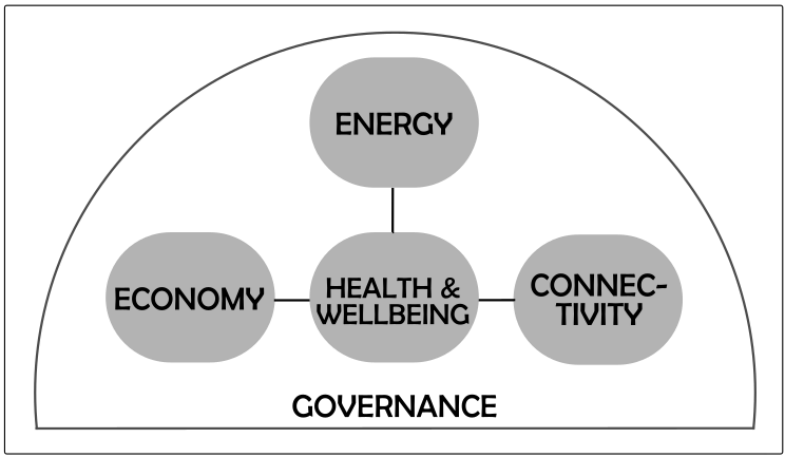

Figure 4. Birmingham's plexus of critical challenges.

When the plexus was cross referenced with the City Council's published priority areas (children, housing, jobs & skills, and health (Birmingham City Council, no date)) there was clearly some mismatch. This raises the question as to what might the implications be for a city if the local authority promotes policy priorities that do not address the city's critical challenges and plexus.

It is possible to envisage identifying critical challenge plexuses in cities other than Birmingham. A comparison across plexuses may reveal common plexus elements, perhaps even common complete plexuses that could (should) be addressed at national or even global scales. Understanding the relationships between the critical challenges of multiple cities in this way offers the promise of illuminating critical points of intervention and thus focusing to deliver the greatest effect from scarce resources. It speaks to thinking beyond ‘city systems’ to ‘systems of cities’ and it moves the ‘urban challenges diagnostic methodology’ described herein towards becoming a ‘challenges of urbanisation diagnostic methodology’.

Although the Birmingham critical challenges plexus provided a useful evidence base and framework within which Birmingham's policymakers and decision-makers

could think about the challenges faced by the city, it did not provide specific insights into how to address them. For this, further, deductive diagnostics are clearly needed (and are the subject of future work).

4. Discussion and conclusions

Cities are complex interdependent systems of soft and hard systems. Existing approaches to understanding urban challenges have tended to focus on previously (often politically) defined challenges rather than the identification of challenges by a more independent and objective diagnostics process. This study has explored the development of such a process for the first time by drawing upon approaches developed in medicine. A medic develops an overview of a patient by reading signs displayed by a patient. An abductive diagnosis is made and then a process of testing commences (deductive diagnostics). The application of this process to cities provides an approach in which an assessment of assumptions of the challenges facing a particular city can be tested through a more formal evaluation of data.

Cities are where opportunities and challenges emerge from a complex confluence of multiple individual and societal activities, the built environment, infrastructures, the economy, the natural environment and numerous systems of formal and informal governance. The approach to urban diagnostics developed in this paper was based on the analysis of a large city, but the approach can also be applied at various densities of living and geographical scales. This diagnostic methodology is both globally transferable and scalable: via a common geography it provides a framework for bringing together datasets and documents with different characteristics, and via a layered geography it allows for replication to other areas (smaller and larger). Datasets and documents that have national

coverage are supplemented and enhanced by locally-defined and collected evidence that adds richness to the analysis – built within a framework that makes comparisons between places possible.

This study found that there are almost no existing studies where an individual city's challenges are holistically and exploratively diagnosed through an open process that does not focus upon a specific problem, issue, or system. The reasons for this are not fully clear. One possible contributing factor is the long-term, dynamic-yet-incremental nature of some city challenges. Intractable challenges, such as poverty and inequality, are understood and addressed over decades. Such challenges are complicated to address and there is no 'magic bullet' for quick and easy resolution. Such challenges also become part of the fabric of a city – perceived as ever present. Another possible contributing factor is that some challenges can probably be found, to a greater or lesser extent, in all cities. The recent and global emancipation of data (Kitchin *et al.*, 2015) and its use in measuring and monitoring cities in particular (Symons, 2016; Leach *et al.*, 2017) has given rise to an increasing number, and sophistication, of studies exploring city challenges (Leach *et al.*, 2017). However, it seems these data are not being used to diagnose urban challenges, but rather to better understand and address known challenges. This study argues that using data to diagnose a city's critical challenges is as important as using the data to address those challenges (and, potentially, influences how they are addressed, as with Birmingham's challenge plexus). Without diagnostics, electoral cycles and visible problems disproportionately influence planning and policy interventions. An urban diagnostics approach provides planners and policymakers with the opportunity to create a grounded set of evidence-based interventions alongside a set of benchmarks of city performance against which future city performance can be compared.

This study designed a mixed-methods approach to urban challenges diagnostics and successfully applied it to the city of Birmingham, UK. Although the outcomes of the analysis did not identify any previously unknown challenges within the city, they did identify a plexus of critical challenges that the authors argue should be collectively addressed rather than addressed in isolation if interventions are to be effective.

In addition, the following insights emerged regarding the potential to transfer the urban challenges diagnostics methodology to other cities across the world.

- Urban challenges diagnostics should be applied for the purpose of holistically and exploratively identifying the (potentially critical) challenges faced by a city, and their interactions. Moreover, with limited time and resources, an urban challenges diagnostics method has to be bounded to make it manageable: the limits should be made explicit and should seek to retain as holistic and explorative an approach as possible. Bounding with regard to time, areas of focus and geography were successfully used in the Birmingham case study. Furthermore, urban diagnostics should seek to include as wide a breadth of evidence types as possible, including datasets and documents (especially as availability issues are likely to limit analyses). To paraphrase: if you analyse what you've always analysed you will get the results you always got. Thinking creatively about what constitutes usable evidence may lead to identifying new sources. A comprehensive data and evidence identification framework was developed for this study.
- Analysis techniques should be selected to match the gathered evidence, not the other way around, so as not to unnecessarily limit the breadth of the evidence. For this study a principal components analysis was chosen to analyse the datasets as it is a proven explorative method for preliminary data analysis. Similarly, building

an evidence map was chosen to analyse the documents as it is a proven explorative method for identifying information and geographical gluts (i.e., data hotspots) and gaps. Crucially, it is important to recognise that it is highly unlikely that all the evidence will be able to be analysed using a single technique. Complementary analysis techniques should be selected so as much of the available evidence as possible is analysed in some way, even if those ways are different. For this study, the PCA and evidence map methods were selected as they provided explorative oversights of the evidence with only minimal segmentation of the evidence.

- Robust and repeatable (and, if possible, innovative) analysis techniques should be selected that interrogate the evidence from a variety of angles and in complementary ways. In this study, the methodological refinement and application of evidence mapping for the purpose of identifying urban challenges is both innovative and new. The research revealed two further critical lessons: Firstly, care should be taken not to bias outcomes by using hypothesis-driven approaches. Secondly, interpreting outcomes from different analysis techniques using varying evidence sources (likely with different geographical, cohort and time elements) is challenging and requires those interpreting the outcomes to have experience in research synthesis and interpretation, as well as a good knowledge of the city under study. To assist with this, consulting as broadly as possible is desirable. For the Birmingham case study policymakers, urban design decision-makers, urban professionals, and academics, all of whom were familiar with Birmingham, were consulted.
- Interpretation of the diagnostic outcomes should take cognisance not only of the challenges that have been revealed, but also where the gaps in knowledge are

located (i.e., what are the analyses not saying, how might missing evidence bias the outcomes?). In the same vein, biases should be made explicit. For example, do the evidence and data hotspots arise because they reflect research funding hotspots, ease of data availability or local authority priorities; do the study's bounding criteria provide a skewed perspective?

- Cities don't behave in isolation within their own borders, and, in terms of the challenges they face, change over time. Interpretation should consider how representative the diagnostics are of these elements.

Perhaps the most important question those conducting an urban challenges diagnostics analysis can ask is: are the diagnostic outcomes a true reflection of the city's challenges? Answering this question requires critical reflection upon the diagnostic methodology and its outcomes alongside consultation with local authorities, planners, policymakers, urban design decision-makers, urban professionals, academics, businesses, financiers and communities. The diagnostic approach taken in this study was inspired by the medical literature, and yet medical diagnostics are not as scientific as they might appear. Medical diagnostics are both an art and a science. Some symptoms are read without, perhaps, any explicit appreciation that they have been seen or considered – in other words, diagnostics can be, in part, intuitive (Brush *et al*, 2017). Medical diagnostics are also partly subjective, with some symptoms being more subjective than others (Pallagrosi *et al.*, 2016). There is no reason to think urban diagnostics are any different.

It might be argued that the problems faced by any given city are well known. Birmingham's local government certainly thought this: that it knew what the city's challenges were and thought that the main problem it had was in effectively addressing

those challenges. This study revealed that this was not necessarily the case and it makes the argument that urban diagnostics can lead to reconceptualising a city's challenges (in Birmingham's case, as an interconnected system of critical challenges: a plexus), which can lead to more effective ways of addressing them.

Effectively and efficiently addressing urban challenges is increasingly important (Acuto *et al*, 2018); however, the degree to which new strategic frames, such as a city's 'critical challenges plexus', overlap with those of other cities, travel in tact (i.e., move from one department, organisation or group to another) and the degree to which they are lost, in whole or part, through translation back into established systems (Healey, 2007) materially affects their potential to create better outcomes for people.

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Data statement

All data created during this research are openly available from the University of Birmingham data archive. The Principal Components Analysis (PCA) dataset is available from https://edata.bham.ac.uk/241/, DOI 10.25500/eData.bham.00000241. The evidence analysis dataset is available from https://edata.bham.ac.uk/240/, DOI 10.25500/eData.bham.00000240. Application of the PCA and evidence analysis are published in full in the supplementary data for this paper.

Declaration of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2018.09.012.

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Paper 6. Analysis methods used when applying the mixed-methods diagnostics approach to Birmingham, UK.

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Evidence-identification framework

Variations in evidence types meant that in implementing the mixed-methods approach in Birmingham it was not possible to apply a single analysis method to all the datasets and documents. Two analysis methods (a principal components analysis and an evidence map) were selected and are described below. These analysis methods were selected for their appropriateness for conducting a diagnostic assessment, exploratory approaches (i.e., not hypothesis-directed), suitability to the gathered evidence, and ability to be interpreted together.

In the first instance, a resource-based identification framework was constructed to guide the selection and categorisation of datasets and documents (Table A.1). The framework identified resource groups for the individual, household and place that together provided proxies for urban living in Birmingham. This was based on standard categories used to organise data in repositories and key variables in datasets as well as a small number of necessary additions required to fully accommodate the scope of the

study: timeframe (2010 onwards), focus (urban services and systems) and geography (Birmingham city's political boundary).

Table A.1. Evidence-identification framework.

Theme	PCA sub-themes	Evidence mapping sub-themes
Economy and finance	Economic output (GVA, productivity), Financial resources, Assets, Business rates,	Economic profile, Economic activity, Financial activity, Financial resources, Cost effectiveness, Investment, Economic demography, Economic health, Economic initiatives
Business and industry	Business demography, Location, Productivity	Business demography, Business sector, Business development, Assets
Employment and labour market (including earnings)	Employment/unemployment, Economic activity, Labour market, Industrial relations, Travel to work, Occupation, Workplace location, Hours worked, Recruitment, Vacancies	Employment profiles, Employment opportunities, Labour market, Employment trajectories, Youth unemployment
Skills and training	Qualification, Apprenticeships, Training, Work experience	Skill attainment, Training schemes, Training activities, Skill profiles, Training opportunities, Public awareness
Science, technology and innovation	Business innovation	Business innovation, Creative innovation, Smart, Enterprise, Digital infrastructure
Inclusion	Community, Anti-social behaviour	Communities, Social inclusion, Social change, Community cohesion, Disadvantaged communities, Community relations, Sense of place, Key figures in communities, Segregation, Relational practices, Civil society, Inequality, Sense of identity, Stigma, Access (and equality of access)
Income and poverty	Income/wage, Individual assets and investments	Household income, Individual income
Health and wellbeing	Child and adolescent health, Child development, Mental health, Disability, Social care, Levels of activity, Obesity, Primary care, Vaccination and immunisation, Dental health, Drug and alcohol use, Hospital admissions, Sexually transmitted diseases, Life satisfaction, Variation in healthcare, Public health outcomes, Elderly care, Quality of life	Medical disorders, Physical health, Mental health, Sense of wellbeing, Sport provision, Physical activity, Leisure activities, Nutrition, Illness, Disease, Mortality, Spiritual needs, Drug use, Smoking, Accidents, Disease transmission, Trauma, Healthcare system, Healthcare practices, Medical technology sector, Health and wellbeing support services, Mental Health Act, Treatment, Healthcare workers, Ambulance services, Alternative and complementary medicines, Provision (of city services)

Housing	Affordable housing, Dwelling stock, Social housing composition, Demand, Development sites, Registered providers, Price ratios, Temporary accommodation	Housing supply, housing provision, housing demand, housing design, housing sector, housing market
Crime and safety	Street-level crime, Fire incidents	Crime rates, feeling safe, Crime incidents, Offending
Education and learning	Admissions, Performance, Pupil attainment, Destinations of leavers, School demographics and locations	Education provision, Education sector, Academic attainment, Teaching, Learning, Education outcomes
People and society	Society, Culture (social behaviour), Child development, Social attitudes and behaviour, Cultural resources and use, Tourism	Culture (social behaviour), Culture (arts, sport), Heritage, Conservation, Brand image
Demography (including ethnicity and aging)	Migration, Aging, Population characteristics	Demographics, Ethnicity, Religion, Age, Gender, Population characteristics, Diversity
Deprivation	Need, Indebtedness, Welfare, Worklessness	Deprivation, Socio-economic status
Information and Communication	Broadband, Mobile	
Food	Allotments	Urban agriculture
Mobility and transport	Mode of transport, Transport networks, Connectivity, Mobility, Passenger counts, Public transport, Traffic counts, Congestion, Common land	Transport infrastructure, Transport services, Connectivity, Mobility, Public transport, Private transport, Transport sector, Traffic management, Travel behaviour, Passenger experience, Accessibility, Congestion, Public rights of way
Natural Environment (including green spaces)	Green spaces, Conservation, Wildlife and biodiversity, Allotments, Statutory common land	Green spaces, Parks, Open spaces, Natural environment, Biodiversity, Habitat, Green belt, Landscape character, Ecology, Rivers, Trees, Species, Ecosystem services, Natural capital, Productive landscapes, Playing pitches, Weather, Climate, Natural features, Urban water cycle, Green infrastructure
Built environment	Urban form, Local centres, Unsatisfactory sites	Housing, Urban form, Local centres, Building height, Community facilities, sports facilities, Buildings, Architecture, Urban design, Built features, Built infrastructure (excluding water, waste, energy, transport, green), Public space, Civic space, Public realm
Energy	Consumption, Renewable energy, Energy efficiency, Fuel poverty, Energy-related schemes	Energy performance, Supply, Demand, Infrastructure, Renewable energy

Land use and planning	Land use, Planning applications, Developments, Vacant land	Industrial land, Employment land, Rural urban fringe (RUF), Regeneration, Development, Reconstruction, Provision
Waste	Waste material, Recycling	Waste material, infrastructure
Water (potable)	Performance	Performance, infrastructure, Supply, Demand
Environmental risk	Flooding, Vulnerability to climate change, Air quality, Emissions, Pollution (inc. light)	Flooding, Road dust, Pollution, Air quality, Climate change mitigation, Climate change adaptation, Climate change vulnerability, Carbon emissions, Heat, Urban heat island
Governance	Engagement of citizens, Elections, Council budgets, Attitudes to council service provision	Engagement of citizens, Policymaking, Management, Maintenance, Resilience, Strategy, Decision making, Political parties, Legal framework, Public services
Growth		Economic growth, Built environment growth, Population growth, Demand growth, Supply growth
Creating an evidence base		Monitoring, Research, Mapping, Evaluation, Modelling, Performance assessment, Provision, Supply, Demand, Consumption, Quality
Resources (excluding water, energy, waste and food)		Resources, Minerals, Hydrogen, Metals, Resource security, Resource supply, Resource demand
Sustainability and resilience		Sustainability, Resilience, Green

Principal components analysis (PCA)

The issues regarding analysing the datasets were first the identification of the datasets (a total of 258 separate datasets were identified) and second to what degree they could be combined into a single, analytical approach. PCA was selected as it is a proven method for preliminary data analysis used specifically to inform selection of further data for analysis (e.g., for deductive diagnostics).

A principal components analysis using SPSS was conducted for the purpose of understanding and grouping the most important variables for characterising the city, and their interactions and geographical attributes. The datasets were statistically analysed

following an approach used by Cutter *et al.* (2003) to develop a Social Vulnerability Index for environmental hazards – it described the key variance in the data and reduced the quantity of data needed to represent that variance. In order for a dataset to be included in the PCA, data points had to cover the Birmingham Metropolitan District (Birmingham, E08000025) – Birmingham is not a merged district and has no merged wards since 2001 – and had to be geocoded at the lower layer super output area (LSOA). These requirements excluded a number of datasets.

In total, 58 variables were included in the analysis from across the suitable datasets. The PCA identified 14 significantly separate groups of variables, which together accounted for 79.221% of the total variance in the dataset (Table A.2). The extracted communalities are also high on all variables, with the majority in excess of 0.7. All 14 components have eigenvalues greater than 1, indicating that these components are a more important description of variance than the observed variable (Tabachnick and Fidell, 2011).

Table A.2. Total variance explained.

	Rotation sums of squared loadings		
Component	Total	% of variance	Cumulative %
1	9.833	17.878	17.878
2	8.035	14.610	32.487
3	5.097	9.267	41.754
4	4.275	7.773	49.527
5	2.613	4.750	54.277
6	2.481	4.512	58.789
7	1.954	3.554	62.342
8	1.837	3.340	65.682
9	1.475	2.682	68.365
10	1.295	2.354	70.719
11	1.287	2.340	73.059
12	1.166	2.121	75.179
13	1.139	2.072	77.251
14	1.084	1.970	79.221

The first six principal components were retained for analysis as they represented stable groupings (Table A.3). Inspection of the scree plot indicated that components beyond 8 should not be retained because this is the elbow point (sharp break). In addition, principal components 7 onwards have too few variables loaded onto the component (1-2), suggesting the component is unstable. As an orthogonal varimax rotation was used, the component loadings represent direct correlations between variables and factors. This aids interpretation because the relationships between variables and components are clearer. The strongest correlations were retained in the component loadings (above 0.5) to indicate accepted 'good fit' (Tabachnick and Fidell, 2011, p. 625 citing Comrey and Lee, 1992).

Table A.3. Stable principal components from PCA analysis.

	Principal Component	**Interpretation**
1	Deprivation, Skills and Health	The first component, accounting for 17.878% of the variance, has identified a relationship between income and deprivation, skill and occupation, health, housing value and energy consumption. Income deprivation relates to long term unemployment, rates of homelessness, elementary occupations, lone parent households, youth population (under 18 years old), low value housing and higher incidences of residents reporting 'bad or very bad' health. The counter of this group is highly skilled residents, professional occupations, high GCSE results, self-employed residents and domestic gas consumption.
2	Ethnicity and Living Conditions	The second principal component, accounting for 14.610% of the variance, identified a strong correlation between ethnicity, non-UK born residents and household overcrowding (too few bedrooms). A poorer outdoor living environment (proxy for road accidents and air pollution), social exclusion (proxy by inability to speak English well) and access to schools by public transport or walking were also linked. The counter of these variables is economic activity levels. Again, the spatial distribution identifies a central band across the city.
3	Connectivity and Wellbeing	The third principal component, accounting for 9.267% of the variance, identified a relationship

		between wellbeing (measured by subjective wellbeing) and connectivity (both access to services and journey times). These variables do not load significantly into any other groups, indicating this to be a distinct group of variables.
4	City Core	The fourth principal component, accounting for 7.773% of the variance, is less clear. Home ownership is negatively loaded to the component and illustrates a spatial pattern, again with the central core having relatively low levels. This is likely to be an indication of the housing stock and resident group in the city core (privately rented). The positively loaded variables do not illustrate a clear spatial pattern. The negatively loaded variables display a less clear spatial pattern when examining the upper quartile distributions. However, all these factors display outliers with the extreme values occurring in the city centre core in parts of Ladywood, Aston and Nechells. Travel to work by foot or bike is heavily concentrated in the city centre (with over 75% of residents travelling by foot or bike). Vacancies are located in patches across the city but the extreme values are also in the city core, as too for pensioners living alone and crime rates.
5	Mobility and Economic Advantage	There is another mobility component identified (principal component 5, representing 4.750% of the total variance), which draws together a group of variables related to economic activity and mobility. These variables highlight the relationship between economic activity opportunities and access to employment and further education centres.
6	Density and Green space	The sixth component, accounting for 4.512% of the variance, group reflects the relationship between resident population density, domestic building density and green space in the city.

The principal components were then combined with the following additional evidence sources to aid interpretation of the results, giving rise to the identification of five challenge areas (Table A.4). This process required synthesis and interpretation of the principal component groupings.

- City-scale data profiles of economic, societal and environmental domains constructed from existing reviews and databanks;

- Information gathered from consultation with policymakers, urban design decision-makers, urban professionals and academics via two workshops (12 September and 29 November 2016) and email follow-up after each workshop.

Table A.4. Five challenge areas identified from the principal component analysis.

	Challenge area	**Interpretation**
1	Economic Advantage, Equity and Healthy Households (arising from principal component 1)	There is a thematic link between economic advantage, housing, energy and health, which presents a wider framework for understanding and supporting more equitable growth across the city.
2	Healthy Living Environments and Community Prosperity (arising from principal component 2)	There is a distinct spatial band around the city core that reflects a transition zone into the city core but is also a key residential population that has disadvantaged living conditions.
3	A Connected and Liveable City (arising from principal components 3 and 5)	There is an indicative pattern related to internal connectivity by access to local services by public transport or walking, which suggests a challenge around relative 'distance' and transport networks within the city to support community-based approaches to wellbeing.
4	A Prosperous Core (arising from principal component 4)	The zone around the immediate city core may be disconnected from the regeneration of various parts of the centre. Increased levels of negative liveability suggest the area is not integrated with the prosperity and brand of the city centre.
5	Integrating Urban Form and Natural Capital (arising from principal component 6)	This challenge area highlights a disconnect between the natural and urban form of the city and the resident population characteristics.

In addition, three themes were found to be common across the challenge areas.

1. A significant socio-spatial divide across the city. The central band, including the city core and to the eastern boundary, demonstrate higher levels of deprivation and ethnic diversity than the north and south of the city.
2. An apparent disconnect between the users of the city. The resident population is segmented through the central band, with younger populations and higher levels of deprivation found here. The older age group (45-59 years old) have noticeable

concentrations in the north of the city. This raises issues about how well the city serves the needs and desires of residents in particular locations. In addition, the city has a significant in-migration of workers from outside the authority, who on average earn more than the residents of the city and the wider West Midlands. This indicates a mismatch between those travelling into the city to work and those living in the city.

3. Health and wellbeing is a common theme across the challenges. There is an inter-relationship between deprivation and economic wellbeing, urban form, connectivity and health. This theme connects the individual or household with the physical structure of the city.

Challenge area 1: Economic advantage, equity and healthy households.

There is a clear spatial divide in the level of economic advantage across Birmingham. Economic advantage is defined here as advanced skill levels (N.V.Q. level 4 and above), category of occupation (professional and elementary), educational performance (average G.C.S.E. points score) and self-employment. The north of the city (Sutton Coldfield) and parts of the south (notably Edgbaston and Selly Oak) record higher proportions of resident populations with these characteristics. Counter to this, income deprivation is clustered in the central band across the city (Ladywood, Hodge Hill and Yardley). This area also has higher levels of lone parents with dependent children, long term unemployment and the lowest value housing stock (Council Tax Band A). These variables are represented in the first principal component, as shown in Table A.5.

Table A.5. Results of principal component 1.

Variable	Component loading	Variable	Component loading
Percentage of lone parent households with dependent children	0.882	Percentage of economically active age in professional occupations	-0.801
Score of income deprivation	0.873	Percentage of residents with level 4+ qualification	-0.778
Percentage of economically active age residents long term unemployed	0.837	Percentage of economically active age residents that are self employed	-0.720
Percentage of economically active age residents in elementary occupations	0.761	Average domestic gas consumption	-0.717
Percentage of dwellings in council tax band A	0.695	Average GCSE score of resident pupils	-0.706
Percentage of residents reporting bad or very bad health	0.650		
Rate of statutory homelessness applications (priority need) per 100 households	0.632		
Percentage of residents under 18 years of age	0.590		

Domestic gas consumption levels are also related to the housing stock and consumer behaviour of households across the city, which replicates the above distribution pattern. The relationship between housing and energy (gas) consumption is outlined in Figure A.1. This relationship is again identified in a subsequent challenge area that correlates electricity consumption with above average value housing stock (Council Tax Band E-I). The relationship between housing and domestic energy consumption is most likely to be a reflection of heating. It would be expected that the size of housing (proxy by value) would influence consumption levels, as well as the type of the housing stock (use of gas or electric heating). However, the variable 'no central heating' was not identified, suggesting that the relationship is also a reflection on the cost of energy and consumer behaviour.

The results indicate a common spatial pattern between economic disadvantage and high levels of reported 'bad or very bad' health (Figure A.2). The central band across the city core to the boundary of the city is comprised of high levels of deprivation, lower value housing and higher levels of reported 'bad or very bad health'. There are also pockets to the south of Birmingham that reflect these patterns but there is a sharp divide to the north of the city. This health-related pattern is also present in levels of child obesity in children aged 10-11 (school year 6) (Figure A.3). The central band is apparent, as well as the sharp divide to the north. The difference in profiles of residents across the city impacts life chances of individuals (proxy by educational performance and child obesity).

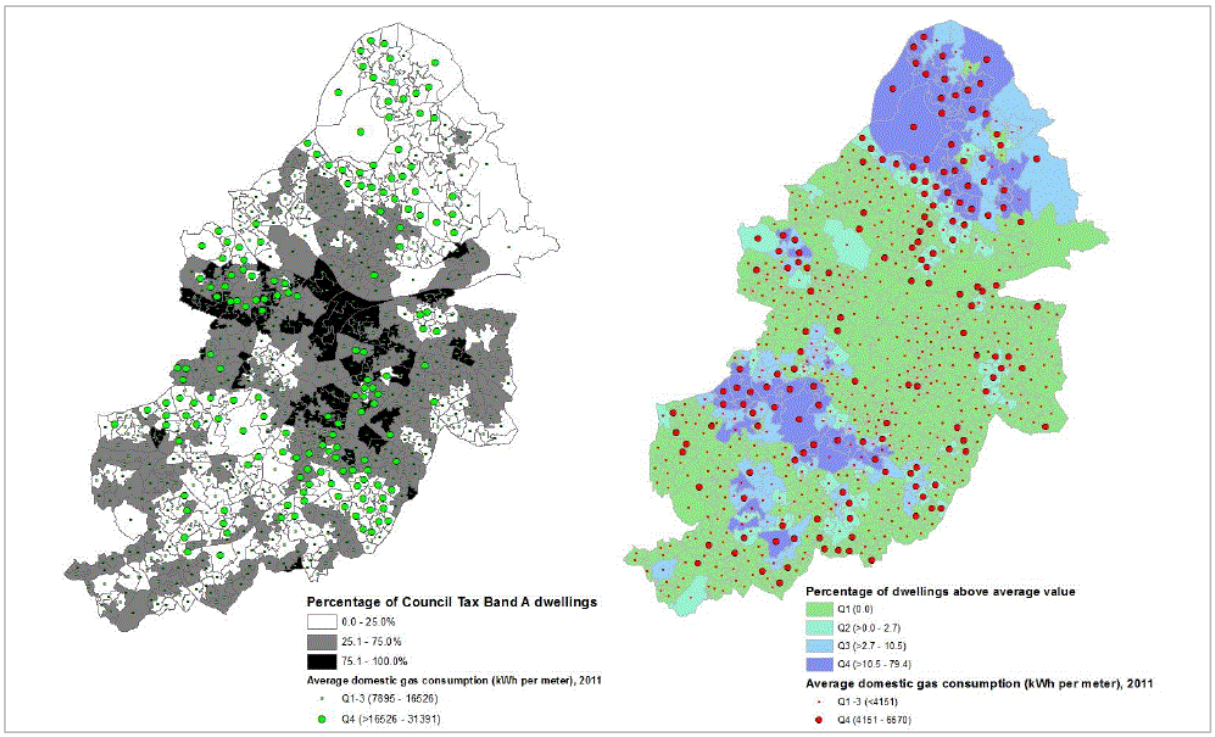

Figure A.1. (a) Low value housing stock and domestic gas consumption; (b) Above average housing stock value and domestic electricity consumption.
Source: Data from Department for Energy and Climate Change Sub-National Consumption Statistics released under OGL v3.0. Contains Valuation Office Agency data 2015; Contains National Statistics data © Crown copyright and database right 2016; Contains Ordnance Survey data © Crown copyright and database right 2016; Data provided by the ESRC Consumer Data Research Centre funded by: Economic and Social Research Council ES/L011840/1.

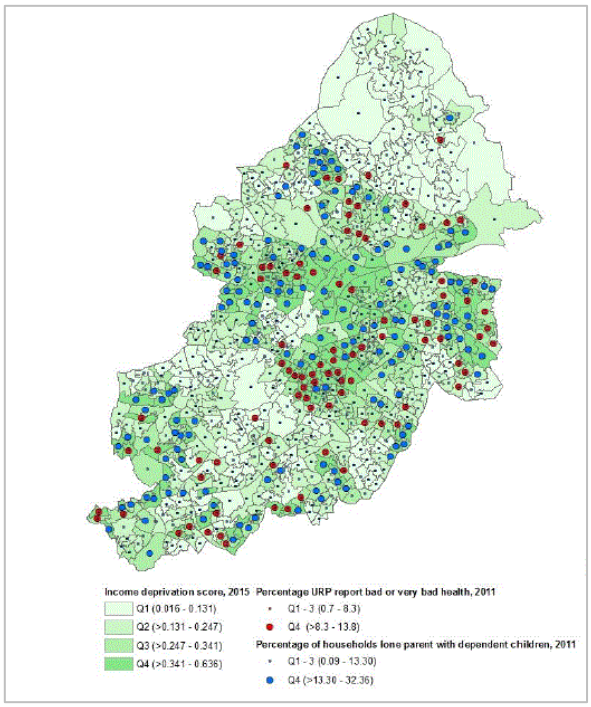

Figure A.2. Income deprivation, health and lone parent households.
Source: Contains National Statistics data Crown copyright and database right 2016.

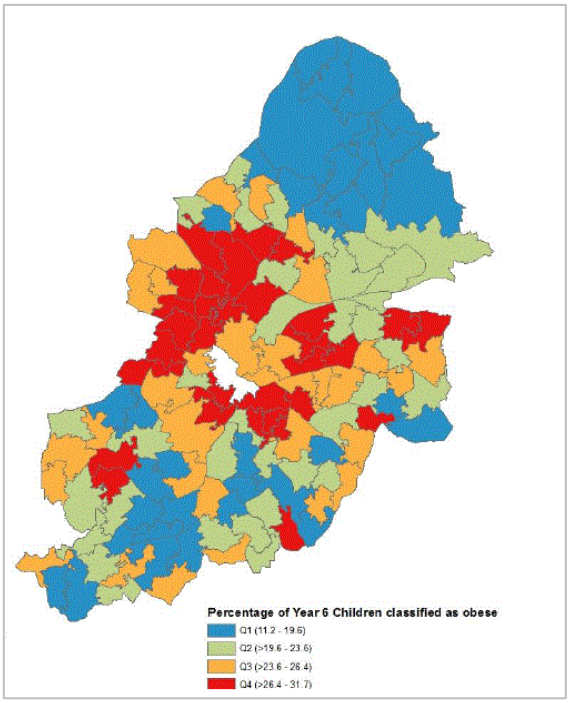

Figure A.3. Child obesity (Year 6) at the middle-layer super output area level.
Source: Data sourced from Local Health England. Contains National Statistics data Crown copyright and database right 2016.
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Challenge area 2: Healthy Living Environments and Community Prosperity

The outer city core has a distinct community group, with higher levels of black and ethnic minority residents and also non-UK born residents (Table A.6). The results indicate this community group correlates with a lower standard of living conditions. Bedroom overcrowding (at least one too few bedrooms) features highly. The outdoor environment, indicated by road accidents involving pedestrians and cyclists as well as air pollution, suggests the area is at relative disadvantage to other parts of the city. The proximity and density of the road network in this part of the city explains the hotspot of disadvantage here but this disproportionately affects this community group. Access to schools is also positive, reflecting the greater mobility (via public transport and walking) and also the higher concentrations of school-age children in these areas (Singleton, 2015: Figure 9-11). Forecasts for school places in the area show that these areas are at low risk in the short-term for primary (reception) places but do have an increased risk of insufficient places for secondary (year 7) places (Birmingham City Council, 2016).

In addition, there is an inverse association with these household living conditions and economic activity (Figure A.4). At a city level there is a far lower employment rate of females of Pakistani/Bangladeshi ethnicity than other ethnic groups (Greater Birmingham Chamber of Commerce, 2016, p. 22). The spatial distribution also correlates with higher levels of part-time working (both males and females), as well as higher densities of female economic inactivity to look after home or family (Singleton, 2015: Figure 235 and 236).

Table A.6. Results of principal component 2.

Variable	Component loading	Variable	Component loading
Percentage of residents black or ethnic minority	0.940	Percentage of residents of economically active age who are economically active	-0.558
Percentage of residents who cannot speak English well or at all	0.917		
Percentage of residents who were not born in the UK	0.897		
Percentage of households with bedroom overcrowding	0.832		
Outdoor environment deprivation score	0.695		
Number of residents with reasonable access to primary schools	0.626		
Percentage of hours worked by residents that are part-time	0.585		
Number of residents with reasonable access to secondary school	0.506		

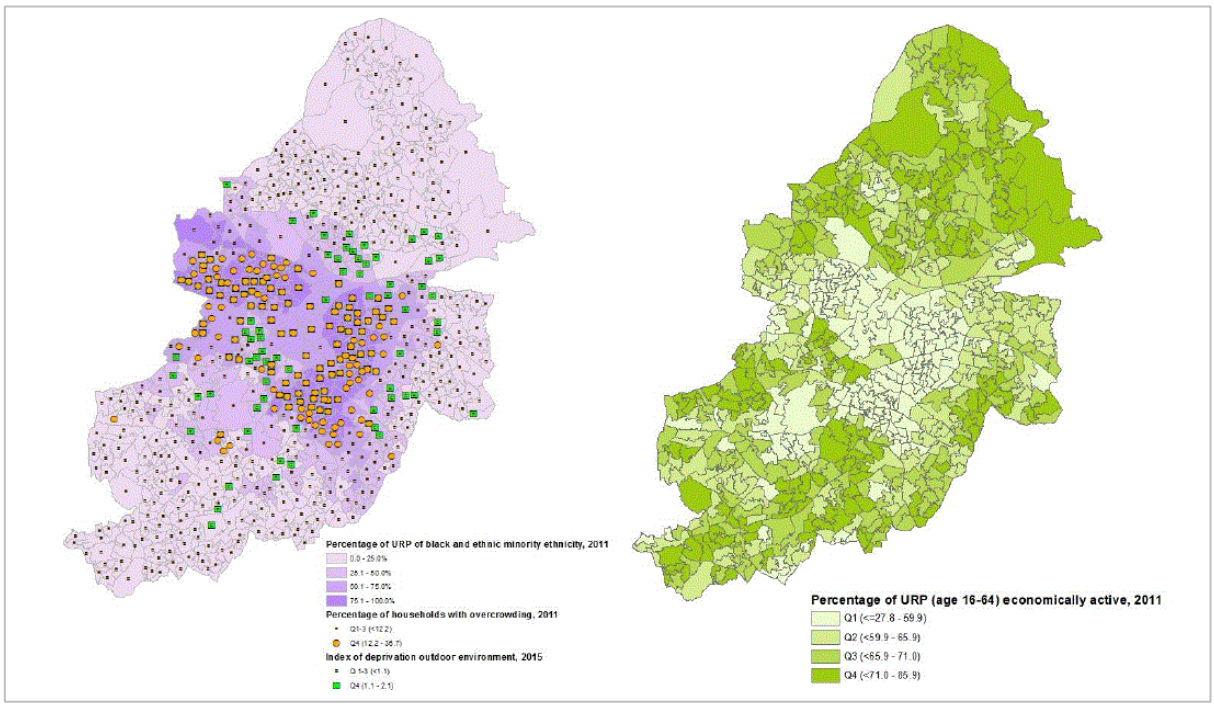

Figure A.4. (a) Ethnicity composition, outdoor living environment and overcrowding; (b) Economic activity levels.

Challenge area 3: A connected and liveable city

These results indicate a relationship between the level of connectivity, associated access to services and levels of life satisfaction. The interaction extends across the city and shows no clear spatial pattern or hotspot of disadvantage for accessibility. These variables do not load significantly into any other groups, indicating this to be a distinct group of variables (Table A.7). Although the spatial distribution of life satisfaction scores illustrate a central band of lower levels (Figure A.5), overall the scores for life satisfaction are within the low to medium range (between 6-8) and are similar to the UK average (7.46) (Office for National Statistics, 2014).

The relative 'distance' experienced by people using the city is reflected in the connectivity indicators in the data. These include access to the nearest major road junction (by car) and the nearest airport (by public transport). The weighted connectivity indicator is based on the estimated minimum journey time and also the number of onward connections. Access to services is based on average journey times to key service points.

Table A.7. Results of principal component 3.

Variable	**Component loading**
Number of households with access to GP within reasonable travel time by public transport or walking	0.871
Number of households with access to food within reasonable travel time by public transport or walking	0.848
Mean subjective wellbeing score	0.796
Weighted connectivity (travel time) indicator to key road junction by car (morning rush hour)	0.790
Number of households with access to town within reasonable travel time by public transport or walking	0.783
Weighted connectivity (travel time) indicator by public transport (morning rush hour)	0.699
Number of working age residents with access to employment centres within reasonable travel time by public transport or walking	0.695

There is also another mobility component identified (principal component 5, representing 4.750% of the total variance), which draws together a group of variables related to economic activity and mobility (Table A.8). These variables highlight the relationship between economic activity opportunities and access to employment and further education centres.

Table A.8. Results of principal component 5.

Variable	**Component loading**	**Variable**	**Component loading**
Number of residents (16-19) with access to further education in a reasonable time by public transport or walking	0.686	Economic activity rate of economically active age residents	-0.552
Number of working age residents with access to employment centres in a reasonable time by public transport or walking	0.568		
Average distance travelled to work	0.552		

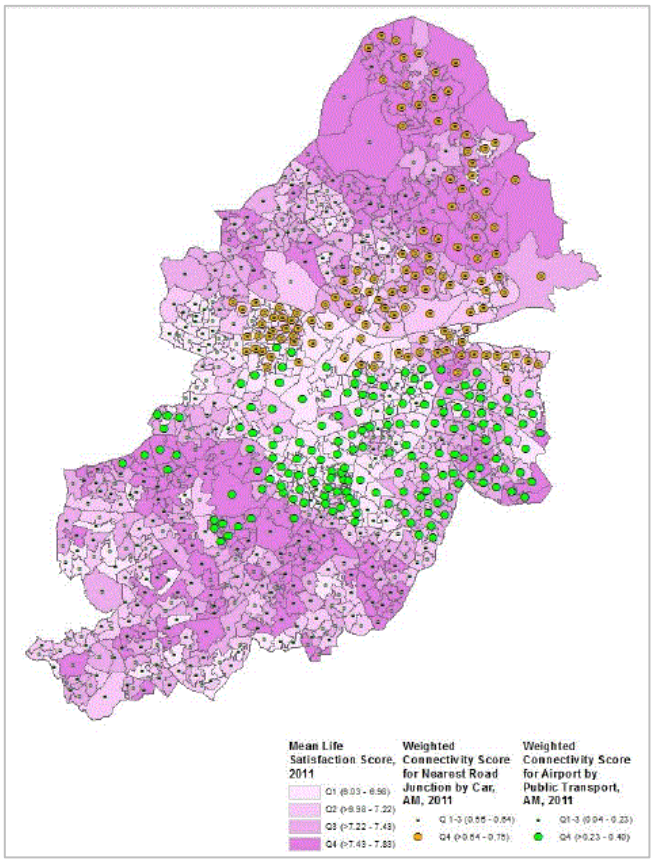

Figure A.5. Wellbeing and connectivity.
Source: Data from Department for Communities and Local Government (DCLG) modelled estimate of the expected wellbeing of residents at Lower-layer Super Output Area (LSOA) level from the national level ONS Annual Population Survey 2011-2012. Data released under OGL. Access times and connectivity statistics sourced from the Department for Transport under OGL v3.0. Contains Ordnance Survey data. © Crown Copyright and database right 2015. Data provided by Digimap OpenStream, an EDINA, University of Edinburgh Service.

Challenge area 4: A prosperous city core

The city core has been identified in the results as having a distinct sub-profile. Table A.9 outlines the loadings of the variables. The positively loaded variables do not illustrate a clear spatial pattern. However, all these factors display outliers with the extreme values occurring in a defined zone around the city centre core in parts of Ladywood, Aston and Nechells (Figure A.6). There are negative aspects to the core found in rates of street crime, for which it would be expected to have a higher proportion in the city centre. Higher

proportions of pensioners living alone are found in this area, but also across the city in patches. Live unfilled vacancies is a proxy for hard-to-fill vacancies. These occur across the city and occupations, with the highest numbers found in associate professional and technical, personal service and sales and customer service occupations. There is, however, a hotspot again in the city core, which may reflect the number of business located there, and also in pockets to the north of the city.

The percentage of people who travel to work on foot or bike is highest in the city core but shows distance decay from the city centre as would be expected. Home ownership is negatively loaded to the component and illustrates a spatial pattern (Figure A.7), again with the central core having relatively low levels. This is likely to be an indication of the housing stock and resident group in the city core (privately rented).

Table A.9. Results of principal component 4.

Variable	**Component loading**	**Variable**	**Component loading**
Percentage of residents who travel to work on foot or bike	0.819	Percentage of households who own their own home	-0.636
Number of live unfilled vacancies	0.656		
Percentage of pensioners living alone	0.624		
Rate of street level crime incidents (aggregated for a year)/1000 residents	0.607		

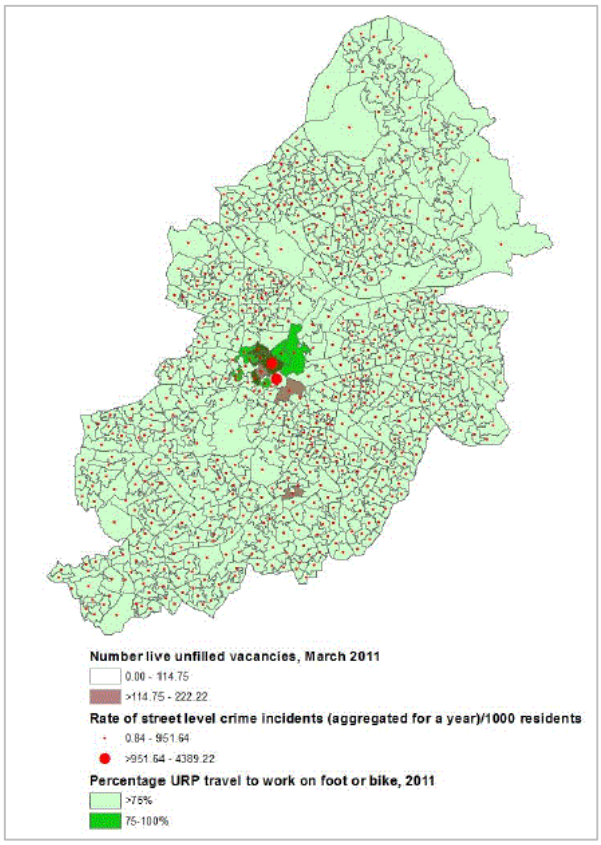

Figure A.6. City core.

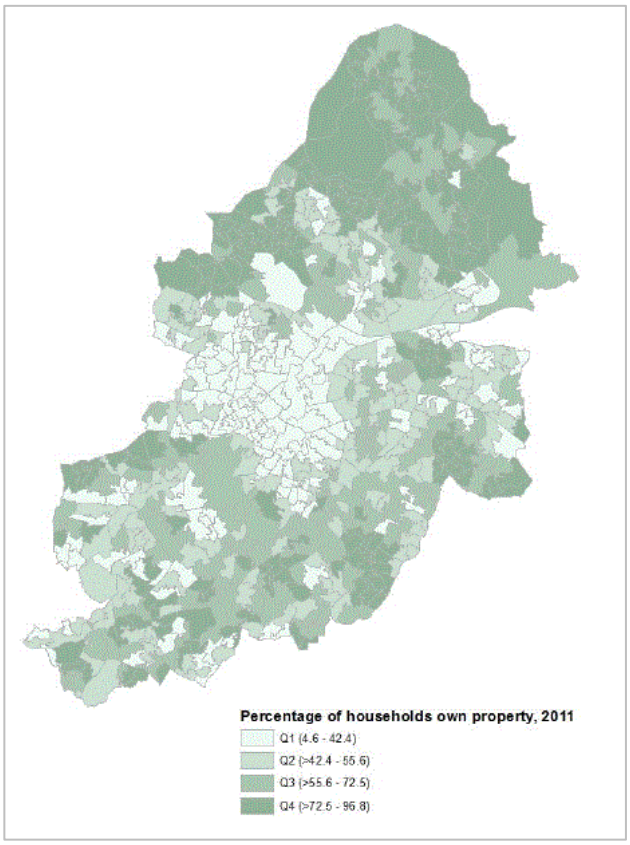

Figure A.7. Home ownership.
Contains Ordnance Survey data. © Crown Copyright and database right 2015. Data provided by Digimap OpenStream, an EDINA, University of Edinburgh Service.

Challenge area 5: Integrating Urban Form and Natural Capital

The PCA identified a significantly separate group of variables related to density: resident population, domestic buildings and, inversely, green space (Table A.10 and Figure A.8). These variables are naturally related and explain the urban form of the city within the dataset. Interestingly, the density variables have not been related to socio-demographic, resource use or connectivity variables. The impact of building and green space density is seen in spatial patterns of environmental risk. The intensity of the urban heat island is most significant across the central band of the city, extending eastwards from the city core (Tomlinson *et al.*, 2013). Significant flood risk from rivers (1 in 75 year likelihood) is also present across the north of the central band (Figure A.9). This central band has

been identified in earlier challenges as a distinct area of relative socio-economic and health disadvantage.

Table A.10. Results of principal component 6.

Variable	Component loading	Variable	Component loading
Percentage of total area covered by domestic building density	0.845	Percentage of total area covered by green space	-0.832
Resident population density (number of people per hectare)	0.764		

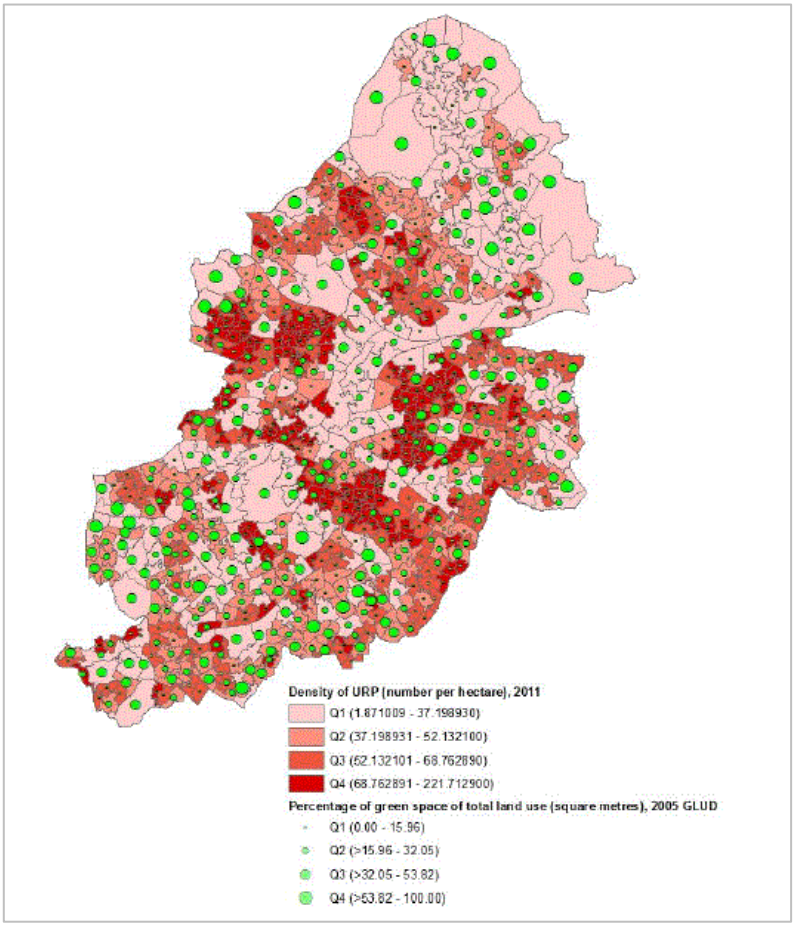

Figure A.8. Population density and green space.
Source: Data sourced from Generalised Land Use Statistics 2005 available under OGL. Contains Ordnance Survey data. © Crown Copyright and database right 2015. Data provided by Digimap OpenStream, an EDINA, University of Edinburgh Service.

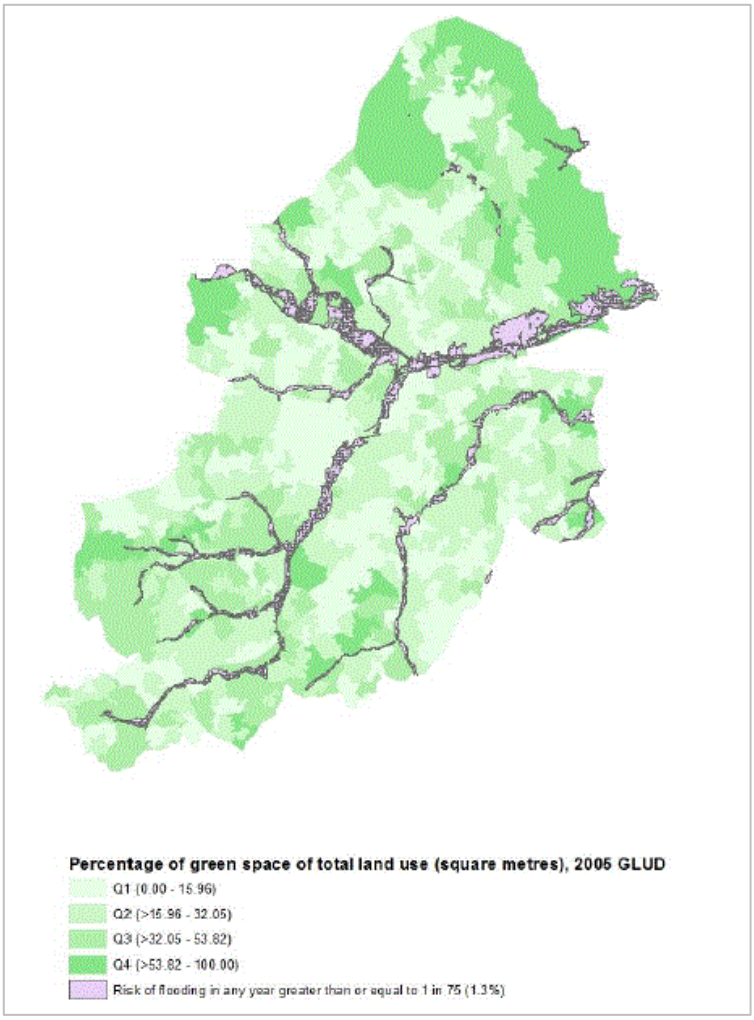

Figure A.9. Green space and flood risk.
Source: Data and map layer sourced from CDRC 2015 RoFRS Geodata Pack by the ESRC Consumer Data Research Centre.
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Contains Environmental Agency data copyright 2015 (under Open Government Licence). Funded by: Economic and Social Research Council (ES/L011840/1).

Evidence mapping

As with the datasets, one issue regarding analysing the documents was first their identification (a total of 380 documents were identified, 266 from academic literature and 114 from policy-related literature) and then determining to what degree their content could be combined to allow for analysis. The approach used by McKinnon *et al.* (2015) to develop an 'evidence map' was selected as it is a proven method for determining what

is already known about an area of interest (in this case, the city of Birmingham, UK), provides pointers to related datasets (potentially for inclusion in the PCA analysis), and identifies information and geographical gluts and gaps (McKinnon *et al.*, 2015). The analyses methods used by McKinnon *et al.* (2015) were modified to suit the document sources. Three analysis methods were developed, as follows.

1. A network analysis of documents to understand how the city services/functions they addressed are interconnected.
2. A hot & cold spot analysis to understand how numerous the document themes are.
3. A geographical bias analysis to understand the scales covered by the documents.

Included documents comprised the following.

- The Birmingham Development Plan (Birmingham City Council, 2013) and those documents and studies that informed it (83 in total)
- Academic studies arising from a Web of Science search, topic search: "Birmingham" and within this "UK", language: English, timespan: 2010-2016. 426 results returned. 262 relevant documents included.
- Other documents that adhered to the selection framework (21 in total).

A spreadsheet was created to drive the three analysis methods, as follows.

1. Each document was given a unique identifier.
2. Each document was identified as arising from either the policy-related or academic literature.
3. Each document's primary and secondary area of city service/function focus were recorded as relational topic pairs (e.g., growth and housing, economy and

innovation, heritage and conservation, waste and recycling, mobility and accessibility), with the foci arising organically from reviewing the evidence base. The foci were subjected to very little aggregation.

4. Each document's primary and secondary area of city service/ function focus were aggregated into themes. The themes were those used in the resource-based identification framework.
5. The geographical focus of each document was described as either regional (with specifics listed, such as the West Midlands Combined Authority area), whole city or sub-city (with specifics listed, such as Eastside). Geographical foci were not dis/aggregated to correspond with any official boundaries, such as political boundaries.

Network analysis

A network analysis of the city services/functions foci was undertaken for the purpose of understanding how the foci are interconnected. Using the Microsoft Excel plugin NodeXL, the city services/functions were subjected to a Harel-Koren Fast Multiscale network visualisation (Harel and Koren, 2001). This allowed for the network to be viewed with as few overlaps as possible. This revealed two distinct groupings (Figure A.10): a large group containing a mix of academic studies and policy-related documents and a small group that further investigation revealed not to be a group at all but rather a collection of largely binary relationships comprising predominately academic medical studies. These results suggest that health is discussed in very different terms within the policy documents (which are much more general about health and wellbeing) and within

the academic papers (which focus upon specific ailments, illnesses and demographies). Such a disconnect is not exclusive to Birmingham (Singh and Beagley, 2017).

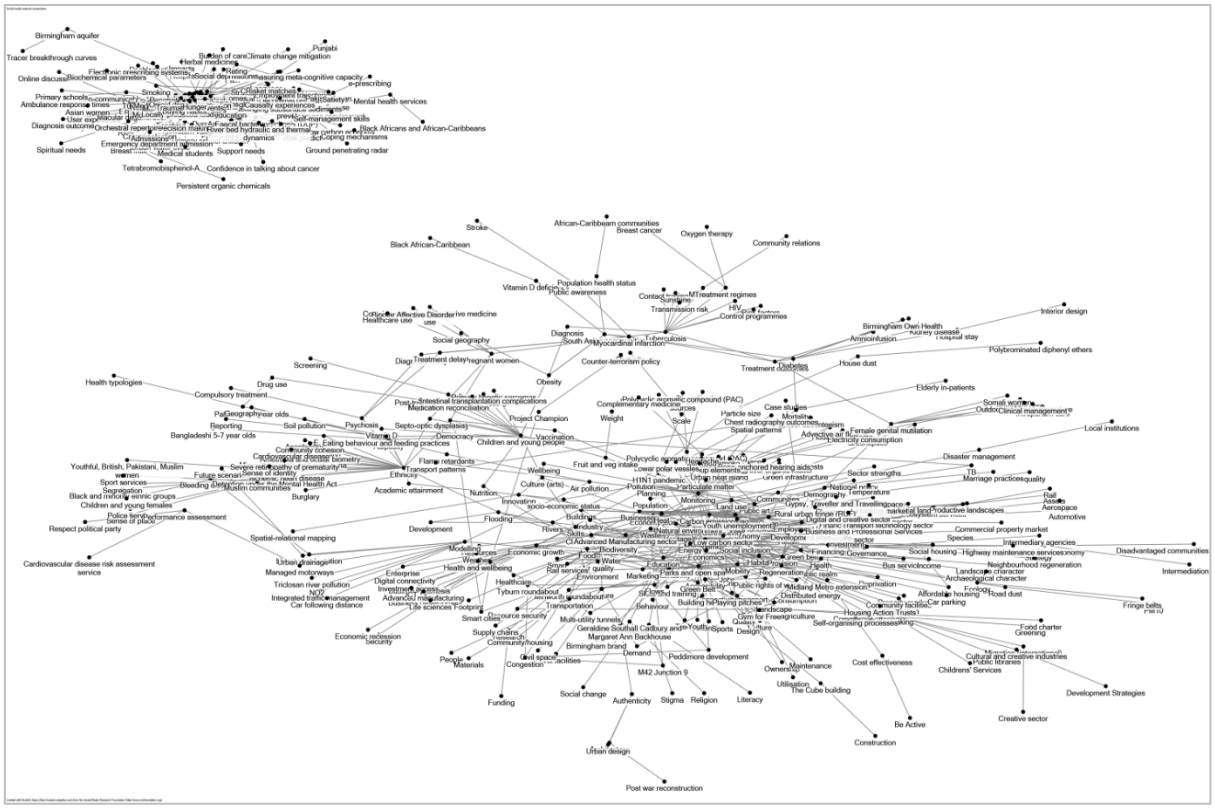

Figure A.10. Harel-Koren Fast Multiscale network visualisation of city service/function foci.

A Harel-Koren Fast Multiscale network visualisation using a circular representation revealed that, in general, Birmingham's policy literature is highly connected with itself, but less so with the academic literature (Figure A.11). This result suggests that Birmingham's policy evidence documents are only very loosely linked to academic evidence – a science-policy gap. Further investigation revealed that this is more than an issue of language; it is an issue of breadth as academic papers are much more narrowly scoped. Such issues are relatively well-known, but the underpinning types of disconnect (such as lack of breadth) is, perhaps, less understood.

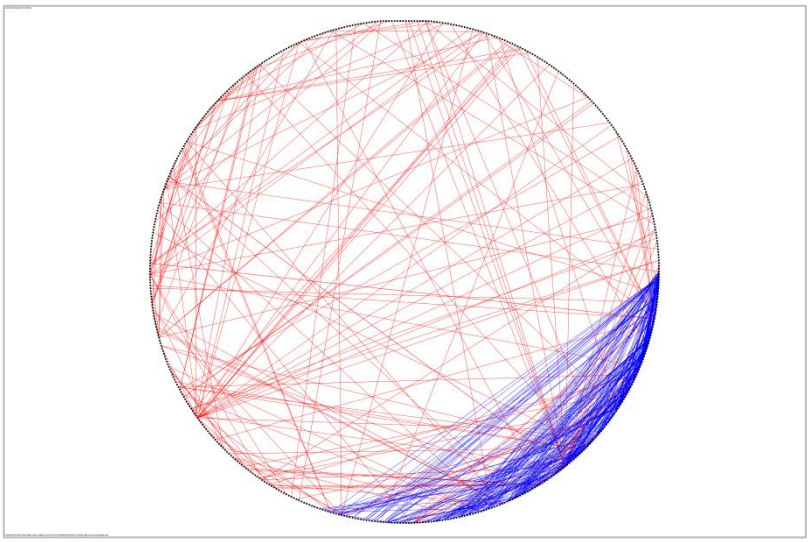

Figure A.11. Circular visualisation of city service/function foci coded by literature type. Blue = policy-related, red = academic.

Hot & cold spot analysis

A hot & cold spot analysis of document themes was conducted for the purpose of understanding how numerous the themes were. Using the Microsoft Excel plugin NodeXL, edge weights were used to count the theme pairings, which were then visualised using a Harel-Koren Fast Multiscale network visualisation with a grid representation (Figure A.12). Two hundred and ten unique theme pairings are apparent from the evidence documents. The top five most common pairings (hot spots with 20+ connections) were identified, after which there was a natural break.

1. ‘Health and wellbeing’ to ‘health and wellbeing’ x 86
2. ‘Health and wellbeing’ to ‘demography (including ethnicity and aging)’ x 66
3. ‘Mobility and transport’ to ‘creating an evidence base’ x 25
4. ‘Environmental risk’ to ‘creating an evidence base’ x 23
5. ‘Mobility and transport’ to ‘mobility and transport’ x 22

Cold spots were found to be numerous and so were arbitrarily defined as those pairings with only one connection. Seventy nine theme pairings accur only once. One hundred and sixty six pairings (more than half of the total number of pairings) have five or fewer connections.

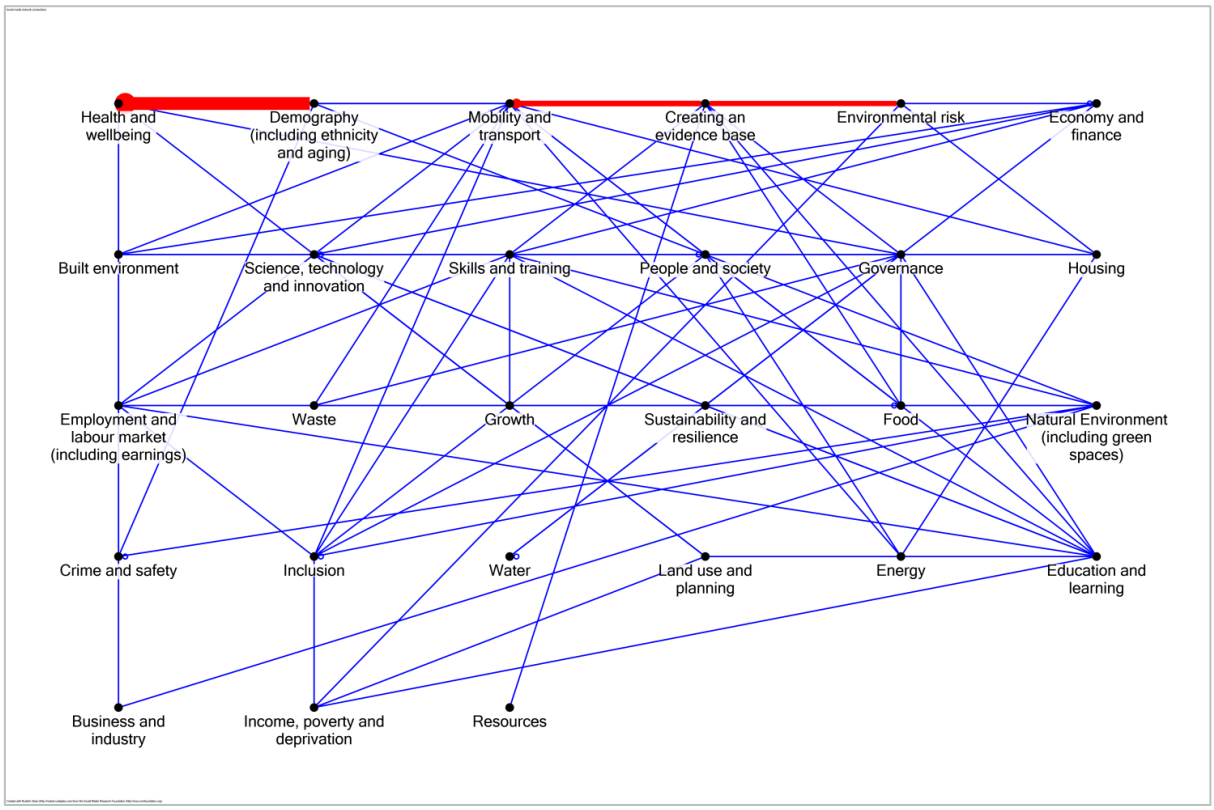

Figure A.12. Grid visualisation of themes.
Red = 20+ connections, blue = 1 connection.

The hot spots reflect three themes that are numerously reported: ‘health and wellbeing’, ‘mobility and transport’ and ‘environmental risk’. ‘Health and wellbeing’ is often reported in connection with other aspects of ‘health and wellbeing’ and ‘mobility and transport’ is often reported in connection with other aspects of ‘mobility and transport’. However, aside from these two inward-looking connections, ‘health and wellbeing’, ‘mobility and transport’ and ‘environmental risk’ are not frequently reported in connection with each other. This, combined with the high number of cold spots and the

high prevalence of lower numbers of connections within the evidence, means that Birmingham appears to have a deep, narrow and disconnected understanding of itself.

Geographical bias analysis

A geographical bias analysis of documents was conducted for the purpose of understanding the scales these evidence sources covered (e.g., sub-city, whole city or region). A geographical bias analysis was conducted using Microsoft Excel to record each document's scale.

- 36 documents consider a geographical area larger than Birmingham.
- 200 documents consider the Birmingham city geographical area.
- 163 documents consider the sub-city geographical area.
    - 56 of these consider a sub-city geographical area that do not correspond with established sub-city boundaries (e.g., neighbourhood, ward or district).
    - 107 of these consider a sub-city geographical area that do correspond with established sub-city boundaries. The most frequent of these are below.
        - City Centre x 11
        - Sutton Coldfield x 10 (green belt)
        - University of Birmingham x 9

Further investigation revealed that the academic treatment of Birmingham is piecemeal at the sub-city scale: piecemeal in geography and in city service/function focus. Policy treatment of Birmingham at the sub-city scale is more even in both these areas, but further work is required to determine the full scope of sub-city scale policy documents.

The outcomes from the evidence map were then combined and synthesised alongside the following additional evidence sources to aid interpretation of the results, giving rise to the identification of four challenge areas for the city (Table A.11).

- City-scale profiles of economic, societal and environmental domains constructed from existing reviews;
- Information gathered from consultation with policymakers, urban design decision-makers, urban professionals and academics via two workshops (12 September and 29 November 2016) and email follow-up after each workshop.

Table A.11. Four challenge areas identified from the evidence map analyses.

	Challenge area	**Interpretation**
1	Promoting healthy living and healthy long lives	The network analysis shows a clear disconnect between an extensive, highly specific and narrow academic medical literature and policy literature, which deals with health and wellbeing in little detail. The hot & cold spot analysis shows 'health and wellbeing' in the top two literature hotspots (linking most often with itself and then with demography). At the ward scale health outcomes are variable and clearly health and healthcare do not follow ward boundaries (or ward-level policies). Health and healthcare cut across city services, drawing in the medical health system, green spaces, transport and food, for example. This challenge also touches upon gaps in knowledge, such as Birmingham's food demand profile.
2	Minimizing high-carbon mobilities whilst maximizing connectivity	The hot & cold spot analysis shows 'mobility and transport' as the third and fourth top literature hotspots (linking most often with itself and then with creating an evidence base). Some wards suffer from disproportionately high levels of traffic congestion whilst other wards (notably those further away from the city centre) have poorer access to public transport. Some wards are less connected in non-physical ways. For example, some wards rely more heavily upon working practices that don't lend themselves to working remotely and some wards have higher percentages of older residents who are less likely to use digital services.

3	Reducing environmental risks through the sustainable use of low-carbon energy	The hot & cold spot analysis identifies environmental risks associated with carbon emissions, air pollution and flooding as the last of the top five hot spots. Surprisingly energy, the largest contributor to climate change and the resultant environmental risks, is identified as a cold spot. Energy does form part of city-scale and ward-scale policy documents, primarily in relation to reducing carbon emissions, featuring in general terms and it is clear that in recent years (and in particular following the Financial Crisis) reducing carbon emissions and being environmentally friendly has fallen down Birmingham City Council's list of priorities (and economic growth has come up this list, setting the scene for obvious tensions between growing whilst reducing high-carbon energy demands).
4	Developing appropriate governance models to ensure economic vitality and establish the city's brand	The link between economic performance and city governance is less evident from the evidence mapping, but is generally evident in the academic literature and was highlighted repeatedly in the workshops and email engagement. Economic performance (especially in relation to growth) and city governance are, without doubt, two of Birmingham City Council's top priorities. The Kerslake Review captured the city's governance challenges, with an emphasis upon the need for effective leadership and visionary thinking and reflecting an apparent lack of confidence in Birmingham's policymakers to be able to create an economically vibrant city, something that was mirrored at the workshops and in the email engagement. This lack of confidence is, perhaps, reinforced by the city's science-policy gap (revealed by the network analysis), its narrow and disconnected understanding of itself (revealed by the hot & cold spot analysis) and its geographically piecemeal evidence base (revealed by the geographical bias analysis). It also has knock-on effects upon attracting inward investment, new businesses and new residents and establishing the Birmingham brand.

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Paper 7. The Liveable Cities Method: establishing the case for transformative change for a UK metro.

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Abstract

There is currently great interest in the creation of sustainable and liveable cities, both in the UK and globally. While it can be argued that good progress is being made in thinking about the needs of future cities, meeting these needs and aspirations in practice poses major challenges of understanding and measurement (what is meant by these terms and how can progress towards their achievement be measured?), complexity (cities are complex systems of systems with many interacting parts) and resilience (will interventions made today be relevant and effective in the future?). The Liveable Cities research programme created a systematic decision-making process for improving urban sustainability and liveability: the Liveable Cities Method (LCM). The LCM prioritises four criteria – individual and societal well-being, resource security, resource efficiency and carbon dioxide emissions as a proxy for environmental harm – in an interconnected framework and assesses the need for, and the resilience of, interventions designed to move cities towards improved sustainability and liveability. This paper illustrates the LCM through an example intervention made to the city of Birmingham, UK, and highlights

how addressing sustainability and liveability in this way offers unique opportunities for the UK civil engineering profession to lead thinking among urban professionals.

1. Introduction: challenges to achieving urban sustainability and liveability

Civil engineers use ingenuity to address the problems and take advantage of the opportunities posed by society and the dual influences that the environment and economy have on it. They use creative thinking to develop processes and strategies and systems and artefacts, which in many cases are required to function for decades and sometimes even centuries ((Balmforth, 2015); for an example, see the paper by de Silva and Paris (2015)). This means that engineers are well placed to affect progress towards sustainability, resilience and liveability (Pearce *et al.*, 2012) and are encouraged to do so – not least through this journal: see the paper by Fenner *et al.* (2006) for an early perspective and the papers by Byrne and Mullally (2014) and Fenner *et al.* (2014) for implications for civil engineering education. Sustainability has been much defined, being enriched from Brundtland's (WCED, 1987) oft-quoted concept of intergenerational equity and opportunity by a multitude of insights published in this journal. Likewise, resilience – ensuring that engineering interventions continue to function and deliver their benefits, in the face of contextual change no matter how rapid (Arup, 2015; LRF, 2015; Rogers *et al.*, 2012a) – is well understood and embraces adaptability as one effective response. However, the longevity of engineered systems and artefacts also means that there is a danger that engineers create path dependencies for problems that are by their nature dynamic and, therefore, deliver outcomes that cease to be efficient and/or effective in the medium to long term. In contrast, liveability is less clearly established (Leach *et al.*, 2017a), a weakness that this paper seeks to address hereafter. Moreover, the outcomes

of the civil engineering profession are inevitably context dependent (Pearce *et al.*, 2012; Shareef and Altan, 2017), and it is this dynamic, changing context that adds to the complexity of the civil engineer's role in serving society (see the paper by Roohnavaz (2017) for the implications for construction projects in developing countries).

Given that the changing contexts in which civil engineers currently operate include a markedly growing population, increasing urbanisation, climate change and a changing demography (UN Desa Population Division, 2014; Balmforth, 2015; Hunt *et al.*, 2018), improving the performance of cities provides one of the primary points of focus for the civil engineer. In turn, it is a vision of cities of the far future that must inform today's activities if future outcomes are to deliver the efficiency and efficacy that the often considerable investment demands within the context of sustainability and liveability (Rogers, 2018). This leads to fundamental questions of what is the nature of cities of the future and, more specifically, what is the nature of citizens and societies of the future? Also, what is "the nature of any compromises or trade-offs that need to be made in balancing such requirements in order for us [engineers] to be explicit about the impacts associated with our choices"? (Gaterell, 2016, p. 223) – the focus of a recent issue of this journal. Answers are required to develop policies and strategies, and associated briefs and designs, for future sustainable and liveable city systems and the infrastructures and organisations that support them (see the paper by Whitehead (2015) for a case study of Balfour Beatty's sustainability journey).

While there is great interest in the creation of sustainable and liveable cities, both in the UK and globally, there is no convergence as to the best processes for achieving the desired outcomes (Leach *et al.*, 2016a). The need for tools and techniques to enable engineers to engage in the many and varied decisionmaking processes involved in

improving sustainability was recognised by this journal in 2013 (Gaterell, 2013). At about the same time, the research programme Liveable Cities (LC) (LC, 2018) set out to transform the engineering of cities by ensuring that radical engineering solutions to the problem of engineering future sustainable and liveable cities take into account the human dimensions of living and working in a city, including quality of life, well-being and citizen aspirations. One outcome is a systematic decision-making process for improving urban sustainability and liveability: the Liveable Cities Method (LCM).

This paper introduces the nine-step LCM, a decision-making process that identifies potential barriers to achieving urban sustainability and liveability by making explicit how strategic ambitions (i.e. for the desired future performance of a city and its citizens) link to operational activities (i.e. interventions) and how vulnerable operational activities are to future change. The LCM enables users to explore possibilities and aspirations for a city as opposed to being a deterministic procedure towards quantifiable results. Importantly, it is applicable across scales, which is crucial within a multiscalar discipline such as engineering (Gaterell (2016), see also the editorial by Keaton (2017) for a brief discussion about the scales at which the concepts of sustainability and resilience operate and their relevance for geotechnical engineering). This paper illustrates the LCM through the example of an intervention made to the city of Birmingham. It highlights how addressing sustainability and liveability in this way offers unique opportunities for the UK civil engineering profession to lead thinking among urban professionals.

This section has briefly described some of the challenges for engineers in achieving sustainability and liveability in cities. The following section describes and illustrates through a case study how the LCM can be used to address them. This is

followed by reflection on the implications for UK civil engineering. Crucially, the LCM, and its extensive evidence base (LC, 2018), has the potential to transform the engineering of cities to deliver a more profound set of benefits when meeting the basic needs of cities and their infrastructure systems.

2. The LCM: a method for improving urban sustainability and liveability and its application to the city of Birmingham, UK

The LCM was developed from a comprehensive review of the sustainability, resilience, liveability and city performance, measurement and assessment literature; primary research to address the evident research gap; a series of consultations with local authorities, urban designers and planners and other urban experts from the private, public and third sectors (including academics); and testing in three UK cities: Birmingham, Lancaster and Southampton (Leach *et al.*, 2017a). It builds on the Designing Resilient Cities Method (Lombardi *et al.*, 2012; Rogers *et al.*, 2012b), which is incorporated into the LCM and is shown in Figure 1 as steps 5 to 9.

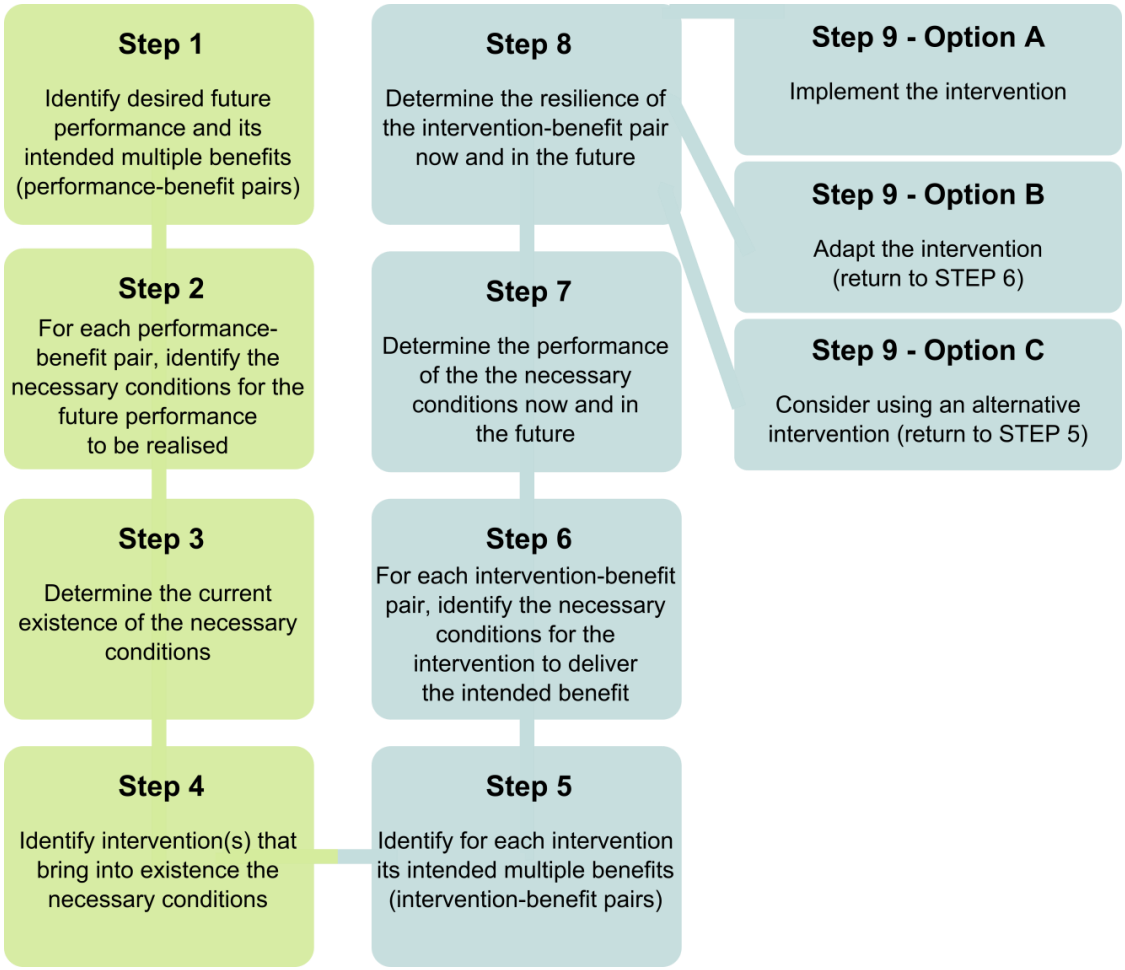

Figure 1. The Liveable Cities Method (LCM).

The LCM assesses the need for and the vulnerability of interventions designed to move cities towards improved sustainability and liveability. Figure 1 illustrates the LCM's nine steps, acknowledging that the illustration presents only the very essence of the process (its critical path) and strips away the inevitable messiness and iterative nature of decision-making (Mintzberg and Westley, 2001). However, iteration is an essential part of engineering decision-making processes – it is the mature engineering response to systems thinking – and will occur throughout steps 1–5 and, once step 9 has been reached, a return to any of steps 1–5 might happen to refine the thinking. Only once the

intervention has been finalised can its likely resilience be determined using the Designing Resilient Cities Method by following steps 5–9.

2.1. Step 1: identify desired future performance and its intended multiple benefits (performance–benefit pairs)

The first step in the LCM is for a city to identify what it wants to be like in the future (i.e. its desired future performance). For each element of performance, concomitant 'intended benefits' (i.e. the benefits that have been designed to arise from implementing performance improvement measures, which will take the form of 'interventions' in the city and its infrastructure systems) should be identified, where possible taking advantage of multiple intended benefits (Rogers, 2018). If more than one intended benefit is identified, then the LCM should be followed for each intended benefit.

Describing future performance (desired or predicted) is a subject of great interest, and there exist several approaches (Hunt and Rogers, 2015a; GOScience, 2016a; Rogers, 2018). However, none of the approaches is specific to LC's four criteria (individual and societal well-being, resource security, resource efficiency and carbon dioxide emissions). In order to identify performance–benefit pairs relevant to these criteria effectively, LC created a vision for a future sustainable and liveable city – the Ideal City Model (Ortegon-Sanchez and Tyler, 2015) (see Figure 2) – and this model will be used herein to illustrate the LCM. The Ideal City Model incorporates five future city visions (desired performances) and their underlying principles (which will inform the intended benefits of city interventions); see Table 1.

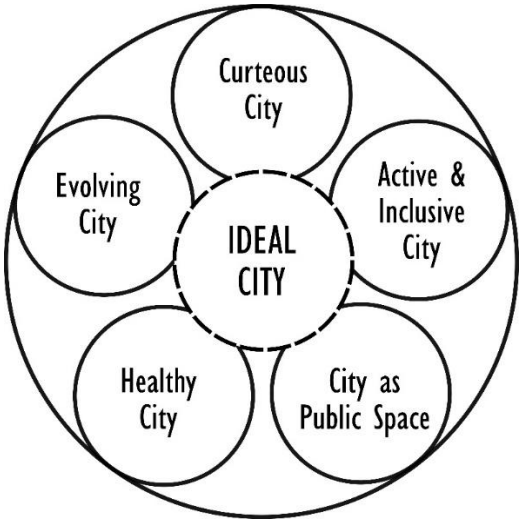

Figure 2. The Liveable Cities' Ideal City Model.
Adapted from Ortegon-Sanchez and Tyler (2015).

Table 1. The Liveable Cities' Ideal City Model: future performance and intended benefits.

FUTURE PERFORMANCE	**INTENDED BENEFITS**
Courteous City	Stimulates positive social interactions and promotes behaviours that facilitate the functionality of the city
Active and Inclusive City	Ensures people's fair access to opportunities to meet their needs and aspirations
City as a Public Space	All public spaces are designed as open and accessible to provide protection, safety and security and create a sense of belonging and ownership
Healthy City	Ensures the good health of people and the environment today and for future generations
Evolving City	Designed to be adaptable, flexible, innovative and responsive especially for its soft infrastructures (i.e. governance, policies, financing and economy, amongst others), and which learns and adapts dynamically accordingly to people's behaviours

From the Ideal City Model, one desirable future performance is to create an 'active and inclusive city'. This is chosen as the case study for this paper because it complements the city of Birmingham's objectives "[t]o develop Birmingham as a city of sustainable neighbourhoods that are safe, diverse and inclusive with locally distinctive character" and "[t]o provide high quality connections throughout the City and with other places including encouraging the increased use of public transport, walking and cycling" (Birmingham

City Council, 2017, p. 18). Moreover, and importantly, it aligns well with the aspirations of Birmingham's stakeholders (Hunt and Rogers, 2015b).

Creating an active and inclusive city has an intended benefit of 'ensuring people's fair access to opportunities to meet their needs and aspirations'. Achieving this intended benefit means, among other things, enabling affordable, safe, sustainable and accessible mobility, including active mobility, and that there need to be public transport options that promote walking and cycling as part of the overall journey (see the paper by Deegan (2016) for a useful analysis of the London Cycle Network Plus project). There are, of course, other aspects to creating an active and inclusive city, such as ensuring opportunities (employment) and other activities (leisure, culture, education, health) which are not only accessible physically and spatially, but also accessible financially (affordable) to promote inclusiveness. There are also additional benefits to be generated by creating not just an active and inclusive city, but also a healthy city and an evolving city and so on. This paper will focus on 'enabling affordable, safe, sustainable and accessible mobility, including active mobility' and the additionalities described earlier will not be pursued, but it is to be noted that it is in the bringing together of multiple desirable future performances and their benefits where the strength of the LCM lies

- performance: to create an active and inclusive city
- benefit: to ensure people's fair access to opportunities to meet their needs and aspirations by enabling affordable, safe, sustainable and accessible mobility, including active mobility.

2.2. Step 2: identify the necessary conditions for the future performance to be realised

The next step in the LCM is to identify the conditions that are necessary to enable delivery of the intended benefit. It is helpful here to consider 'what if ?' questions for changes in Society, Technology, Economy, Environment and Policy (a STEEP analysis) (Lombardi *et al.*, 2012). Quantitative modelling can also be employed (Hall *et al.*, 2017). It is also helpful to consider the current barriers to achieving the desired future performance. One way of doing this is to backcast from the desired future performance to today's performance, which was undertaken for this study. UK City Liveability Indicators Framework Edition 1 (UK City Life$_1$) (Leach *et al.*, 2017a) was used to describe the current performance of Birmingham, UK, although numerous other city measurement and assessment frameworks exist and can be used (Astleithner and Hamedinger, 2003; Ness *et al.*, 2007; Mayer, 2008; Colantonio, 2010; Pires *et al.*, 2014; Kitchin *et al.*, 2015; Leach *et al.*, 2015). For the authors' identified performance–benefit pair, the following necessary conditions were identified (noting that this list is kept purposefully simple).

The necessary conditions required to enable affordable, safe, sustainable and accessible mobility, including active mobility for the purpose of creating an active and inclusive city, are

- that affordable, safe, sustainable and accessible transport alternatives exist where they are needed
- that affordable, safe, sustainable and accessible transport options will exist into the future
- that affordable, safe, sustainable and accessible transport options are environmentally, socially and economically sustainable

- that low-carbon dioxide ('low-carbon') options exist where affordable, safe, sustainable and accessible transport is not feasible (e.g. during inclement weather, under time and distance constraints)
- that the urban form facilitates affordable, safe, sustainable and accessible mobilities (i.e. an equitable land use mix within the city)
- that transport options (in particular public transport) provide the required linkages (e.g. suburbs to centre) and are affordable, safe, sustainable and accessible for all.

2.3. Step 3: determine the current existence of the necessary conditions

Step 3 asks if each necessary condition currently exists. This requires judgement and synthesis, drawing on expertise, experience and knowledge of the local context. This also requires knowledge of the city's current performance, and UK City Life$_1$ has been used here to assess the current performance of Birmingham, UK (Leach *et al.*, 2017b) alongside an in-depth review of Birmingham's transport ecosystem (Leach *et al.*, 2016b). The results of this analysis can be found in Table 2, noting that they have been vastly simplified in order to retain clarity (UK City Life$_1$ contains a total of 346 potentially relevant indicators of city performance, from which the most relevant have been chosen to illustrate the method).

Table 2. Existence of the necessary conditions in Birmingham, UK.

NECESSARY CONDITION	**EXISTENCE IN BIRMINGHAM (base year 2016)**
That affordable, safe, sustainable and accessible transport alternatives exist where they are needed.	At risk, as buses and taxis were (and still are) the primary public transport alternatives in Birmingham and these are privately operated. Walking and cycling in the city centre requires improvement in terms of wayfinding, quality of

	the environment and connectivity of public transport systems.
That affordable, safe, sustainable and accessible transport options will exist into the future.	At risk, as bus and taxi operators need to make a profit and so operate accordingly. The cycling network in Birmingham is being expanded, but in the least-cost, least disruptive way (e.g., via existing canal towpaths) and while some will be 'protected' those associated with road layouts could easily be reversed.
That affordable, safe, sustainable and accessible transport options are environmentally, socially and economically sustainable.	At risk, as they were (and still are) primarily buses and taxis – which currently respond primarily to commercial (i.e., economic) pressures – and more limited walking and cycling – and these modes of transport require improvement and protection in Birmingham (see other necessary conditions for commentary on some of these).
That low-carbon options exist where affordable, safe, sustainable and accessible transport is not feasible (e.g., during inclement weather, under time and distance constraints).	No, as in Birmingham taxis and buses were the main public-transport alternatives (although there are now air quality targets for these modes of transport).
That the urban form facilitates affordable, safe, sustainable and accessible mobilities (i.e., an equitable land use mix within the city).	No, as there were (and still are) local concentrations of employment, retail and housing of different types throughout the city.
That transport options (especially public transport) provide the required linkages (e.g., suburbs to centre) and are affordable, safe, sustainable and accessible for all.	No, as buses and trains were (and still are) ineffective in connecting the suburbs to the city centre in many cases: for many these are not a reliable mode of travel, and few alternatives exist for 'hop on, hop off' travel.

2.4. Step 4: identify interventions that bring into existence the necessary conditions

Once the existence or absence of the necessary conditions is known, it becomes possible to design interventions (i.e. potential solutions to problems) that can overcome the barriers to and exploit the opportunities for bringing the necessary conditions into being and thus achieve the desired future performance. Interventions can be anything from physical interventions (and for engineers this often means infrastructure, which is highly interdependent with and interconnected with policies promoting behaviour change (Montgomery *et al.*, 2012)). In some cases, large-scale interventions are demanded; in

others, a portfolio of smaller interventions is preferable. How these play out for desirable long-term agendas may vary: "[s]ustainable options can be mundane, as well as magnificent" (Keaton, 2017, p. 1).

For the purpose of this example, an intervention that was in the process of being implemented in 2016 has been chosen. This intervention addresses the existence of the necessary condition 'that low-carbon options exist where affordable, safe, sustainable and accessible transport is not feasible (e.g. during inclement weather, under time and distance constraints)'. In Birmingham, the electric light rail (Metro) was undergoing a phased expansion that in 2016 saw it extended into the city centre as a low-carbon alternative to traversing the wider city centre area and, in particular, connecting to the Birmingham New Street railway station, a major station on the UK passenger rail system (Bourke, 2015) – see Figure 3

- intervention: extending Birmingham's light rail (Metro) into the city centre
- to satisfy the necessary condition: that low-carbon options exist where affordable, safe, sustainable and accessible transport is not feasible (e.g. during inclement weather, under time and distance constraints).

Figure 3. The Birmingham City Centre Metro extension outside New Street railway station.

It is beyond the scope of this paper to explore the possible additionalities afforded by interventions that address more than one necessary condition, but it should be noted that doing so is important when engaging in a full analysis. For example, the Metro extension could have been designed to satisfy the following necessary condition additionally: 'that transport options (in particular public transport) provide the required linkages (e.g. suburbs to centre) and are affordable, safe, sustainable and accessible to all'. If this were the case, then the Metro would be designed not only to provide a service in the city centre and its immediate surroundings, but also to connect in a systematic manner the city's suburbs to its city centre (not currently part of the phased extension plans, although the authors acknowledge that such plans may be part of a long-term strategy not in the public domain). In other words, the Metro extension plan does not appear to deliver a strategic suite of necessary conditions.

2.5. Step 5: identify for each intervention its intended multiple benefits (intervention–benefit pairs)

Once designed, an intervention must be tested for potential future vulnerabilities, as well as its potential in maximising the range of additional benefits that it might realise, and redesigned and retested as necessary. Although there exist a number of tools and methodologies for achieving this – and particularly so within engineering (Pearce *et al.*, 2012) – the Designing Resilient Cities Method is relevant as it uses UK-based future urban scenarios to pressure-test the resilience of interventions to future change. A full description of this method alongside examples and case studies is available from the book by Lombardi *et al.* (2012) and the paper by Rogers *et al.* (2012b). As such, the Designing Resilient Cities Method has been revised and incorporated into the LCM and comprises steps 5–9.

Step 5 requires that, for each intervention, intended benefits are identified (intervention–benefit pairs). Where more than one intended benefit is identified (multiple benefits), then steps 5–9 should be carried out for each intended benefit (Lombardi *et al.*, 2012). It is also possible to use UK City Life$_1$ to identify multiple benefits. A description of how this works for the Metro extension is available in the paper by Leach *et al.* (2016a). Identifying multiple benefits is desirable, but beyond the scope of this paper. The intervention–benefit pair identified from this paper's example is

- intervention: Birmingham's light rail (Metro) city centre extension
- intended benefit: to create a low-carbon, public transport option in the city centre that is affordable, safe, sustainable and accessible.

2.6. Step 6: for each intervention–benefit pair, identify the necessary conditions for the intervention to deliver the intended benefit

Next, taking each intervention–benefit pair in turn, the conditions that enable the intervention to keep functioning and delivering its intended benefit into the future are identified. In other words, what are the conditions that enable people to use the intervention so that it delivers its intended benefit (Lombardi *et al.*, 2012)? Necessary conditions can be identified by using the previously identified methods as well as by using quantitative modelling and assessment. For this example, the authors have identified the following necessary conditions (the list has been kept purposefully short and simple in order to retain clarity)

- that the Metro connects the city centre in useful ways
- that the Metro is reliable
- that the Metro is affordable to all
- that the Metro is safe to use
- that the Metro is sustainable (economically, socially and environmentally)
- that the Metro is accessible to all.

2.7. Step 7: determine the performance of the necessary conditions now and in the future

Step 7 guides the user in determining whether each necessary condition is present now and if it is likely to be present in the future. Regarding the 'now', the user should make their determination in the most appropriate way, such as by reviewing documentation, observation and deduction. Regarding the 'future', there exist a number of ways of determining the presence of necessary conditions (Rogers, 2018). For consistency, the authors have used the Designing Resilient Cities Method for this purpose. Table 3 shows

the outcome of this analysis. The Designing Resilient Cities Method uses future scenarios to pressure-test the existence of each necessary condition in each of four extreme, yet plausible, futures in different directions of travel from today's world. The reasoning is that, if a necessary condition exists today and in the four scenarios, then it is likely to exist no matter how the future actually develops since the scenarios cover the essential range of societal structures (Lombardi *et al.*, 2012). The four scenarios are 'Fortress world', 'Market forces', 'Policy reform' and 'New sustainability paradigm' (see Figure 4). Fortress world is characterised by a bifurcated society: the 'haves' (i.e. the rich and empowered) and the 'have-nots' (i.e. the poor and disenfranchised). Market forces lets the free market dominate unrestricted by social and environmental concerns. Policy reform steers citizens towards sustainability through policy interventions and strong governance, whether citizens and businesses like it or not. New sustainability paradigm is characterised by citizens who want to live as sustainably as possible (Lombardi *et al.*, 2012).

Table 3. Future performance of necessary conditions determined using the Designing Resilient Cities Method.

Necessary Conditions	**Now (2016)**	**Fortress World**	**Market Forces**	**Policy Reform**	**New Sustainability Paradigm**
Connects the city centre in useful ways	At risk as the expansion of the Metro is currently incomplete and relies, at least in part, upon the completion of the national high-speed rail link	Haves: yes, as the money is available and other resources are scarce so maximum functionality must be achieved. Have nots: at risk, as money and	At risk as the route and stops will be determined by their potential for making a profit.	Yes, as this will have been required as part of the permission granted by the City to extend the Metro, and it will be retained as part of	Yes, as this will be desired by the City, the citizens and the Metro's operators (all of whom will value the social and environmental, as well as economic,

	between London and Birmingham (HS2).	other resources to achieve connectivity to poorer areas are scarce.		strong governance of such city assets.	benefits it delivers).
Is reliable	Yes, as the Metro system runs mostly to schedule. In addition, in the city centre the trams run close together, enabling a 'hop on, hop off' user experience.	Haves: yes, as there is money and a safety imperative for this. Have nots: at risk, as services to the disenfranchised poor will be a low priority in financially-constrained times.	Yes, as reliability is linked to greater usage and thus greater profits.	At risk, as although reliability can be legislated, in practice those maintaining the Metro may not be as rigorous or respond to breakdowns as quickly as necessary.	Yes, as this will be desired by the City, the citizens and the Metro's operators (all of whom will value the social and environmental benefits it delivers).
Is affordable to all	At risk. Although the Metro is competitively priced, it is not free and so inevitably excludes some members of society.	Haves: yes, as the 'haves' are (relatively) wealthy. Have nots: at risk, as the 'have nots' are poor and their accessibility needs will not be prioritised.	No, as this would probably reduce the profit margin – market forces will determine the most profitable charging structure.	At risk, as although prices for travel can be legislated, there will be many demands on budgets and priorities will determine this aspect of service provision.	Yes, as this will be desired by the City, the citizens and the Metro's operators (all of whom will value the social benefits affordability delivers).
Is safe to use	At risk. The Metro is built to a high standard with safety as a priority, but economic factors (cost) will have impacted this.	Haves: yes, as safety is a priority. Have nots: no, as there is little resource for ensuring safety on routes servicing solely the have nots.	At risk, as in order to achieve this safety measures must align with economic priorities.	Yes, as safety is legislated.	Yes, as this will be desired by the City, the citizens and the Metro's operators (all of whom will value safety).

Is sustainable (eco-nomically, socially and environ-mentally)	At risk. The Metro has been designed to be economically sustainable first, followed by environmentally and socially sustainable.	Haves: at risk, as the haves prioritise safety and utility over other factors. Have nots: at risk, as in order to achieve these priorities they must align with maximising use of limited resources.	At risk, as in order to achieve social and environmental priorities they must align with economic priorities.	Yes, as sustainability is legislated.	Yes, as this will be a top priority for the City, the citizens and the Metro's operators (all of whom will value sustainability).
Is accessible to all	At risk as excluding some potential customers may serve to maximise profit.	Haves: yes, as the money is available and other resources are scarce so maximum functionality must be achieved. Have nots: at risk, as the money and other resources are not available to service the disenfranchised.	At risk, as excluding some potential customers may serve to maximise profit.	At risk, as although accessibility can be legislated, those operating the Metro may opt to exclude potential customers in order to maintain service delivery (which is also legislated for).	Yes, as this will be desired by the City, the Metro's designers and the citizens.

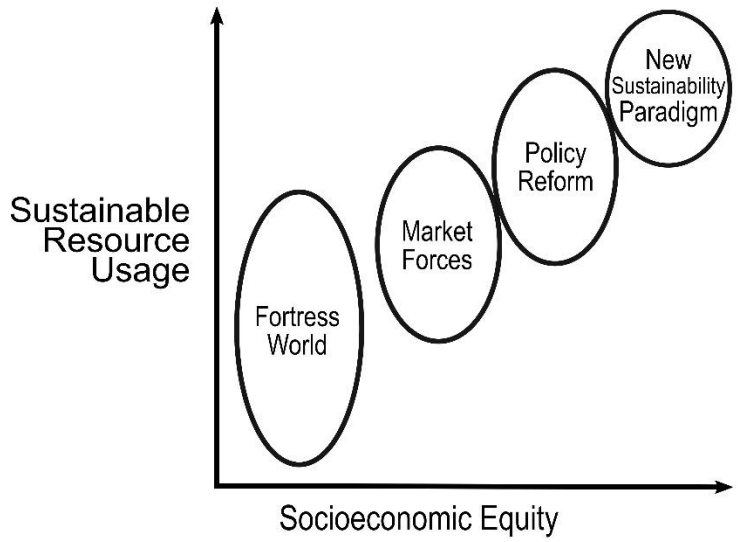

Figure 4. Designing Resilient Cities' four future city scenarios.
Adapted from Rogers *et al.* (2012b).

2.8. Step 8: determine the resilience of the intervention–benefit pair now and in the future

At this point, it becomes possible to determine the current and future resilience of the intervention. This requires judgement and synthesis, prioritising the importance of the necessary conditions and balancing these against the potential vulnerabilities identified (Lombardi *et al.*, 2012). From the simplified example presented here, it is evident that Birmingham's Metro extension delivers a 'low-carbon, public transport option in the city centre that is affordable, safe, sustainable and accessible' only if the world view embraced by the city develops towards New sustainability paradigm – thus it is at risk – unless strong governance safeguards are put in place to legislate for its continued service functionality (affordability, accessibility etc.). It is also evident that the market cannot deliver the intended benefit on its own; reliance on policy might result in delivery compromises and there is a clear polarisation of service delivery between the rich and the poor.

2.9. Step 9: (a) implement the intervention, (b) adapt the intervention (and return to step 6) or (c) consider using an alternative intervention (and return to step 5)

It is now up to the user to decide whether (and how) to implement the intervention; adapt it to make it more resilient to future change or to deliver additional benefits; or replace it altogether. The LCM informs this decision by elucidating the implications of implementing the intervention without adjustments and identifying how the intervention can be improved. For example, for Birmingham's Metro line extension, accessibility and affordability are highlighted as particular vulnerabilities. Birmingham may therefore wish to address explicitly these aspects of the intervention. For example, it could follow Manchester's lead by augmenting its Metro with a free city centre bus service while at the same time ensuring that the buses are low-carbon and recognising that financing such an intervention may be difficult in the current climate of austerity. Providing strategic linkages with walking and cycling routes to facilitate a 'hop-on, hop-off' mode of travel in uncertain weather (helping to improve citizen health) and ideally aligning the walking/cycling routes with green corridors (bringing people into routine close contact with nature and improving their well-being) would enhance the benefits that could be achieved (Hunt and Rogers, 2015b).

3. Implications for civil engineering

This paper uses the LCM in combination with UK City Life$_1$ and the Ideal City Model to identify where a city should be in terms of future performance; analyse where it is currently; identify the conditions that need to be in place to support the desired future performance; and make specific recommendations that are optimal for ensuring that those conditions exist today and into the far future. The LCM provides a process for

constructing an evidence base and a plausible narrative describing how to get from a city's current performance to a desired future performance. In essence, it establishes the 'business case' for the intervention, from which alternative business models can be constructed directly using the intended benefits to point to the value that is realised (Rogers, 2018), enhanced by systems mapping to enrich the opportunities for value creations and realisation (Bouch and Rogers, 2017; Bouch *et al.*, 2018) and set against alternative forms of investment (Bryson *et al.*, 2018). Through determining how the intervention can deliver multiple benefits to advance the city substantially in its journey towards a more sustainable, resilient and liveable future, it makes the case for transformational change. Such a narrative forms the basis for the engineering strategies that are needed now and in the future.

Civil engineers engineer for the betterment of society and their ultimate client, and their creations are often required to function and deliver their benefits for very many years, usually decades. Equally, what they create is inevitably context dependent – it must function in the context in which it is created, and it must continue to function as the context changes if it is not to become inefficient or redundant. When this context is cities, the context is a highly complex system of systems, all of which are interdependent to different degrees (GO-Science, 2016b): intervene in one system and substantial impacts can be felt in many others. Civil engineers therefore need to develop both a deep understanding of the current context and a broad appreciation of how this context might change into the far future.

Aided by the LCM, civil engineers and civil engineering as a profession can take a more prominent role in addressing the wicked problems of today's cities – such as the energy/water/food nexus, soil nutrient levels, high-density living and well-being; all can

be tested using the LCM. Moreover, because of the inherently multidisciplinary spectrum embraced by the civil engineering discipline (Byrne and Mullally, 2014), engineers are well equipped to take a lead in these debates among urban professionals, reaching back to the profession's roots when civil engineering covered the totality of societal support before specialisms initiated by the industrial revolution (mechanical, electrical and electronic, aerospace etc.) were required.

The LCM is at the heart of a set of processes that have been established as good practice in the engineering of cities by a major, and largely coherent, portfolio of research into sustainable urban environments, the resilience of cities and their infrastructure systems and urban liveability. These processes are summarised in Table 4, along with references to some of the sources of evidence generated by the LC team members. However, this is far from (and was never intended to be) complete, and many of the papers published in this journal, for example, will support and enrich the processes, as will the findings from the many UK and international research teams who have been working on these topics. A logical structure to the research findings has been created for the purpose of this discussion. The specific programmes referred to are as follows

- Birmingham Eastside Research (BER) (University of Birmingham, 2018a)
- VivaCity2020 (Cooper *et al.*, 2009; V2020, 2018)
- Designing Resilient Cities (Lombardi *et al.*, 2012; DRC, 2014)
- the many Sustainable Urban Environment (SUE) programmes, including a three-phased programme of research funded by the Engineering and Physical Sciences Research Council (EPSRC, 2014)
- LC, in particular, the tools, case studies, Little Books and papers (LC, 2018)

- the two consortia researching infrastructure interdependencies and novel business models
    - Infrastructure Business Models, Valuation and Innovation for Local Delivery (iBuild, 2018)
    - International Centre for Infrastructure Futures (ICIF, 2018)
- Urban Living Birmingham (ULB, 2018)
- the Foresight Future of Cities (FFoC) project (GO-Science, 2016b; Gov.UK, 2018)
- the University of Birmingham Policy Commission on Future Urban Living (FULPC) (Rogers *et al.*, 2014; University of Birmingham, 2018b).

Table 4. Lessons from the UK Cities Research Portfolio of LC team members.

Lessons from Cities Research Portfolio	**Evidence Base**
To address a specific problem in a city, assemble an appropriately-broad, multi-disciplinary, multi-sectoral group of potentially interested parties who are able to represent the views of all stakeholders affected by the problem and its potential solutions.	BER, V2020, DRC, LC, FULPC, many SUE projects and the sustainability literature.
Understand deeply the aspirations of the city and its citizens, and the context in which the city exists (including both its history as well as its current context).	FFoC, LC, FULPC, BER, V2020, DRC, Rogers (2018), and the sustainability literature.
Diagnose fully the problem, noting the DRC experience that engineers focus upon solutions to problems while social scientists focus upon problem exploration, and other disciplines lie within this spectrum – a balance is required.	ULB, DRC, LC, Leach *et al.* (2018)
Establish the baseline performance of the city in terms of its sustainability, resilience and liveability. It is helpful to make explicit the components of the city and infrastructure systems related to the problem and those that will be impacted by potential interventions by mapping them and establishing the dependencies and interdependencies between these systems.	DRC, Boyko *et al.* (2012), LC, Leach *et al.* (2017a; 2017b), iBUILD, Bouch and Rogers (2017), Bouch *et al.* (2018), ULB. *Covered explicitly in the LCM.*
Apply ingenuity to the solution of the problem, yielding a number of alternatives from which to choose the most appropriate.	Arguably what engineers (should) do.
Assess the impact of the interventions on the city's urban and infrastructure systems using one of the many sustainability assessment frameworks, resilience frameworks	BER, V2020, DRC, SUE and the literature. LC tools, case

and the LC Liveability Framework (the City Assessment Methodology embodied in UKCityLIFE; see Leach *et al.* (2017a; 2017b). Iteration will be needed between the design of alternative solutions and impact assessment.	studies and papers. *Covered explicitly in the LCM.*
Conduct a futures analysis to explore whether the interventions are vulnerable to future contextual change (resilient), i.e., they will continue to deliver their benefits and therefore the investment proves good into the long-term.	DRC, Lombardi *et al.* (2012), Rogers *et al.* (2012) LC. *Covered explicitly in the LCM.*
Make the case for change – establish a compelling 'business case' for the proposed intervention. The LCM was created specifically for this purpose and provides perhaps the most comprehensive evidence base.	While much research supports the action, this is LC's specific target. *Covered explicitly in the LCM.*
Develop a suite of alternative 'business models' that capture the different forms of value that might be generated by the intervention, set against the investment required to implement it (perhaps in different ways).	Much research supports the identification of economic, social and environmental value. iBUILD and ICIF, Bouch and Rogers (2017; 2018), Bryson *et al.* (2018), Rogers (2018)
Understand all of the dimensions of governance (formal and informal) relevant to the intervention and the context in which it is to be implemented, and engineer changes to all of these systems in order that the intervention can be implemented without impediment.	DRC, LC, Honeybone *et al.* (2018). *Covered explicitly in the LCM.*
Influence policy by drawing on research findings to help shape local and national government policy and make the case for the intervention to policy-makers.	FFoC, FULPC, LC, Honeybone *et al.* (2018)
Influence practice via tools and case studies that enable the research findings to be translated to practice.	V2020, DRC, LC tools and case studies
Inform the public of the issues and how they might be addressed.	LC videos and Little Books, ULB, outreach activities

BER, Birmingham Eastside Research; DRC, Designing Resilient Cities; FFoC, Foresight Future of Cities; FULPC, University of Birmingham Policy Commission on Future Urban Living; iBuild, Infrastructure Business Models, Valuation and Innovation for Local Delivery; ICIF, International Centre for Infrastructure Futures; SUE, Sustainable Urban Environment; ULB, Urban Living Birmingham; V2020, VivaCity2020.

This research portfolio is now being taken forwards in part under the umbrella of a new multi-university initiative: the UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC, 2018). UKCRIC has seen an investment of £138 million, matched by institutional and industrial funding, in a suite of new laboratory, urban observatory and modelling and simulation facilities across the UK between 2016 and 2021. It is exploring new ways of working and delivering on collaborative research, exploring, for example,

how learning frameworks can support the generation of new knowledge across multidisciplinary teams engaging on engineering challenges (Taylor *et al.*, 2017).

4. Conclusions

This paper introduces the LCM, a decision-making process that identifies the conditions that need to be in place to support a sustainable and liveable city of the future and provides an important contribution to building the transitional narrative and engineering strategies needed to get there. In so doing, it provides the essential component when making the case for transformational change towards a more sustainable, resilient and liveable future and, crucially, the transformative step to make it happen.

The LCM is demonstrated through the example of Birmingham's ambition to create a more active and inclusive city achieved, in part, by extending its light rail (Metro) system into the city centre. The example follows the nine-step LCM in a linear fashion, starting at step 1 and finishing at step 9, in order to demonstrate the value offered by the method. In doing so, this paper has ignored the necessarily messy and iterative nature of decisionmaking and the fact that it is not always possible, or even desirable, to start at step 1 and work forward, while acknowledging that pervasive iteration is a vital component of the systems thinking that lies at the heart of the LCM. In addition, by focusing narrowly on the given example, the richness of simultaneously considering multiple ambitions and multiple interventions, their sequencing and scales and their arising benefits has been lost. Yet, it is argued by the authors that these have the potential to offer very considerable additional value and insights, for example, by aligning interventions so that they not only simultaneously deliver multiple benefits, but also simultaneously address multiple strategic ambitions.

The example has demonstrated that the LCM provides the necessary decision-making process to engender bold and assured policymaking and, crucially, make explicit how cities can advance towards their common goals of sustainability, resilience and liveability. As one member of Birmingham's City Council explained: society must change how it thinks about making decisions so that it does so in an evidence-based way – this is different from how things are currently done. This has particular implications for engineers, who often consider these common goals as simply 'good engineering' (Keaton, 2017). The LCM facilitates such a transformation by making explicit the thinking behind decisions and by aligning goals, designs and interventions. In doing so, engineers can use the LCM to move actively from 'good engineering' to 'better engineering': "[w]hat we call 'sustainable engineering' today is more than just good engineering, but it is less than what good engineering will become in future decades" (Keaton, 2017, p. 1). By embedding transformation within an evidence-based and repeatable process that encourages innovative approaches for positive additionalities, the LCM overcomes some of the reasons that engineering innovation is "hard and slow" (Ainger, 2015, p. 9) and contributes to the "systemic approach to engineering sustainability" called for by this journal in 2014 (Mayfield, 2014, p. 187), a call which continues to be relevant today.

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APPENDIX A. PERMISSION TO USE PUBLISHED MATERIALS

This appendix contains the permissions for reproducing the published materials included in this thesis.

It is noteworthy that Papers 2 to 7 were published at a time when the University of Birmingham considered applications for open access publishing with any publisher. This has now changed. The University's funding pot for open access publishing came under such strain that it shortlisted publishers for which funding for gold open access could be sought. The criteria for the shortlist includes the publisher's perceived commitment to the principles of open access publishing (University of Birmingham, 2019). Unfortunately, Thomas Telford, the publisher for the Institution of Civil Engineers and the publisher of Paper 7, is no longer on this list. The implication is that were we to publish Paper 7 now, we could not do so as gold open access. Although an analysis of the implications of open access publishing is beyond the scope of this thesis, it is highly relevant. Urban assessment and diagnostics rely upon data and information availability. Despite the ambitions for open access data and publishing, the economic barriers, within academia, at least, appear intractable.

Permission to reproduce an abridged and updated version of published material for the Conceptual Framework

The paper is cited as follows.

J. M., Lee S. E., Braithwaite P. A., Bouch C. J., Grayson N., Rogers C. D. F. (2013) 'What makes a city liveable? Implications for next-generation infrastructure services'. In *Infrastructure for a better future: A forum for vision, leadership and action*, 1-4 October 2013. Wollongong, Australia: Wollongong: Smart Infrastructure Facility, 397-405.

From: pascal@uow.edu.au <pascal@uow.edu.au>
Sent: 11 July 2019 07:47
To: Joanne Leach (Department of Civil Engineering) <J.Leach@bham.ac.uk>
Cc: Peter Campbell <pcampbel@uow.edu.au>
Subject: RE: Request to use a revised version of a paper from ISNGI 2013

Dear Joanne,

We happily grant you the authorisation to reproduce your contribution to ISNGI 2013 as a section of your PhD thesis.
I take the opportunity to congratulate you on your (nearly) completed PhD journey!
Best Regards
Pascal

Pascal Perez, Prof, FRSN, FMSSANZ
Director
SMART Infrastructure Facility
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From: pcampbel@uow.edu.au <pcampbel@uow.edu.au>
Sent: 10 July 2019 20:11
To: Joanne Leach (Department of Civil Engineering) <J.Leach@bham.ac.uk>
Subject: Re: Request to use a revised version of a paper from ISNGI 2013

OK with me Joanne
Peter
Sent from my iPhone

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: Thursday, 11 July 2019 2:52 AM
To: Pascal Perez <pascal@uow.edu.au>; Peter Campbell <pcampbel@uow.edu.au>
Subject: Request to use a revised version of a paper from ISNGI 2013

Dear Professors Perez and Campbell,

In 2013 I attended the ISNGI conference at the SMART Infrastructure Facility at the University of Wollongong. I was fortunate to have been selected to present a paper, which I duly did and it was published as part of the conference proceedings, which you edited.

I would now like to use extensive extracts of that paper for my PhD by published works thesis. The section of the thesis drawing from the paper will be credited as follows. "This section is an adapted version of a conference paper published as Leach JM, Lee SE, Braithwaite PA, Bouch CJ, Grayson N, Rogers CDF (2013). What Makes a City Liveable? Implications for Next-Generation Infrastructure Services. In 'Infrastructue for a Better Future: A Forum for Vision, Leadership and Action'. Wollongong, Australia, 1-4 October 2013. Wollongong: Smart Infrastructure Facility. 397 – 405."

I do hope this is acceptable. If so, all that I require is confirmation via return email.

Kind regards, Joanne

Joanne Leach
Research Fellow
University of Birmingham
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@joanneleach1

Currently working with UKCRIC to create a world-class national infrastructure research capability.

Did you know that Civil Engineering at the University of Birmingham is first in the Russell Group for overall satisfaction, teaching, assessment and feedback (see the National Student Survey)? We also hold a Queen's Anniversary Prize for Higher Education.

UNIVERSITY OF BIRMINGHAM UKCRIC

Permission to reproduce Paper 1

Paper 1 was published prior to the funder's requirement for open access publishing. Copyright is owned by the publisher, Thomas Telford. In 2015, the paper won the Reed and Mallik Prize for the best paper published in 2014 in The Proceedings of the Institution

of Civil Engineers – Urban Design and Planning. As a result, the paper was made free to read and is openly available on the publisher's website.

Thomas Telford stipulates "If you are the author of the content that you wish to use, please simply cite us!" (ICE Publishing, 2019)

The paper is cited as follows.

Leach J. M., Boyko C. T., Cooper R., Woodeson A., Eyre J. and Rogers C. D. F. (2015) 'Do sustainability measures constrain urban design creativity?', *Proceedings of the ICE: Urban Design and Planning,* 168(1), 30-41. DOI: 10.1680/udap.13.00034.

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The paper is cited as follows.

Leach J. M., Braithwaite P. A., Lee S. E., Bouch C. J., Hunt D. V. L. and Rogers C. D. F. (2016) 'Measuring urban sustainability and liveability performance: the City Analysis Methodology (CAM)', *International Journal of Complexity in Applied Science and Technology (IJCAST)*, 1(1), 86-106. http://dx.doi.org/10.1504/IJCAST.2016.081296.

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The paper is cited as follows.

Leach J. M., Lee S. E., Hunt D. V. L. and Rogers C. D. F. (2017) 'Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK', *Cities*, 71, 80-87. https://doi.org/10.1016/j.cities.2017.06.016.

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The paper is cited as follows.

Leach J. M., Lee S. E., Boyko C. T., Coulton C. J., Cooper R., Smith N., Joffe H., Büchs M., Hale J. D., Sadler J. P., Braithwaite P. A., Blunden L. S., DeLaurentiis V., Hunt D. V. L., Bahaj A. S., Barnes K., Bouch C. J., Bourikas L., Cavada M., Chilvers A., Clune S. J., Collins B., Cosgrave E., Dunn N., Falkingham J., James P., Kwami C., Locret-Collet M., Medda F., Ortegon A., Pollastri S., Popan C., Psarikidou K., Tyler N., Urry J., Wu Y., Zeeb V. and Rogers C. D. F. (2017). 'Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions', *Data in Brief*, 15, 691-695. https://doi.org/10.1016/j.dib.2017.10.004.

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The paper is cited as follows.

Leach J. M., Mulhall R. A., Rogers C. D. F. and Bryson J. R. (2019) 'Reading cities: Developing an urban diagnostics approach for identifying integrated urban problems with application to the city of Birmingham, UK', *Cities*, 86, 136-144. https://doi.org/10.1016/j.cities.2018.09.012.

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The paper is cited as follows.

Leach J. M., Mulhall R. A., Rogers C. D. F. and Bryson J. R. (2019) ‘Analysis methods used when applying the mixed-methods diagnostics approach to Birmingham, UK’, *Cities*, supplementary information, S1-45.

Permission to reproduce Paper 7

The paper is cited as follows.

Leach J. M., Rogers C. D. F., Ortegon-Sanchez A. and Tyler N. (2019) ‘The Liveable Cities Method: Establishing the case for transformative change for a UK metro’, *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*, Ahead of print. https://doi.org/10.1680/jensu.18.00028.

APPENDIX B. DATA MANAGEMENT PLAN

This appendix contains the data management plan for the studies undertaken as part of this thesis.

1. Overview
a. Researcher's Name: Joanne Leach
b. Title of Research Project: PhD by Published Works
c. Length of Project **Start Date:** 1 May 2012 **End Date:** 18 September 2019
d. A brief statement of the aim(s) of the project The key aims are to: 1. Describe the global landscapes of urban performance measurement and urban challenges diagnostics. 2. Determine how useful they are to urban design decision-making and policymaking in the UK. 3. Build upon them to develop bespoke methods and processes fit for the UK.

2. About the Project Data
- **Briefly describe the data that you will collect for the project** For measuring urban performance: - Interviews with urban design professionals that are summarised and validated by the interviewee - Surveys of members of the public that are transcribed into text - Secondary data collection from data sources such as the Office for National Statistics and the Liveable Cities research programme - Combining existing data from primary and secondary sources to derive new conclusions For diagnosing urban challenges: - Secondary data collection from publically-available datasets and documentation (e.g., academic papers, Local Authority reports) - Combining existing data from secondary sources to derive new conclusions
a. Frequency of new data (how often will you get new data and over what time period?) All of the data come from two data gathering exercises. One for measuring urban performance and one for diagnosing urban challenges.
b. Quantity of data (Terabytes, other forms of storage) For measuring urban performance, ~3GB of data + ¼ drawer of a filing cabinet For diagnosing urban challenges, ~2GB of data
c. What format is the data in? For measuring urban performance:

- Interview data are digital audio recordings and digital written summaries.
- Survey data are either digital Excel spreadsheets (if completed online) or paper copies + digital written transcriptions.
- Secondary data are predominantly in the form of Excel spreadsheets and tables.

For diagnosing urban challenges, the data are digital and are either pdfs of written documents (e.g., papers and reports) or are geocoded data at the Lower-layer Super Output Area of resolution.

d. Could the data be considered high value and/or vulnerable? E.g. is your data likely to attract "hactivists"? How could this be mitigated?

No
All secondary data are publically available.
Interviews and survey data are to be protected (to avoid identifying participants), but are not high value.

3. Data Collection and Storage

a. What different versions of the data do you create? E.g. versions of data files

For measuring urban performance:

- Interview data are thematically analysed, written-up in narrative form, and saved as a new file.
- Survey data are entered into an Excel spreadsheet and saved as a new file.
- Secondary data are inputted into an Excel spreadsheet and saved as a new file.

For diagnosing urban challenges:

- Secondary data are inputted into SPSS for Principal Components Analysis, which are then saved as new files
- Secondary data are also inputted into GIS software, visualised geographically, and then saved as new files

b. What additional information is necessary to understand the data? E.g. abbreviations, supplementary notes.

For measuring urban performance:

- I keep notes about the interviews with the audio recordings and interview summaries.
- I keep notes about the surveys (for those that are completed with me present) with the survey data.
- I keep information about the secondary data with the data files.

For diagnosing urban challenges:

- I keep information about the secondary data with the data files.

c. Where will the data be stored? (For electronic data there should be 3 places, including one off campus.)

Primary copies of all data are on my encrypted laptop with one backup copy on an encrypted University drive.

d. Describe the system to name and structure any electronic files.

For measuring urban performance:

- Interview folders and filenames are coded by interviewee code.

- Survey folders and filenames are coded by participant code.
- Secondary data folders and filenames match the indicator names used in UK City LIFE.

For diagnosing urban challenges:

- Secondary data folders and filenames match the evidence-identification framework developed for the study.
- Data in the form of papers and reports are named <author><number starting from 001> and the full title is saved in a Excel lookup sheet.

e. Describe the regime for backing up the data.

Working data is backed up to an encrypted University drive every month when not in use, week when in light use, and daily when heavily used (e.g., analysis is being undertaken).

f. Describe the procedure to be used to ensure files can be restored from the backups.

Weekly check that files on the encrypted drive are usable.

4. Data Availability to Others

a. Who owns the data?

In accordance with University regulations, the University owns all primary data.
All secondary data remain the property of the original owner.

b. Are there restrictions on who can use the data, and if so, what are they?

Interview and survey data identify individual participants and cannot be shared in non-anonymised forms.

c. If the data can be made openly available, at what point can this happen?

Data that can be made publically available will be so alongside the publishing of the related studies.

5. Archiving (preserving the data for future use)

a. What data should be kept beyond the end of the project?

All data, raw and processed, will be kept for a minimum of 10 years from last use.

b. How long should it be kept?

All data, raw and processed, will be kept for a minimum of 10 years from last use.

c. Where will the data be archived?

Data that can be made publically available will be deposited in the UoB Research Data Archive.
Data that cannot be made publically available will be kept on my encrypted laptop and backed up to an encrypted University drive for a minimum of 10 years from last use. They will then be deleted.

d. Who will create and maintain the archive of data?

I am responsible for archiving the data. For the publically-available data, the archive service is responsible for maintaining them. For the data that is not publically-available, I am responsible for maintaining them.

e. Are there restrictions on who can access the archived data?

Publically-available data have no restrictions.
The data that are not publically available cannot be accessed beyond the original research teams.

f. What are the likely (estimated) costs of preserving the data?

The small storage requirements (~5GB) are easily manageable by modern computers and drives. No special arrangements need to be made.

6. Implementing this Plan

a. Name of person responsible for implementing this plan.

I will take responsibility for carrying out the actions required by this plan and report them to my supervisor as appropriate.

b. Frequency of review and/or updates of this plan.

My line manager / supervisor and I will review it every 6 months during my PhD studies yearly thereafter and update if necessary.

c. Actions required in order to implement this plan.

Data storage facilities are already in place
The backup system has been set up and fully tested
I am aware of how to anonymise data for archival purposes

d. List any further information needed to carry out the actions above.

None, but should I need information in the future I will consult the University's guidance and speak with my line manager / supervisor.

APPENDIX C. PAPER 1 INTERVIEW QUESTIONS

This appendix contains the semi-structured interview questions for Paper 1.

Q1

What does urban design mean to you?

- Is there an art to urban design?

Q2

What promotes innovation and creativity in urban design?

Q3

What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Q4

Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

Q5

What is your experience of sustainability assessment methods (such as BREEAM, Council sustainability checklists, Balanced Scorecard)?

- Do you use any sustainability assessment methods even if not required to?

Q6

Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

- Specifically which ones... good and bad... and why?

Q7

Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

APPENDIX D. PAPER 1 INTERVIEW SUMMARIES

This appendix contains the interviewee-validated interview summaries for Paper 1.

Interviewee A

Q1: What does urban design mean to you?

Urban design is a vague term. 'Urban' is often used to mean 'city'. 'Design' is about manipulating things, about making things useful. Together, 'urban design' is the physical design of 'stuff' for urban environments.

'Stuff' incorporates:

- Aspects such as property: who has ownership, who has control? Planners control by design
- Things other than public space
- History ('stuff' up to now)
- Physical (natural and artificial)
- People
- Context

Urban design is not properly understood, is complex and is vulnerable (e.g. it can be accused of being wasteful of public expenditure). It is often driven by powerful people.

Cities that do well have continuity of urban design. Those that do badly are more 'hit and miss'.

Urban design today is about mapping and actualising.

Perceptions of 'urban design' are quite different to 'built environment' and therefore require quite different parameters for environmental assessment.

Sub question: What does the art of urban design mean to you?

‘Art’ can mean public art, both official and unofficial (e.g. graffiti).

‘Art’ can also mean creative inputs into urban design.

‘Art’ has non-functional aspects, incorporating intuition and feelings.

Berlin and New York are examples of successful cities.

Urban Designers need to harness the inventiveness and energy of new generations.

Q2: What promotes innovation and creativity in urban design?

Thomas Heatherwick jumps to mind. Heatherwick’s work speaks to the value of not being constrained by the context in which a design will be placed.

There used to be ‘grand plans’ in city planning, but this does not seem to currently be the case. The emphasis now is on cross-cutting interventions with the ‘old guards’ of the city having less and less influence. Both approaches have positive and negative aspects. There is a place for engineered and intuitive approaches.

Urban design is about adapting what exists, because it is rare to be designing from a completely blank canvas. This does not necessarily constrain creativity and innovation. In fact, it can promote them, especially in large, sophisticated cities where functionality is not the overriding concern.

The quality of individual artefacts in an urban environment is of great importance to young, urban design professionals today.

Q3: What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Sustainability appraisals are process-driven because their aim is assessment. However, some aspects of sustainability appraisals do not fit with the urban design approach, which is situational and is not dominated by process, but by instinct and creativity.

Some sustainability appraisals append other urban design processes, for example the Design Quality Indicator (DQI).

There is a sense that sustainability is not well understood and sustainability appraisals are useful in that they can incorporate under the sustainability umbrella aspects for consideration in urban design that might otherwise be marginal or that are poorly understood.

Urban designers need to determine when, which and if sustainability appraisals are the most appropriate tools to use.

Sustainability appraisals that incorporate aspects wider than sustainability should be considered with scepticism.

Models (e.g. pictures, images or physical models) of a city are interesting and useful urban design tools.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

Sustainability appraisals at the building scale are not particularly used at the urban design level. Achieving a BREEAM score is on an urban designer's 'list of things to do'.

Good urban designers are influenced by and understand sustainability, which is rare. Mediocre urban designers have some sustainability ideas. Less able urban designers have to be pushed towards sustainability.

In order for sustainability to work for urban designers it requires urban designers to have self-driven, quality processes internal to their organisation that are related to sustainability.

External processes are required to benchmark sustainability. This is especially important for poor urban designers.

Creativity and innovation in urban design requires an integrated team, responsible clients, responsible contracting, self-governance and a level of understanding of what is needed to achieve sustainability.

There is currently too much fragmentation with regard to urban design teams.

Having a single individual controlling the urban design vision can have negative as well as positive impacts.

Whole life costing is an effective way of engaging clients with regard to sustainability.

Sustainability needs to be translated into economic terms (money and assets) for clients (those with financial control of projects). If sustainability is presented in vague, aspirational terms then it will not engage clients who require a business case to be made.

BREEAM is the 'stick' approach (as opposed to the 'carrot' approach) to sustainability compliance.

Sustainability is better integrated into urban design if the architect considers it in from the beginning. If this does not happen, incorporating sustainability can be a much more difficult process.

Urban designers would have engaged with sustainability even if not required or pushed to do so by regulations or best practice, as sustainability has cultural drivers. For example, energy cost increases cause energy use efficiencies which contribute to sustainability.

Q5 (Sub): Do you use any sustainability assessment methods even if not required to?

No, in the context of urban design as presented in the abstract – all projects I am currently enabling are committed to BREEAM Excellent, Government policies and best practice.

Q6: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

The barriers posed by sustainability do cause increased creativity and innovation in urban design. The tick box approach to urban design incorporated in a question and answer process can be managed in support of a creative outcome. The deciding factor is how well the process is managed.

(E.g. The mention of embodied energy say in specification of materials in urban design projects. As major difference between urban design and design of buildings can be non-occupation and therefore different parameters to carbon and environmental impact. Relates back to definition of exactly what urban design is? If it is something that encompasses all the built environment then it is very different from say the design of public spaces.)

Q7: Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

Design Quality Indicator (DQI)

Defence Related Environmental Assessment Method (DREAM)

Building Information Modelling (BIM)

BuildingSMART (example of an integrated team approach)

Passivhaus

Whole life costing

CEEQUAL, which crosses disciplines

LEED

Interviewee B

Q1: What does urban design mean to you?

Urban design is a set of seven principles

1. Character
2. Continuity and enclosure
3. Quality of the public realm
4. Ease of movement
5. Legibility
6. Adaptability
7. Diversity

Urban design has tangible and communicable outputs.

Urban design is a wide-ranging process (not just outputs).

Urban design is an immature discipline. The scale and scope of urban design is still being discussed and urban designers come from a range of disciplines (e.g. architecture, planners, etc.). This is at odds with humans' long history of intervening in urban environments.

Urban design is a platform for quality of life and wellbeing.

Urban design is proactive engagement, not just mitigating the effects of urbanisation. There is something aspirational about urban design.

Urban design is a spectrum of approaches that have to be brought together. It is orchestrating and choreographing information.

Urban design can be a catalyst for communities to 'do something'.

Urban design is not about adhering to a design code or specification; it is about general principles.

Sub question: What does the art of urban design mean to you?

Creativity is a large part of creating spaces people want to be.

Creativity raises issues such as transport above mere functionality.

Harnessing and engaging.

Innovation is not creativity. Innovation involves taking risks. Creativity and innovation are part of the same spectrum.

Creativity seeps through the cracks. Innovation breaks through.

The information is out there, the creativity comes in extracting meaning from it.

Q2: What promotes innovation and creativity in urban design?

A visionary expert is required to make the case for the design – the convincing argument to try something different.

Good urban design includes a masterplan with the capacity for poor architecture.

Understanding that designs are unique to their context. The exact same design in a different context is experienced and works differently than the original.

Q3: What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

It is not about one technique, but many. It is about selecting the most appropriate techniques and having the confidence to 'let things run' – not intervening too soon.

Understanding the process and not trying to transplant x design into y place.

View everything from the urban design scale.

The communication of urban design may be at varying scales (e.g. a particular street or square), but functionality has to be achieved at the larger scale (larger than a big development).

Positive effects of an urban design can spill over to affect areas external to the original design.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

It depends upon the method used.

A well-designed urban place has to be sustainable.

Q7: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

Many sustainability tools are good at the middle ground, but hopeless at identifying what is really good (innovative) or really bad (wrong).

BREEAM Communities can be useful, but is very self-referential (i.e. a credit for completing a community engagement plan, not is it a good / relevant plan). BREEAM Communities is about assessment and evaluation and is not discursive. In some places it is extremely specific, almost too prescriptive. What is needed is the discussion of what is required in that particular circumstance - so benchmarking is useful, but targets should be adjusted depending on opportunities or constraints. The making of the place is too thin a slice of the process.

Urban design is at a larger scale and is about guiding principles. Tools should reflect this.

Tools that try to do everything become distorted from their original intent. Therefore more focussed tools are better. E.g. tools for various stages in the design process: visioning tools, assessment tools and compliance tools.

Codifying leads to baselines and thresholds and drives out innovation.

It is important to gather information to inform the urban design process and tools can help with this.

Tools themselves can be used in innovative ways.

Tools help designers prioritise issues and in so doing lead to creative outcomes.

Tools help designers gather information; they provide the preparation required for creativity.

There is almost too much information out there. Tools help organise this information.

Tools are not about what they are but how they are used (and mis-used and creatively used).

One problem with tools is that there are so many of them.

Tools that engage communities and raise awareness of communities are very attractive. The sustainability tools required are those that continue to nudge and influence. There is a body of literature on community engagement with sustainability which has often been overlooked. This includes earlier communities facing assessment tools such as the rather dry but well intended European Common Indicators of Local Environmental Sustainability that measures citizen satisfaction with governance alongside material resources and other sustainability criteria.

Tools are useful to set benchmarks and commonality of language but are too detailed, scientific and assume a solution so are unable to engage with the bigger picture. Cities and people are not rational.

Tools help those who are less creative and innovative, but are not always predictors of a good outcome.

Q8: Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

BREEAM Communities (mentioned above)

LEED Neighbourhoods

Building for Life

Young Foundation's toolkit for sustainability

Interviewee C

Q1: What does urban design mean to you?

Urban design is a mechanism society uses to restrict access to scarce resources in an urban setting.

Typically, it maintains inequitable access to scarce resources.

Urban design professionals are those used to enable this process.

It is possible to be egalitarian in urban design, but this is rare in the UK. There are some examples of communities fighting against imposed, top down, visions by developing and fighting for bottom up ones of their own (e.g. Craigmillar, Edinburgh).

New Urbanism imposes social norms by embedding standards into design codes.

The UK has a less privatised view of urban design than that of the USA, but more so than that of Europe.

The built environment is the way we attach value to the resources and relationships it helps configure and how we attempt to externalise that attached value and embed it in physical structures that we then live in.

The built environment is too important to leave to urban design professionals.

Q1 Sub question: What does the art of urban design mean to you?

Aesthetics is a specialised language that can be used to manipulate those who don't speak it.

'Art' is a difficult category to apply to urban design and when it is, it should be used carefully.

Q2: What promotes innovation and creativity in urban design?

New opportunities, especially in the form of social solution spaces, that did not previously exist.

Cultural urbanism is very creative and innovative and can incorporate co-production and co-design.

Urban design is typically very conservative and has remained protected from developments that have occurred in other areas of design/product manufacturing (e.g. co-production and co-creation).

The built environment is a repository of values: it expresses current values and expresses aspirations for the future.

Five generation planning: when we intervene in an urban environment we should keep the best from our parents' and grand parents' generations and pass these on to our children and grand children.

Q3: What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Very interested in techniques to help others do what they want to do and to build consensus.

In urban design, it is important to raise aspirations without inducing unrealisable expectations.

Innovation and creativity depend on protecting degrees of freedoms.

Creating sustainable, healthy, attractive places is important.

Urban design is preoccupied with built form; urban design interventions do not have to be buildings. The Urban Futures Game in its original form had an outcome that was not necessarily a built form. When RIBA took the game forward the name was changed to the Building Futures Game and the outcome was always a building.

Enabling non-experts to take part in the urban design process is desirable (equitable) but does not necessarily increase the quality, creativeness or innovativeness of the outcome.

Urban design does not equal aesthetics.

A high quality urban setting is most commonly the accretion of form and settlement patterns over time reflecting the use and adaptations over generations.

Successful spaces are those that are cherished by the people that use them.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

Regulations have been very important in pushing urban designers to engage with sustainability. Built environment professionals at past workshops have indicated that without regulation their engagement with sustainability would have been limited.

Sustainability changes the nature of the ammunition available for negotiations. This has allowed for the value of sustainability to be argued for in a way not previously allowed.

Q5: What is your experience of sustainability assessment methods?

Little first-hand experience of assessment methods.

Assessment methods do not change the terrain, but can change the outcomes of battles.

Assessment methods can take quite different forms - local government appraisals (often qualitative) or academic multi -criteria methods (often quantitative). Both tend to lack a social element.

Sustainability may be manifested in urban design through the use of assessment methods. However, the methods are not a fair representation of sustainability (not holistic), focus upon performance, set benchmarks that are too low (not withstanding BREEAM's use of the word 'outstanding') and are too narrow.

Most urban design and regeneration is predicated on the notion of continued economic growth.

The rise of assessment methods is socially useful because they highlight sustainability and set benchmarks and compliance requirements.

Sustainable places can be designed without the use of assessment methods.

BEQUEST and BREEAM persist because they do not incorporate a value framework. They are technocratic and the outcome appears to be value free. Their use does not necessarily lead to a better outcome.

A major question is how can a communities' values be protected and embedded into urban design changes?

Can you build sustainable projects in unsustainable places?

Q7: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

Assessment methods are not necessarily a constraint on design because constraints are needed to design – the issue is when or if they impose too much.

Interviewee D

Q1: What does urban design mean to you?

There are two definitions: (1) the ability of a collection of buildings to be more than the sum of their parts, and (2) for the spaces between buildings to support a range of activities without being prescriptive.

Urban design endures different types of societies moving through it and allows people to use the spaces (access, e.g. cycle races, charity runs, gathering, demonstrations), to use them in different ways now and over time. It does not prescribe who can use the spaces or seek to exclude groups of people (e.g. 'undesirables').

Walkable and cyclable.

Human in scale; additive in value. Good urbanism is more than the sum of its parts.

Good urbanism allows society to do things. It has nothing to do with sustainability in the broad terms of social sustainability.

In existing cities, urban design is about where you put the kerb (public spaces are already defined).

Good urbanism is an investment in quality of life issues.

Ground level is desirable because this is the level at which life is lived.

Urban design is the plan. It is not architecture, objects, detailed design, land use, planning or density.

Cities have memories – their form is largely laid out by their infrastructure. Such history adds to a city's quality of place and sense of permanence, belonging and meaning.

Q2: What promotes innovation and creativity in urban design?

There must be someone with a vision (e.g. a mayor) who sees value in urban design and in land uses. Someone who can see the city in 100+ year's time (a long term approach). That what is designed today will, largely, still be there in 100+ year's time (the latter is a quality of all good urbanists).

There must be a client or land owner who understands urban design (that it is not land use or architecture).

Someone must have the skills to articulate a sense of place.

There is a non-design element to good urban design that really good urbanists understand.

Q3: What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Serendipitous places, creative and innovative spaces, can be engineered.

Examples of good and bad urbanism, urban design and urban design techniques were discussed. A selection of these are captured below:

- Ground figure drawings – highlight features at the urban design scale such as major views, major entrances, etc.
- Strip architecture – Las Vegas is an example, where the urban environment is a series of objects (e.g. buildings) related to by a road. It is an example of poor urban design. Vegas has created enormous value and a worldwide iconic place arguably because of its strip. Attempts to move value away from the strip have, to date, consistently failed and the strip as a form is not normally seen as a value creation piece of urbanism; but, Vegas has clearly achieved that historically as well as today, whilst going through several iterations in terms of its economy, ie: pure gambling, then to a family resort with more family shows and attractions and

now back to slightly more adult orientated entertainment. Quite significant changes in terms of an entertainment city. The fact that it is in the desert is no different from huge amounts of California which relies on water from elsewhere and its sustainability issues vis-a-vis water and food are similar but more extreme than probably one third of America and many other parts of the world. I am not sure what design tool would lead you to create the sort of value and enduring legacy that Vegas has done.

- Integration of public transport. If people cannot get to a place then that place will not work.
- Multiple uses of spaces over the course of a day. For example, street use can be changed by time of day.
- Public owned private spaces empower owners to remove those they consider undesirable. It allows people to be excluded and undermines good urbanism.
- Railways and tubes are considered public spaces although they are privately owned. These are a city's public circulation system.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

There is a problem with sustainability in that it implies social justice and values; it is arrogant to attribute sustainability to a piece of urban design.

Cities have to be flexible, continually reinventing themselves economically (primarily), socially and environmentally.

Decarbonisation is a must, but decarbonisation is not sustainability. It can be done in unsustainable ways.

Sustainability in cities is social sustainability, which underpins economic sustainability. Sustainability in cities is not about environmental sustainability.

Urbanism cannot make the world sustainable.

Good designers can meet design guidelines and sustainability requirements but those requirements of themselves will not create good urbanism.

Sustainability cannot be achieved simply by good, sensitive urbanisation as a creation of phenomenal public spaces. For instance the pricing of transit systems can, in and of itself, become socially divisive or socially inclusive without any change to the urban form or in any manner of using the public space. There are specific issues like the trade off between the energy intensity and amount of public lighting and security for people. Sustainability policy will often lead to cutbacks in security lighting in poor neighbourhoods rather than rich.

Q6: Do you use any sustainability assessment methods even if not required to?

Sustainability assessment methods fall into various categories:

- Prescriptive standards: mandatory performance requirements such as energy efficiency standards.
- Tick boxes about quality: engender discussions about quality, this is all they do. E.g. design reviews such as defending a design in front of CABE [Design Review] are really good.

Q7: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

Sustainability assessment methods that incorporate tick boxes where points are accumulated do not add a lot, and conversely don't take much away from urban design. If a designer is good at what he or she does then it is not difficult for them to sell what is

being designed on its merits. However, a receptive client is required; one who wants what is being designed.

If a sustainability assessment method is considered restrictive by an urban designer then they are probably designing in too much detail.

Interviewee E

Q1: What does urban design mean to you?

Urban design has two parts:

1. It is the relationship between buildings, infrastructure and green spaces for the creation of a functional, attractive and sustainable space.
2. It is balancing density, access/transport, views, legibility and way finding. It is the feel of a place (what is the feel of a place?); the human impact. Happiness is a very important aspect that is missed in assessment tools).

Q1 Sub question: What does the art of urban design mean to you?

There is definitely art in urban design.

Part of the art is to create something attractive, to make people feel they belong and to make them happy. It is the creative flair.

Creative flair needs to be blended with requirements from, for example, the client, regulations, technical aspects and set parameters.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

Tools contribute to the technical aspects of urban design, but not the creative aspects. This may be because it is hard to measure design quality, so they don't.

A Design Review Panel (such as the one run by CABE, but not exclusive this one) is the only way of discussing quality that stands up to scrutiny.

There are suspected issues of credibility with including softer assessments / woolly issues in tools, which prefer to keep things business-like and measurable.

Sustainability does offer opportunities for being creative.

Sustainable design = good design.

Sustainability and similar agendas can be used to justify design decisions, which is a good thing.

Sustainability is nebulous and can be meaningless so tools provide the framework for understanding. They also benchmark and can be used to sway clients.

Three elements are required for sustainability to be incorporated into a design (but rarely found together):

1. A committed and enthusiastic client
2. A good, committed and enthusiastic team
3. A committed and enthusiastic local authority

If there were no sustainability assessment methods then urban design would not engage with the sustainability agenda. Business as usual would persist.

Sustainability can be included in designs without being marketed as explicitly sustainable, but these elements risk being dropped during cost reviews.

Q5: What is your experience of sustainability assessment methods?

Tools are only as good as the team using them.

Tools can justify what has been done and what can be gotten away with.

A good team will incorporate sustainability with or without tools.

Tools can create perverse outcomes that do not make sense in the scope of the design.

Tools are a jumping off point. They provide pointers for thinking about issues. They elucidate the topics.

Teams can design in the spirit of a BRE credit, for example, but not achieve the credit because BRE is quite rigid about how credits are attained.

Achieving credits is an onerous process requiring significant resources to gather evidence.

Constraints can foster creativity. Starting with a blank sheet can be extremely difficult for a designer.

Interviewee has used:

- BREEAM (is an assessor and AP (Accredited Professional))
- BREEAM Communities (the old version)
- LEED (at the building scale)
- SKA Rating

Q7: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

Fostering creativity means referencing best practice and allowing time for designs to evolve and be commented upon. Urban design is often created in a hurry and fixed too soon with little chance for stakeholder input.

Fostering creativity means designers putting themselves in the place of those who will use the design (e.g. live in the place). This is not possible if the design is hurried.

A committed client and team can use tools and be creative.

On the whole assessment methods are not conducive to creativity and they always come down to being a checklist because of the nature of the development process. The

design team reports to the project manager, who is only interested in distance to targets and not in design quality.

The form the tools take is important. They need to fit with the development process.

From a developer's/client's point of view the best tools are BREEAM New Construction and LEED Building Design + Construction (both for building scale) because they are common, are marketable and provide benchmarks.

From an urban designer's POV the best tools are probably BREEAM Communities and LEED Neighborhood Development (both for neighbourhood / master plan scale) as tools to prompt thinking – not going as far as designing for credits. This approach frees the designer to work within his or her own parameters. For proving quality would use a design review.

Q8: Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

CASBEE

Green Star

They are all very similar in approach, with the nuances being in how the points are allocated. There is nothing really different currently out there.

Tools will have to change in the future to become easier to use and more integrated into the development process and timescales.

It would be good to see a design review panel approach incorporated into future tools.

Evidence gathering should be fit for purpose, less onerous and should be transparent so all in the process can contribute.

It would also be good to see more time allowed in the design process.

The role of the BREEAM Accredited Professional is in many ways a mechanism by which BRE is attempting to champion sustainability within the design team. This was the intention for the role of BREEAM Assessor, but in reality the Assessor simply came in late on in the process and gathered the evidence. The AP role is better, but not fully, integrated into the design team (e.g. the AP is not usually able to attend all design meetings due to consultancy income constraints).

Interviewee F

Q1: What does urban design mean to you?

Creating an environment for people to live in.

Of particular importance are the infrastructure elements and the spaces between buildings (the latter is often forgotten).

Sub question: What does the art of urban design mean to you?

Each urban area is unique

The 'art' of urban design should not be proscriptive or overly methodical.

Art includes culture.

There is no art in the current, linear planning system which focuses upon compliance.

Large-scale projects do not simply rely upon gaining planning approval and so can be, and frequently are, more innovative and creative. Small projects rely upon gaining planning approval in the easiest way and so contain less art.

The degree/inclusion of the 'art' can be influenced by who is driving a project, what is the vision and why they are doing it. Public authorities are driven by community needs and take more risks whereas private developers are driven by profit and brand

image. For example, a project driven by house builders in London was rejected as sub-standard. In contrast, Newham Council is driving a project that is encouraging creativity and innovation to drive the creation of 'something different'.

Leadership plays a part in the art of urban design. For example, Eastside had a good vision, but weak leadership.

Q2: What promotes innovation and creativity in urban design?

Planning for Real because it encourages community involvement which, when done well, contributes to creativity and innovation.

Community involvement works well in a healthy community (usually middle class) but does not work well in a failing community as members find it difficult to move beyond everyday concerns.

Sustainability is a middle class concern.

Trust, honesty and confidence need to be a part of the engagement system.

Timing of engagement is important. Too soon and the discussion is too open; too late and ideas are constrained by advanced designs and changes can be costly.

A constraint on creativity of Planning for Real is that it cannot start with a blank sheet, so boundaries and initial directions are imposed from the start.

The number of participants in each engagement activity impacts the outcomes. Too many risks no convergence of ideas; too few and patterns don't emerge. Nonetheless, good participants are ones who are willing to compromise.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

Yes, with mobility and transport systems/infrastructure being key areas. There is a deep-seated realisation that movement around cities must change and this will have considerable impact upon urban design and urban designers.

Q5: What is your experience of sustainability assessment methods?

There is no suitable sustainability assessment method currently available.

BREEAM (including Communities), LEED (including ND – Neighbourhood Development) and CASBEE are not sustainability assessment methods because they do not holistically consider sustainability. They are mired in their building-scale and environmental roots. They do not consider communities or the art of urban design. They lack breadth and robustness.

The Arup SPeAR is the best method currently available. It considers the three pillars of sustainability, interrelationships, identifies strengths and weaknesses of projects and assesses the impacts of changes. It promotes creativity because it makes the users think, qualitatively, which is necessary for creativity and innovation (however, such qualitative indicators make it difficult for engineers to quantify). It does not provide an award. It also considers changes over time, realising that an assessment carried out today will be different than one carried out in a year's time. It also has the capacity to raise questions, for example, if one changes a weakness to a strength, what does it do to the other strengths?

There is a problem with getting building occupiers to understand and comply with desired building use. Their misuse of a building can reduce its sustainability and stop it reaching its designed targets.

The answers below were provided in writing following the interview.

Q5 (Sub): Do you use any sustainability assessment methods even if not required to?

Yes, in order to ensure that all aspects of sustainability are addressed. These can be anything from standard tools to simple frameworks and processes.

Q6: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

When used appropriately, they need not hinder creativity or design – check out the Olympic Park, the landscape design is pretty innovative as are the permanent structures. Indeed, sustainability can encourage innovation and creativity by posing new challenges and 'lateral thinking'

Q7: Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

Not that I can immediately think of. Most organisations have their own assessment methods but they are internal tools and not suited for wider consumption.

Interviewee G

Q1: What does urban design mean to you?

Urban design is a process of incorporating cross-disciplinary approaches to come out with a holistic plan for whatever is being done with the urban environment.

Q1 Sub question: What does the art of urban design mean to you?

Understanding the opportunities presented by the place being designed (the local context), the environment at scale (recognising the wider the context), the team (people are brought in at different points in the process with their own particular foci) and translating the issues into opportunities.

Not taking a formulaic approach; drawing upon experience and being open to opportunities.

Creating a place that functions as efficiently as possible.

Q2: What promotes innovation and creativity in urban design?

Someone has to have a vision and legitimise risk taking. It does not matter who this person is, but they need to have the appropriate authority to have the vision, empower risk taking and make the business case (be persuasive), for example the leader of a council.

People can be threatened by new ideas so visions should be actioned in positive ways, generating an atmosphere of excitement.

Looking at other countries and contexts for inspiration and best practice.

Not sure how much blue sky thinking really goes on in urban design.

A common understanding of the design from the start of the design process.

Q3: What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Individual capability and capacity and organisational investment and priority.

It is down to the individual.

Taking time for blue sky thinking. Organisations should invest in blue sky thinking and give employees the time for it.

Mentoring and encouraging creativity (by others).

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

All innovative approaches are in response to complex situations.

Urban design is complex. Simple responses to urban design are one-dimensional responses.

The sustainability agenda makes urban design simpler because it provides an umbrella under which all urban design is carried out.

The sustainability agenda provides a high-level focus for urban design.

Need to recognise and respect that everyone has their own interests and expertise.

All conflicts cannot be resolved, so issues must be prioritised.

Q5: What is your experience of sustainability assessment methods?

There are quantitative approaches that help prioritise issues.

They elucidate issues, providing a foil for intuition.

They provide baseline standards.

Urban design is broader than the site level and quantitative approaches can help focus discussion at the site level.

BREEAM Communities can work at the urban design level.

Visioning sets the baseline standards at the urban design level.

Tools are designed for those who need to be 'brought up to speed'. Innovative leaders are working at the forefront and in advance of many tools.

Different tools are designed for different parts of the urban design process and to address specific issues and are brought together by the design team. Compliance and discussion tools are both useful.

Every issue needs its own champion.

Q6: Do you use any sustainability assessment methods even if not required to?

Yes

Q7: Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

This depends upon the user, not the tool.

The Sustainability Checklist was not fully understood by all users and where it was not used correctly it was perceived as another obstacle to getting on with the job.

BREEAM can be used to shape developments if used from the beginning.

BREEAM and the Sustainability Checklist address compliance and provide clues to the user as to what compliance looks like (i.e. how to judge what the answer may look like) but more importantly what good and excellent responses to an issue are which will generally exceed basic compliance.

Enplanner is interesting because it gives the user information they might not already have (climate data) and determines if the design complies with local planning.

Part of the problem is that urban designers do not know what tools are out there. Tools need brand recognition.

Q8: Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

Urban Futures Tool – this requires intellectual capacity to engage with, and this can be seen as a barrier.

Sustainability Checklist

Passivhaus

BREEAM Communities

Enplanner – designed by Matthew Rhodes, who would be useful to speak to.

Tools help designers understand the relationship between strategy, structure and details.

Capacity to engage with tools is an issue. People are busy and training budgets have been cut.

Tools that provide an award can be more popular, but only if the award is valued. Awards are only one measure of success.

Urban design awards often prioritise the aesthetic (how things look) and not performance. What looks good is not always what works best.

Would advise you speak to Ted Cullinan, architect. Ted created a vision for Stoke on Trent which was informed by very personal knowledge of the city and its special characteristics and by freedom from the approach that many have, of trying to make Stoke behave like a more usual concentric city.

Interviewees H and I

Q1: What does urban design mean to you?

Interviewee H: recently invented, architecture on a large scale (large extent), master planning in 3d, creating successful communities and places, public realm (Interviewee I added that public realm is not client driven), easier if organic, the best cities are not designed, collection of designs, a way of collecting designs in an organised way, problematic if the product of one mind, the art is making it successful in a number of ways (sustainable, robust, pretty, nice materials, economic, viable, adaptable, etc.), spill over benefits should spread.

Interviewee I: making sense of the chaos (Interviewee H disagreed, saying the alternative is not necessarily chaos), integrating, purposeful design.

The 'art' is about making spaces successful, sustainable, robust, good to feel, economically viable and not designing for a specific thing/person/way; good urban design allows for flexibility and becomes a draw.

Q2: What promotes innovation and creativity in urban design?

Design and creativity come about via constraints that include the physical site.

Overcoming constraints forms the design proposal.

Constraints must be prioritised – a designer cannot overcome all constraints. Constraints are site specific and so their prioritisation is also site-specific. This prioritisation is driven by the dominant vision for the site.

Bad designers have a pre-formed set of solutions in mind.

Q3: What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Design Review (CABE), engaging with others / dialogue, an understanding of criteria against which the design will be tested (including assessment methods like BREEAM, although there was emphasis that this knowledge was not used to create the design criteria).

Early career designers are less constrained by design criteria (the implication being they are more creative and innovative because of this).

UK designers are highly regarded because their design education is loose, free and encourages lateral thinking.

Q4: Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

There is an issue of design professionals not being able to keep up with the complicated and quick-moving issues with which they are dealing, such as sustainability.

Issues such as sustainability, along with regulations, promote creativity (and do not stifle it).

Without a good understanding of complex issues designs can struggle to meet criteria and opportunities fail to be capitalised upon.

A positive role of sustainability assessment methods is making designers aware of the issues. However, misuse of assessment methods can mean they do not achieve this.

A lot of sustainability criteria are not well understood by urban designers. There is a time lag between when the criteria become known to, say, academics, and when urban designers pick it up, understand it and apply it.

[Company Name] would have engaged with sustainability without the regulations or assessment requirements, but acknowledged that their clients may not have been interested.

Not all clients wish to engage with sustainability; however this does not necessarily preclude sustainability from a design. All good design incorporates sustainability.

There is a role for architects to educate clients about sustainability, but not all clients are receptive.

What is the 'next big thing' (taking sustainability as today's 'big thing')?

Interviewee I: increasing and encouraging biodiversity in cities.

Interviewee H: land use (e.g., food, living space, city density, productive land, relations with movement, increasing population, etc.). Increasing densification is not the answer.

Q5: What is your experience of sustainability assessment methods?

BREEAM

Assessment methods can hold back the use of innovative materials because they have not been fully tested and scored, for example.

BREEAM has introduced the role of BREEAM AP (Accredited Professional). The BREEAM AP role underscores that sustainability is not embedded into design teams – if it was this role would not be required.

The ‘design philosophy’ drives the design. Good design teams engage with sustainability as a philosophy.

A client’s attitude to risk impacts upon sustainability solutions incorporated into the design. Risk-averse clients may not wish to incorporate untested green solutions.

Q6: Do you use any sustainability assessment methods even if not required to?

Sefaira – software for green design.

Parametric design – this is the future as it removes the burden of repetitive, time-consuming design elements.

Fosters is working in collaboration with NASA on software that provides building physics information. However, most architects are small firms, and cannot afford to do this.

The Interviewees do not reference any design guidance. They do use software packages.

Q7: Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

- LEED – very trendy at the moment, although better fit to the American market
- Green Star – used in Australia
- Global Sustainability Assessment System (GSAS) – used in the Middle East
- SKA rating – RICS
- CEEQUAL – used at [Company name]
- CS Homes – Communities Scotland
- NPPF – useful for how little it says about sustainability (implying it allows for great flexibility)

APPENDIX E. PAPER 1 ETHICAL APPROVAL

Ethical approval was not obtained for the interviews conducted as part of the study described in Paper 1. This was an honest oversight. The research was conducted ethically and a description of the procedures and processes are contained in this appendix. This documentation has been submitted to the University of Birmingham Ethics Committee for validation, under the understanding that retrospective ethical approval cannot be granted.

Application for Ethics Review Form

Guidance Notes:

What is the purpose of this form?

This form should be completed to seek ethics review for research projects to be undertaken by University of Birmingham staff, PGR students or visiting/emeritus researchers who will be carrying out research which will be attributed to the University.

Who should complete it?

For a staff project – the lead researcher/Principal Investigator on the project.
For a PGR student project – the student's academic supervisor, in discussion with the student.

Students undertaking undergraduate projects and taught postgraduate (PGT) students should refer to their Department/School for advice

When should it be completed?

After you have completed the University's online ethics self-assessment form (SAF), **IF** the SAF indicates that ethics review is required. You should apply in good time to ensure that you receive a favourable ethics opinion prior to the commencement of the project and it is recommended that you allow at least 60 working days for the ethics process to be completed.

How should it be submitted?

An electronic version of the completed form should be submitted to the Research Ethics Officer, at the following email address: aer-ethics@contacts.bham.ac.uk.

What should be included with it?

Copies of any relevant supporting information and participant documentation, research tools (e.g. interview topic guides, questionnaires, etc) and where appropriate a health & safety risk assessment for the project (see section 10 of this form for further information about risk assessments).

What should applicants read before submitting this form?

Before submitting, you should ensure that you have read and understood the following information and guidance and that you have taken it into account when completing your application:

- The information and guidance provided on the University's ethics webpages (https://intranet.birmingham.ac.uk/finance/accounting/Research-Support-Group/Research-Ethics/Ethical-Review-of-Research.aspx)

- The University's Code of Practice for Research (https://www.birmingham.ac.uk/Documents/university/legal/research.pdf)

- The guidance on Data Protection for researchers provided by the University's Legal Services team at https://intranet.birmingham.ac.uk/legal-services/What-we-do/Data-Protection/resources.aspx.

Section 1: Basic Project Details

Project Title: Do sustainability measures constrain urban design creativity?

Is this project a: University of Birmingham Staff Research project

Details of the Principal Investigator or Lead Supervisor (for PGR student projects):

Title: Professor
First name: Chris
Last name: Rogers

Position held: Professor of Geotechnical Engineering
School/Department Department of Civil Engineering

Telephone: 0121 414 5066
Email address: c.d.f.rogers@bham.ac.uk

Project start and end dates:

Estimated start date of project: 01/06/2013
Estimated end date of project: 01/02/2015

Funding:

Sources of funding: EPSRC

Section 2: Summary of Project

Describe the purpose, background rationale for the proposed project, as well as the hypotheses/research questions to be examined and expected outcomes. This description should be in everyday language that is free from jargon - please explain any technical terms or discipline-specific phrases. Please do not provide extensive academic background material or references.

Planners, architects, urban designers and other built environment professionals engage with a myriad of checkboxes, guidelines, requirements and specifications, all of which potentially compromise creativity and innovation in urban design. Approaches that measure performance are accused of belying the nature of places as messy, plural, organic, accidental and emotive; trying to find a formula that works may tick boxes, but it risks creating soulless spaces, oppressing innovation and incorporation of inappropriate design elements. This study investigates the perceived contributions of sustainability assessment methods to creativity and innovation in urban design. It will do this through semi-structured interviews with nine built environment professionals and a critical examination of sustainability assessment methods raised.

Section 3: Conduct and location of Project

Conduct of project

Please give a description of the research methodology that will be used. If more than one methodology or phase will be involved, please separate these out clearly and refer to them consistently throughout the rest of this form.

Semi-structured interviews with nine built environment professionals, a review of the literature on the sustainability assessment methods named during the interviews, a review of the literature on sustainability assessment methods more generally and upon creativity and innovation in urban design.

Geographic location of project

State the geographic locations where the project and all associated fieldwork will be carried out. If the project will involve travel to areas which may be considered unsafe, either in the UK or overseas, please ensure that the risks of this (or any other non-trivial health and safety risks associated with the research) are addressed by a documented health and safety risk assessment, as described in section 10 of this form.

Interviews are conducted in the UK at locations convenient to the interviewees, which are a combination of their offices and public spaces (e.g., coffee shops).

Section 4: Research Participants and Recruitment

Does the project involve human participants?

Note: 'Participation' includes both active participation (such as when participants take part in an interview) and cases where participants take part in the study without their knowledge and consent at the time (for example, in crowd behaviour research).

Yes ☒
No ☐

If you have answered NO please go on to Section 8 of this form. If you have answered YES please complete the rest of this section and then continue on to section 5.

Who will the participants be?

Describe the number of participants and important characteristics (such as age, gender, location, affiliation, level of fitness, intellectual ability etc.). Specify any inclusion/exclusion criteria to be used.

Participants are urban design professionals practicing within the UK (e.g., architects, town planners, engineering consultants). There are no other important characteristics.

How will the participants be recruited?

Please state clearly how the participants will be identified, approached and recruited. Include any relationship between the investigator(s) and participant(s) (e.g. instructor-student). Please ensure that you attach a copy of any poster(s), advertisement(s) or letter(s) to be used for recruitment.

Participants are recruited from the network of contacts known to the researcehers from working in this field over the last 10 years and by word of mouth from this network and from colleagues. They are approached via email and invited to participate in the study. Copies of the template recruitment letter and interview confirmation letter are included with this form.

Section 5: Consent

What process will be used to obtain consent?

Describe the process that the investigator(s) will be using to obtain valid consent. If consent is not to be obtained explain why. If the participants are under the age of 16 it would usually be necessary to obtain parental consent and the process for this should be described in full, including whether parental consent will be opt-in or opt-out.

Consent is obtained verbally and recorded as part of the interview. A copy of the interview script is included with this form. The recruitment letter and interview confirmation letter contain the project information for the participant and these are reviewed verbally before each interview (and this is recorded). Both the letters are emailed and so are retained by the participant.

Please be aware that if the project involves over 16s who lack capacity to consent, separate approval will be required from the Health Research Authority (HRA) in line with the Mental Capacity Act.

Please attach a copy of the Participant Information Sheet (if applicable), the Consent Form (if applicable), the content of any telephone script (if applicable) and any other material that will be used in the consent process.

Note: Guidance from Legal Services on wording relating to the Data Protection Act 2018 can be accessed at https://intranet.birmingham.ac.uk/legal-services/What-we-do/Data-Protection/resources.aspx.

Use of deception?

Will the participants be deceived in any way about the purpose of the study?

Yes ☐
No ☒

If yes, please describe the nature and extent of the deception involved. Include how and when the deception will be revealed, and the nature of any explanation/debrief will be provided to the participants after the study has taken place.

Click or tap here to enter text.

Section 6: Participant compensation, withdrawal and feedback to participants

What, if any, feedback will be provided to participants?

Explain any feedback/ information that will be provided to the participants after participation in the research (e.g. a more complete description of the purpose of the research, or access to the results of the research).

A summary of the participant's interview is sent to the participant for their validation (and amendment, if necessary). Any arising papers are shared with the participants.

What arrangements will be in place for participant withdrawal?

Describe how the participants will be informed of their right to withdraw from the project, explain any consequences for the participant of withdrawing from the study and indicate what will be done with the participant's data if they withdraw.

Participants are made aware of their right to withdraw in the interview confirmation letter and verbally at the start of each interview (which is recorded). Withdrawal is without consequence to the participant. Withdrawal is allowed up to a fortnight following the interview. Should a participant withdraw, their data is removed from the study.

Please confirm the specific date/timescale to be used as the deadline for participant withdrawal and ensure that this is consistently stated across all participant documentation. This is considered preferable to allowing participants to 'withdraw at any time' as presumably there will be a point beyond which it will not be possible to remove their data from the study (e.g. because analysis has started, the findings have been published, etc).

Participants can withdraw up to a fortnight after their interview.

What arrangements will be in place for participant compensation?

Will participants receive compensation for participation?

Yes ☐
No ☒

If yes, please provide further information about the nature and value of any compensation and clarify whether it will be financial or non-financial.

Click or tap here to enter text.

If participants choose to withdraw, how will you deal with compensation?

Click or tap here to enter text.

Section 7: Confidentiality/anonymity

Will the identity of the participants be known to the researcher?

Will participants be truly anonymous (i.e. their identity will not be known to the researcher)?

Yes ☐
No ☒

In what format will data be stored?

Will participants' data be stored in identifiable format, or will it be anonymised or pseudo-anonymised (i.e. an assigned ID code or number will be used instead of the participant's name and a key will kept allowing the researcher to identify a participant's data)?

Participant data is assigned a code, with the key kept by the lead researcher at the University of Birmingham.

Will participants' data be treated as confidential?

Will participants' data be treated as confidential (i.e. they will not be identified in any outputs from the study and their identity will not be disclosed to any third party)?

Yes ☒
No ☐

If you have answered no to the question above, meaning that participants' data will not be treated as confidential (i.e. their data and/or identities may be revealed in the research outputs or otherwise to third parties), please provide further information and justification for this:

Section 8: Storage, access and disposal of data

How and where will the data (both paper and electronic) be stored, what arrangements will be in place to keep it secure and who will have access to it?

Please note that for long-term storage, data should usually be held on a secure University of Birmingham IT system, for example BEAR (see https://intranet.birmingham.ac.uk/it/teams/infrastructure/research/bear/index.aspx).

Data for this study is solely in electronic forms (digital recordings, digital interview summaries). These data are stored on a University of Birmingham encrypted computer and backed up to a University of Birmingham encrypted drive for the duration of the study and for at least ten years. The lead researcher at the University of Birmingham has access to the data. BEAR is used for long-term storage.

Data retention and disposal

The University usually requires data to be held for a minimum of 10 years to allow for verification. Will you retain your data for at least 10 years?

Yes ☒
No ☐

If data will be held for less than 10 years, please provide further justification:

Click or tap here to enter text.

What arrangements will be in place for the secure disposal of data?

The data is deleted from all electronic storage facilities. Any emails held by the research team related to the study are deleted.

Section 9: Other approvals required

Are you aware of any other national or local approvals required to carry out this research?

E.g. clearance from the Disclosure and Barring Service (DBS), Local Authority approval for work involving Social Care, local ethics/governance approvals if the work will be carried out overseas, or approval from NOMS or HMPPS for work involving police or prisons? If so, please provide further details:

No

For projects involving NHS staff, is approval from the Health Research Authority (HRA) needed in addition to University ethics approval?

If your project will involve NHS staff, please go to the HRA decision tool at http://www.hra-decisiontools.org.uk/research/ to establish whether the NHS would consider your project to be research, thus requiring HRA approval in addition to University ethics approval. Is HRA approval required?

Yes ☐
No ☒

Please include a print out of the HRA decision tool outcome with your application.

Section 10: Risks and benefits/significance

Benefits/significance of the research

Outline the potential significance and/or benefits of the research

The insights from the interviews will illuminate the relationship between sustainability assessment methods and creativity and innovation in urban design – addressing an undercurrent of opinion that such assessment methods are barriers for urban design professionals. The named methods are assessed for the presence of characteristics that promote creativity and innovation, with the potential to shape existing and future assessment methods, thereby positively influencing urban design practice.

Risks of the research

Outline any potential risks (including risks to research staff, research participants, other individuals not involved in the research, the environment and/or society and the measures that will be taken to minimise any risks and the procedures to be adopted in the event of mishap.) ***Please ensure that you include any risks relating to overseas travel and working in overseas locations as part of the study, particularly if the work will involve travel to/working in areas considered unsafe and/or subject to travel warnings from the Foreign and Commonwealth Office (see*** https://www.gov.uk/foreign-travel-advice)***. Please also be aware that the University insurer, UMAL, offers access to RiskMonitor Traveller, a service which provides 24/7/365 security advice for all travellers and you are advised to make use of this service (see https://umal.co.uk/travel/pre-travel-advice/).***

The outlining of the risks in this section does not circumvent the need to carry out and document a detailed Health and Safety risk assessment where appropriate – see below.

The following risks exist:

1. **Risk to the safety of the interviewers.**
   Low risk.
   Interviewers travel and interview in pairs, where possible, and always in professional (e.g., offices) and public spaces (e.g., coffee shops), preferably already known to the interviewers. All interviews conducted in the UK. Interviewers are aware of their surroundings at all times and any associated health and safety policies. Interviewers to check in and check out of each interview with a back up person.
2. **Risk of discussing a sensitive topic.**
   Low risk.
   Interviewers offer to stop the interview and can signpost the interviewee to relevant support services.
3. **Whistle-blowing.**
   Low risk.
   Interviewers offer to strike the information and stop the interview. Interviewers remind the interviewee of the study's confidentiality procedures.

University Health & Safety (H&S) risk assessment

For projects of more than minimal H&S risk it is essential that a H&S risk assessment is carried out and signed off in accordance with the process in place within your School/College and you must provide a copy of this with your application. The risk may be non-trivial because of travel to, or working in, a potentially unsafe location, or because of the nature of research that will carried out there. It could also involve (irrespective of location) H&S risks to research participants, or other individuals not involved directly in the research. Further information about the risk assessment process for research can be found at https://intranet.birmingham.ac.uk/hr/wellbeing/worksafe/policy/Research-Risk-Assessment-and-Mitigation-Plans-RAMPs.aspx.

Please note that travel to (or through) 'FCO Red zones' requires approval by the University's Research Travel Approval Panel, and will only be approved in exceptional circumstances where sufficient mitigation of risk can be demonstrated.

Section 11: Any other issues

Does the research raise any ethical issues not dealt with elsewhere in this form?

If yes, please provide further information:

No

Do you wish to provide any other information about this research not already provided, or to seek the opinion of the Ethics Committee on any particular issue?

If yes, please provide further information:

No

Section 12: Peer review

Has your project received scientific peer review?

Yes ☐
No ☒

If yes, please provide further details about the source of the review (e.g. independent peer review as part of the funding process or peer review from supervisors for PGR student projects):

Section 13: Nominate an expert reviewer

For certain types of project, including those of an interventional nature or those involving significant risks, it may be helpful (and you may be asked) to nominate an expert reviewer for your project. If you anticipate that this may apply to your work and you would like to nominate an expert reviewer at this stage, please provide details below.

Title: Click or tap here to enter text.
First name: Click or tap here to enter text.
Last name: Click or tap here to enter text.
Email address: Click or tap here to enter text.
Phone number: Click or tap here to enter text.

Brief explanation of reasons for nominating and/or nominee's suitability:

Section 14: Document checklist

Please check that the following documents, where applicable, are attached to your application:

Recruitment advertisement ☒
Participant information sheet ☒
Consent form ☒
Questionnaire ☒
Interview/focus group topic guide ☐

Please proof-read study documentation and ensure that it is appropriate for the intended audience before submission.

Section 15: Applicant declaration

Please read the statements below and tick the boxes to indicate your agreement:

I submit this application on the basis that the information it contains is confidential and will be used by the University of Birmingham for the purposes of ethical review and monitoring of the

research project described herein, and to satisfy reporting requirements to regulatory bodies. The information will not be used for any other purpose without my prior consent. ☒

The information in this form together with any accompanying information is complete and correct to the best of my knowledge and belief and I take full responsibility for it. ☒

I undertake to abide by University Code of Practice for Research (https://www.birmingham.ac.uk/Documents/university/legal/research.pdf) alongside any other relevant professional bodies' codes of conduct and/or ethical guidelines. ☒

I will report any changes affecting the ethical aspects of the project to the University of Birmingham Research Ethics Officer. ☒

I will report any adverse or unforeseen events which occur to the relevant Ethics Committee via the University of Birmingham Research Ethics Officer. ☒

Please now save your completed form and email a copy to the Research Ethics Officer, at aer-ethics@contacts.bham.ac.uk. As noted above, please do not submit a paper copy.

Recruitment letter

Dear XXXX,

Dr Christopher Boyko and I are leading on an academic paper looking at the relationship between urban design tools and the 'art' or urban design. The focus of the paper is to unpick which aspects of performance-measuring urban design tools (such as BREEAM) encourage innovation and creativity and which aspects hinder it. The paper abstract is below and it has been accepted for a special issue of the academic journal: Urban Design and Planning (see: http://www.icevirtuallibrary.com/content/serial/udap).

Chris and I are very interested in capturing your views on this subject. This would entail us meeting with you to discuss the subject in an interview format.

We do hope this is of interest to you. The paper is due for submission on the 1st of October, so interviewing in August is advisable. Perhaps you can suggest dates that are convenient for you (keeping in mind Chris and I are very happy to meet at your offices in London or anywhere else that suits).

Abstract: The 'art' of urban design: do measures of performance constrain imagination?

Planners, architects and urban designers often become constrained by the myriad of checkboxes, guidelines, requirements and specifications and have to forgo the 'art' of urban

design. Approaches that measure performance belie the nature of places as messy, plural, organic, accidental and emotive; trying to find a formula that works may tick boxes, but it also risks creating soulless spaces, oppressing innovation, and the implementation of inappropriate design elements. This paper argues that such approaches have something to contribute to the art of urban design precisely because they encourage engagement with challenging and often complex societal priorities, such as sustainability, resilience and liveability. Through anecdotal experiences with architects and a critical examination of two urban design tools—the Urban Futures Method and BREEAM Communities—the authors suggest that the 'art' of urban design is not lost; however, more attention needs to be paid to when and how in the process it can flourish.

We look forward to hearing from you and if you would like to discuss this by 'phone please do not hesitate to ring me. I am available this week on 07785 792 187.

Kind regards,
Joanne

Interview confirmation letter

Dear XXX,

I just wanted to confirm that Chris Boyko and I are planning to meet with you [INSERT DAY DATE AND TIME] in [INSERT LOCATION].

Please find below the list of the questions that we would like to ask, bearing in mind that you do not have to have prepared answers ahead of our meeting:

- What does urban design mean to you?
- Is there an 'art' to urban design
- What promotes innovation and creativity in urban design?
- What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?
- Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?
- What is your experience of sustainability assessment methods?
- Do sustainability assessment methods promote or hinder creativity and innovation in urban design?

The questions are not set in stone and may change with the flow of the interview, but we would like to cover certain, overarching themes (e.g., is there an 'art' to urban design, do sustainability assessment methods promote or hinder the 'art' of urban design).

We expect the interview will take up to an hour, but we can reduce the time required if desirable. You are able to stop the interview or withdraw from this study at any time up to two weeks after the interview.

Following the interview, we will send you a summary of the interview for you to approve (and amend as necessary). All information you provide will be confidential and we will take every precaution to ensure you are not identifiable in arising outputs from the study (e.g., reports, papers and presentations).

Please let me know if you have any questions about the above or would like clarification about anything. My contact details can be found in my email signature.

We look forward to seeing you.

Kind regards, Joanne

Interview questions

Interview questions:

Q1
What does urban design mean to you?
- Is there an art to urban design?

Q2
What promotes innovation and creativity in urban design?

Q3
What techniques or methods do you use to encourage innovative and creative urban design both in yourself and others?

Q4
Do you think the trend towards designing sustainable places offers designers an opportunity for creativity and innovation?

Q5
What is your experience of sustainability assessment methods (such as BREEAM, Council sustainability checklists, Balanced Scorecard)?
- Do you use any sustainability assessment methods even if not required to?

Q6
Do sustainability assessment methods promote or hinder creativity and innovation in urban design?
- Specifically which ones... good and bad... and why?

Q7
Are there any urban design assessment methods in addition to those mentioned in this interview that you wish for us to note?

APPENDIX F. UK CITY LIFE$_1$

This appendix contains UK City LIFE$_1$ and the associated Birmingham data, which are presented as the tabs of the Excel spreadsheet. The columns containing information on data sources and data notes (both being primarily hyperlinks) have been removed in the interest of readability.

Notes tab

Notes
Dataset of the livability and sustainability performance of the City of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions
This data file contains the indicators and Birmingham, UK, data for UK City LIFE$_1$.
This data file accompanies the Cities journal article: Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK. Corresponding author: Joanne Leach, University of Birmingham, j.leach@bham.ac.uk, +44 (0)121 414 3544.
Indicators highlighted in light brown (the colour of this cell) are null
All indicators are grouped in two ways, as follows.
The first indicator grouping is by lens framework. For more information about the lens framework see Leach JM, Braithwaite PA, Lee SE, Bouch CJ, Hunt DVL and Rogers CDF (2016). Measuring urban sustainability and liveability performance: the City Analysis Methodology (CAM). International Journal of Complexity in Applied Science and Technology (IJCAST). 1(1): 86-106. The lens framework groupings can be found on the worksheet tab 'Lens Framework', which includes links to each of the indicators.
The second indicator grouping is by theme (demographics, energy, economy, etc.). These groupings are reflected in the tabs of this spreadsheet.
Abbreviations:
ONS - Office for National Statistics, see https://www.ons.gov.uk
UA - Unitary Authority
PUA - primary urban area

Lens framework tab

Lens	Goal	Action	Metric	Indicator
Society	Enhance community and individual wellbeing	Promote healthy living and healthy long lives	Age of usual resident population	Percentage of population that are children (0-14)
				Percentage of population that are youth (15-24)
				Percentage of population that are adult (25-64)
				Percentage of population that are senior citizens (65+)
				Mean age
				Median age
			Physical activity	Percentage of adults (16+) who participate in sport and active recreation for at least 30 minutes on at least 12 days out of the last 4 weeks
			Recreation space	Number of publicly accessible sports halls
				Number of publicly accessible grass pitches in city/area
			Time each week the people have for sleeping	Time/week for sleeping (hours)
			Time each week the people have for leisure	Time/week for leisure (hours)
			Satisfaction with amount of leisure time	Percentage of people who are somewhat, mostly or completely satisfied with the amount of leisure time they have
			Satisfaction with sports provision in local area	Percentage of adults who are satisfied with sports provision in their local area (defined as responding very or fairly satisfied)
			Healthy life expectancy	Healthy life expectancy at birth of the male population
				Healthy life expectancy at birth of the female population
			Life expectancy	Life expectancy at birth of the male population
				Life expectancy at birth of the female population

			Overall health	Percentage of people whose overall health is very good or good
			Satisfaction with health	Percentage of people who are somewhat, mostly or completely satisfied with their health in general
			Long-standing impairment	Percentage of people with a long-standing physical or mental impairment, illness or disability.
			Obese adults	Percentage of adults who are obese
			Obese children	Percentage of children (Year 6) who are obese
			Transportation fatalities	Number of transportation fatalities (fatal road casualties)
			Avoidable mortality	Mortality from deaths considered avoidable (per 100 000 of the population)
				Premature deaths
		Increase the match between city dweller aspirations and wellbeing	Optimism	Percentage of people who feel very or somewhat optimistic about the next 12 months
		Minimise ill-being	Deprivation	Percentage of households not deprived in any dimension
			Homelessness	Number of homeless per 100 000 of the population
			Anxiety	Percentage of people who rated their anxiety yesterday as very low
			Suicide rates	Suicide rate per 100 000 of the population
			Mental health of population	Percentage of people who are mental health service users
				Mental wellbeing of the population
				Percentage of people with some evidence indicating depression or anxiety

		Maximise cultural benefit	Satisfaction with the quality of city/area	Percentage of people who are very or somewhat satisfied with their city/area as a place in which to live
			Levels of volunteering	Percentage of people engaging in volunteering activity more than once in the last year
				Percentage of people engaging in volunteering activity at least once a month in the last year
			Time spent on cultural activities	Percentage of people who have engaged with, or participated in, the arts or cultural activity at least 3 times in the last year
	Ensure equity (fairness)	Ensure an enabling physical environment to maximise individual capabilities in the context of carbon reduction and resource security	Area	City/area land area
			Land use	Percentage area of domestic buildings
				Percentage area of domestic gardens
				Percentage area of non-domestic buildings
				Percentage area of road
				Percentage area of paths
				Percentage area of rail
				Percentage area of greenspace
				Percentage area of water
			Density	Dwelling density
				Usual resident population density
			Vacant dwellings	Percentage of vacant dwelling units
			Jobs/housing ratio	Jobs/housing ratio
			Number of households	Number of households
			Household composition	Percentage of one person households

				Percentage of one family households
				Percentage of households that are neither one person nor one family
			Household size	Average household size
			Occupancy rating of households	Percentage of households with more rooms than required
				Percentage of households with fewer rooms than required
			Tenure of households	Percentage households owned
				Percentage households shared ownership
				Percentage households social rented
				Percentage households private rented
				Percentage households rent free
			Type of accommodation	Percentage accommodation type: whole house or bungalow
				Percentage accommodation type: flat, maisonette or apartment
			Substandard/unfit housing	Percentage of total population/households living in substandard/unfit housing
			Sustainably-classified buildings	Number of BREEAM certified assessments of Good, Very Good, Excellent and Outstanding
			Satisfaction with the quality of accommodation	Percentage of people who are very or fairly satisfied with their accommodation
				Percentage of people who wished they lived in a different house
			Driving	Percentage of households with no car or van

				Average journey times (flow-weighted) during the weekday morning peak on locally managed 'A' roads
			Bicycling	Number of bicycles per capita
			Modal choice	Percentage of people who strongly or somewhat agree that most of the journeys they make by car could also be made on foot, on the bus, train, metro or by cycling
			Kilometres of bicycles paths and lanes	Kilometres of bicycle paths and lanes per 100 000 of the population
			Kilometres of high capacity public transport system	Kilometres of high capacity public transport system per 100 000 of the population
			Kilometres of light passenger public transport system	Kilometres of light passenger public transport system per 100 000 of the population
			Miles of roads	Miles of roads
			Transport access to key services or work	Households with good transport access to key services or work
			Temperature	Annual average temperature
			Rainfall	Average annual rain
			Noise pollution	Noise pollution
			Number of firefighters	Number of firefighters per 100 000 of the population
			Number of police officers	Number of police officers per 100 000 of the population
			Response time for emergency response services from initial call	Response time for emergency response services from initial call
			Number of hospital beds	Average daily available hospital beds per 100 000 of the population
			Number of physicians	Number of physicians per 100 000 of the population
			Number of nurses and midwifes	Number of nursing and midwifery personnel per 100 000 of the population

			Number of mental health practitioners	Number of mental health practitioners per 100 000 of the population
			Perceived quality of public health services	Percentage of people who rate a good or very good the quality of public health services in city/area
			Quality of childcare services	Rating of childcare services in the last independent review
			Satisfaction with the quality of childcare services	Percentage of people who rate as very or fairly satisfactory the quality of state childcare services in city/area
			Quality of services for the elderly	Rating of services for the elderly in the last independent review
			Satisfaction with the quality of services for the elderly	Percentage of people who rate as very or fairly satisfactory the quality of care services for the elderly in city/area
			Student/teacher ratio in primary education	Average primary education student/teacher ratio
			The rating of schools in their last independent review	The rating of schools in their last independent review
				Average amount of time schools spend in special measures
			Quality perception of local education services	Percentage of people who rate as very or fairly good the quality of their local education services
			Happiness at school	Percentage of students who are very or fairly happy about the school that they go to
			Internet and broadband access	Percentage of internet users
				Broadband quality available speed
			Mobile 'phone access	Level of outdoor mobile 'phone coverage

		Ensure an enabling social environment to maximise individual capabilities in the context of carbon reduction and resource security	Gender of usual resident population	Male to female ratio
			Usual resident population	Usual resident population of city/area as a percentage of UK's usual resident population
				Total usual resident population
			Religion of usual resident population	Percentage of population that identify as Christian
				Percentage of population that identify as Muslim (Islam)
				Percentage of population that identify as having no religion
				Percentage of population that identify as having other faiths or unknown
			Ethnic group of usual resident population	Percentage of population whose ethnicity is white
				Percentage of population whose ethnicity is mixed/multiple
				Percentage of population whose ethnicity is Asian or Asian British
				Percentage of population whose ethnicity is Black, African, Caribbean or Black British
				Percentage of population whose ethnicity is none of the above ('other')
			Racial and religious harassment	Percentage of people who feel that racial or religious harassment is a problem in the local area
			Religiously-, ethnically- or racially-motivated crimes	Percentage of religiously-, ethnically-, racially- or other prejudice- motivated (hate) crimes

			Nationality of usual resident population	Percentage of population who are not British nationals
			Sense of belonging	Percentage of people who feel very or fairly strongly that they belong to their neighbourhood
			Life satisfaction	Percentage of people who rate their overall life satisfaction as very high
			Sense of worth	Percentage of people who rate how worthwhile the things they do in their life are as very high
			Happiness	Percentage of people who rated their happiness yesterday as very high
			Notifiable offences recorded by the police per 100 000 of the population	Number of notifiable offences recorded by the police
			Feelings of safety	Percentage of people who feel very or fairly safe in city/area
				Percentage of people who feel that their neighbourhood is safe for children to play outside
			Belief that people in the city/area who are from different backgrounds get on well together	Percentage of people who believe that people in their city/area who are from different backgrounds get on well together
			Feelings of social cohesion	Percentage of people who strongly or somewhat feel close to the people in their local area
				Percentage of people who visit with their neighbours at least once a month
			Social vibrancy	Percentage of people who strongly or somewhat agree that they enjoy meeting up in the city/area.

			Those in city/area who have a partner, family member or friend to rely on if they have a serious problem	Percentage of people who have a partner, family member or friend to rely on if they have a serious problem
			Regularity of face-to-face conversations	Percentage of people who have a face-to-face conversation with a close friend, relative or someone else close to them (apart from your spouse or partner) at least once a week
			Qualifications	Percentage of the population that achieved level 2 as highest level of qualification (includes GCSEs A*-C)
				Percentage of the population that achieved above level 4 as highest level of qualification (above A and AS levels and HNC)
				Percentage of the population aged 16 to 64 with no qualifications
				Percentage of 16 year olds with five or more GCSEs A* to C including English and Mathematics
				Percentage of the population aged 16 to 64 that achieved a qualification at NVQ4 or above
		Ensure an enabling economic environment to maximise individual capabilities in the context of carbon reduction and resource security	Income of households	Gross disposable household income per head
				Average weekly earnings
				Percentage of households with less than 60% of median income after housing costs (low income)
				Median wealth per household, including pension wealth

			Satisfaction of households in city/are with their income	Percentage of people who are somewhat, mostly or completely satisfied with the income of their household
			Key out of work benefits claimed	Percentage of the working age population that is claiming key out of work benefits
			Fuel poverty	Percentage of households in fuel poverty [Low income / high cost definition]
			Satisfaction with overall standard of living	Percentage of people who are completely or somewhat satisfied with their present standard of living
			Satisfaction with financial standard of living	Percentage of people who report finding it quite or very difficult to get by financially
			Housing affordability	Housing affordability ratio
			NS-SES	Percentage of National Statistics Socioeconomic Classification (NS-SES): Higher managerial, administrative and professional occupations
				Percentage of National Statistics Socioeconomic Classification (NS-SES): Lower managerial, administrative and professional occupations
				Percentage of National Statistics Socioeconomic Classification (NS-SES): Intermediate occupations
				Percentage of National Statistics Socioeconomic Classification (NS-SES): Small employers and own account workers
				Percentage of National Statistics Socioeconomic Classification (NS-SES): Lower supervisory and technical occupations

				Percentage of National Statistics Socioeconomic Classification (NS-SES): Semi-routine occupations
				Percentage of National Statistics Socioeconomic Classification (NS-SES): Routine occupations
			Working hours	Average paid hours worked per week
			Full-time and part-time workers	Percentage part-time workers
				Percentage full-time workers
			Job satisfaction	Percentage of the employed population who are somewhat, mostly or completely satisfied with their job
		Ensure an enabling governance environment to maximise individual capabilities in the context of carbon reduction and resource security	Political leanings	Political leanings
			Satisfaction with local authority-provided basic services	Percentage of people who are very or fairly satisfied with the basic services offered by their local authority
			Satisfaction with how the local authority is doing its job	Percentage of people who are very or fairly satisfied with the way their local authority is doing its job
			Perceptions of the local authority's commitment to reducing climate change	Percentage of people who strongly or somewhat agree that the city/area is committed to the fight against climate change
			Level of trust in national government	Percentage of people who have trust in the national Government
			Participation rates in the most recent national election	Voter turnout in most recent national election
Environment	Enhance biodiversity and ecosystem services	Minimise the impact of urban density on biodiversity	Protected areas	Total area of protected areas

				Number of conservation areas per 100 000 of the population
			Quality of parks	Percentage of people who rate as very or quite good the quality of parks within a 5 minute walk of where they live
			Quality of waterways	Percentage of people who rate as very or quite good the quality of waterways within a 5 minute walk of where they live
				Number of major or significant pollution incidents made to water or air
			Ecological status of rivers	Percentage of river length classified as having high or good ecological status
			Quality of green spaces	Percentage of people who rate as very or quite good the quality of green spaces within a 5 minute walk of where they live
			Noise pollution	Noise pollution
			Light emissions	Light emissions
		Maximise cultural services (health benefits, recreation, opportunities for outdoor learning)	Access of to natural environment	Percentage of people who access the natural environment at least once a week / visited public gardens, parks, commons or other green spaces at least once a week
			Proximity to blue and green space	Percentage of the population with easy access to green spaces
			Ease of access to parks	Percentage of people who rate as very or quite good the access to parks within a 5 minute walk of where they live

			Ease of access to waterways	Percentage of people who rate as very or quite good the access to waterways within a 5 minute walk of where they live
			Ease of access to green spaces	Percentage of people who rate as very or quite good the access to green spaces within a 5 minute walk of where they live
			Temperature	Percentage of people living in locations where evening outdoor air temperature is less than 20 degrees C during a moderate heatwave.
			Ecosystem service access	Access of vulnerable groups to ecosystem services (cooling, green spaces and potential biodiversity)
				Percentage of people within 300m of a publically accessible green space that is greater than 2 hectares
				Percentage of residents living in locations with high bee biodiversity potential (where the number of bee species is predicted to be at least 50% of the city maximum).
	Ensure resource efficiency	Increase the match between city dwellers' aspirations and resource efficient living	Appetite for sustainable energy	Percentage of people who strongly or somewhat agree that they want to use more energy that is kinder to the environment
			Appetite for sustainable travel	Percentage of people who strongly or somewhat agree that they want to travel more often in ways that are kinder to the environment
			Appetite for sustainable food	Percentage of people who strongly or somewhat agree that they want to buy more food that is kinder to the environment

			Appetite for sustainable goods	Percentage of people who strongly or somewhat agree that they want to buy more goods that are kinder to the environment
			Difficulty in being more environmentally friendly	Percentage of people who strongly or tend to agree that they find it hard to change their habits to be more environmentally friendly
			Appetite for doing more to help the environment	Percentage of people who want to do more to help the environment
		Minimise energy use and waste (including heat and CO_2 emissions)	Energy saving attributes of households	Average (mean) EPC rating of housing stock: CO_2
				Average (mean) EPC rating of housing stock: energy
			Housing SAP ratings	Mean SAP rating of existing housing
				Mean SAP rating of new housing
			Electrical energy use	Mean electricity consumption: domestic
				Mean electricity consumption: non-domestic
			Energy saving from retrofitting households	Percentage reduction in energy demand through retrofitting loft or roof insulation
				Percentage reduction in energy demand through retrofitting cavity wall insulation
				Percentage reduction in energy demand through retrofitting heating type and controls
				Percentage reduction in energy demand through retrofitting double glazing
				Percentage reduction in energy demand through retrofitting under-floor insulation

			Energy use awareness	Percentage of people who strongly or tend to agree that they don't think about saving energy in their home
			Energy flows	Energy lost as heat
		Increase the match between wellbeing and minimising high-carbon mobilities while maximising low-carbon mobilities and immobilities of people and objects	Driving	Percentage of people who strongly or somewhat agree that driving in city/area is easy
			Bicycling	Percentage of people who strongly or somewhat agree that they are satisfied with the facilities for cycling in and around city/area
				Percentage of people who strongly or somewhat agree that cycling in city/area is easy
			Walking	Percentage of people who strongly or somewhat agree that walking in city/area is easy and safe
				Percentage of people who feel very or fairly safe walking alone in city/area at night
			Accessibility of public transport	Percentage of people who are strongly or somewhat satisfied with the quality and accessibility of public transport in city/area
			Modal choice	Percentage of people who work mainly at or from home
				Percentage of people who travel to work by underground, metro, light rail, tram
				Percentage of people who travel to work by train
				Percentage of people who travel to work by bus, minibus or coach

				Percentage of people who travel to work by taxi
				Percentage of people who travel to work by motorcycle, scooter or moped
				Percentage of people who travel to work by driving a car or van
				Percentage of people who travel to work as a passenger in a car or van
				Percentage of people who travel to work by bicycle
				Percentage of people who travel to work on foot
			Travelling awareness	Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of travelling they undertake
		Minimise potable and non-potable water use and waste (including leakage)	Water flows	Water wasted through distribution losses
			Water demand	Domestic potable water demand
			Water use awareness	Percentage of people to strongly or tend to agree that they don't pay much attention to the amount of water they use at home
		Minimise food use and waste	Food flows	Food waste
			Food consumption awareness	Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of food they use at home
			Food recycling/composting behaviour	Percentage of people who say they recycle/compost food always or most of the time
		Minimise materials use and waste	Material flows	Materials waste

			Materials consumption awareness	Percentage of people to strongly or somewhat agree that they don't pay much attention to the amount of materials they use at home (e.g. paper, plastics, metals, rare earth elements)
		Minimise other waste produced and maximise its reuse, recycling, repurposing	Waste flows	Solid waste entering the city/area from outside the city/area
				Wastewater entering the city/area from outside the city/area
				Solid waste created within the city/area
				Wastewater created by the city/area
				Solid waste exported from the city/area
				Wastewater leaving the city/area
			Waste recycling	Percentage of household waste that is recycled
				Percentage to household waste that goes to landfill
			Waste awareness	Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of waste they produce at home
			Recycling behaviour	Percentage of people who say they recycle always or most of the time
			Air quality management areas	Air quality management area(s) pollutant
				Air quality management area(s) geographic extent
		Increase awareness of, and interest in, environmental and climate change issues	Ecological footprint of city/area	Ecological footprint
				Ecological footprint per capita

			Degree of environmentally friendly behaviour	Percentage of people who are environmentally friendly in most or all of the things they do
			Confidence in reducing carbon footprint	Percentage of people who strongly or somewhat agree that they feel well informed about way in which they can reduce their carbon footprint
			Degree of belief in human-induced climate change	Percentage of people who strongly or somewhat agree that human induced climate change is happening
			Perception of the urgency of change required to prevent climate change	Percentage of people who strongly or tend to agree that the effects of climate change are too far in the future to really worry them
	Ensure resource security	Increase the match between city dwellers' aspirations and resource secure living	Appetite for local energy	Percentage of people who strongly or somewhat agree they want to access locally-produced energy (such as energy from wind farms and solar panels)
			Attitudes to recycling	Percentage of people who strongly or somewhat agree that people have a duty to recycle
			Appetite for sustainable water	Percentage of people to strongly or somewhat agree that they want to use recycled water for some of their water usage (such as rainwater harvesting to flush the toilet)
			Attitudes to recycling/composting food	Percentage of people who strongly or somewhat agree that people have a duty to recycle/compost food
			Appetite for locally-sourced food	Percentage of people who strongly or somewhat agree that they want to buy more local food from local businesses

			Appetite for locally-sourced goods	Percentage of people who strongly or somewhat agree that they want to buy goods containing more local materials from local businesses
			Appetite for alternative means of transport	Percentage of people who strongly or somewhat agree that they want to increase their use of alternative means of transport - including car sharing
		Maximise sustainable use of low-carbon local energy first and then maximise the security of supply of non-local energy	Main heating types of households	Percentage of households without central heating
				Percentage of households with gas as primary central heating
				Percentage of households with electric as primary central heating
				Percentage of households with oil as primary central heating
				Percentage of households with solid fuel as primary central heating
				Percentage of households with 'other' as primary central heating
			Energy flows	Energy entering the city/area from outside the city/area
				Energy generated within the city/area
				Energy exported from the city/area
				Potential electricity generation from rooftop solar PV panels
		Maximise sustainable use of local water first and then maximise the security of supply of non-local water	Water flows	Raw water entering the city/area from outside the city/area (excluding rainfall)

				Raw water stored within the city/area at any one time (maximum reservior capacity)
				Potable water exported from the city/area
		Maximise sustainable use of local food first and then maximise the security of supply of non-local food	Food flows	Food consumed within the city/area
				Food grown within the city/area
				Food exported from the city/area
				Percentage of people who always or often buy their food from supermarkets
				Percentage of people who always or often buy locally-produced food
				Percentage of people who always or often grow their own food
		Maximise the sustainable use of local materials first and then maximise the security of supply of non-local materials	Material flows	Goods imported into the city/area from outside the city/area
				Materials consumed within the city/area
				Goods exported from the city/area
				Percentage of people who buy locally produced goods more than half the time
		Maximise sustainable use of local people first (e.g., utilising the local workforce and leveraging local skills) and then maximise the security of supply of non-local people	Duration of residence	Average (mean) duration of living in city/area
				Median duration of living in city/area
				Mode duration of living in city/area

			Expectation of future residence	Percentage of people who think they are very or quite likely to be living in city/area in 10 years time
			People flows (commuting)	Percentage of commuters who live outside and commute into the city/area
				Percentage of commuters who live in the city/area and commute out of the city/area
				Percentage of commuters who live and work in city/area
			Annual population change	Inwards annual, internal migration
				Outwards annual, internal migration
Economy and finance	Maximise sustainable financial investment	Maximise investment to support liveability objectives (maximising wellbeing, resource security and efficiency, and minimising CO_2 emissions)	Satisfaction with how city/area spends its money	Percentage of people who strongly or somewhat agree that city/area spends its resources in a responsible way
			R&D spend	Expenditure on R&D performed in business [in real terms and in cash terms]
			Environmental R&D spend	Expenditure on R&D related to environmental protection expenditure [in real terms and in cash terms]
			Council spending	Spending for central services to the public per capita
				Spending for cultural and related facilities per capita
				Spending for environmental and regulatory services per capita
				Spending for planning services per capita
				Spending for children's and education services per capita
				Spending for highways and transport services per capita
				Spending for Local Authority housing per capita

				Spending for adult social care per capita
	Ensure economic vitality	Uncouple economic vitality from the CO_2 emissions associated with economic growth	CO_2 emissions	CO_2 emissions per capita
				CO_2 emissions from energy flows
				CO_2 emissions from waste flows
				CO_2 emissions from water flows
				CO_2 emissions from the transport of food consumed within city/area
				CO_2 emissions from materials flows
				CO_2 emissions from personal vehicle flows
			GVA	GVA per capita
				GVA per hour worked
				GVA per filled job
			Number of businesses	Number of businesses per 10,000 of the population
			Business enterprise births and deaths	Business enterprise births
				Business enterprise deaths
				Business churn rate
			Industrial structure	Percentage of agriculture, forestry and fishing services
				Percentage of production services
				Percentage of construction services
				Percentage of motor trades services
				Percentage of wholesale services
				Percentage of retail services
				Percentage of transport and storage (including postal)
				Percentage of accommodation and food services

				Percentage of information and communication services
				Percentage of finance and insurance services
				Percentage of property services
				Percentage of professional, scientific and technical services
				Percentage of business administration and support services
				Percentage of public administration and defence services
				Percentage of education services
				Percentage of health services
				Percentage of arts, entertainment, recreation and other services
				Ratio of expanding to contracting SMEs
			Age of businesses	Enterprises less than 2 years old
				Enterprises 2 to 3 years old
				Enterprises 4 to 9 years old
				Enterprises 10 or more years old
			Employment size	Enterprises employing 0-4 people
				Enterprises employing 5-9 people
				Enterprises employing 10-19 people
				Enterprises employing 20-49 people
				Enterprises employing 50-99 people
				Enterprises employing 100-249 people
				Enterprises employing 250+ people

			Public/private status of businesses	Percentage of publicly-owned business units
				Percentage of privately-owned business units
			Commercial and industrial property vacancies	Commercial and industrial property vacancies
			New patents	Number of new patents per year per 100 000 of the population
			Environmental sector value	Value of environmental goods and services sector
			Employment	Percentage of the working-age population in employment
			Unemployment	Unemployment rate
Governance and policy	Ensure appropriate governance	Uncouple governance structures and timescales from political cycles and 'colour' of governing bodies	Governance model	Governance model (e.g., elected mayor, leader of the council, etc.)
			Government structure	Type of local authority (non-metropolitan district, metropolitan district, Unitary Authority (England), Council Area (Scotland), District Council (N. Ireland), Greater London (and the London Boroughs), Unitary Authority (Wales)
				LEP affiliation
	Ensure appropriate policies	Uncouple policy making and policy timescales from political cycles and 'colour' of governing bodies	Smart city initiative	Presence of a smart city initiative
			Sustainability / green city initiative	Presence of a sustainability / green city initiative
			City networks	Membership in a national or international governance network (e.g., core cities, key cities)?

Demographics tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Indicator units
	Age:			
	Age of usual resident population	Percentage of population that are children (0-14)	Objective	Percentage, persons
		Percentage of population that are youth (15-24)	Objective	Percentage, persons
		Percentage of population that are adult (25-64)	Objective	Percentage, persons
		Percentage of population that are senior citizens (65+)	Objective	Percentage, persons
		Mean age	Objective	Count, years
		Median age	Objective	Count, years
	Gender:			
	Gender of usual resident population	Male to female ratio	Objective	Number of males per 100 females
	Population:			
	Usual resident population	Usual resident population of city/area as a percentage of UK's usual resident population	Objective	Percentage, persons
		Usual resident population density	Objective	Count, persons per hectare
		Total usual resident population	Objective	Count, persons
	Religion and Ethnicity:			
	Religion of usual resident population	Percentage of population that identify as Christian	Objective	Percentage, persons
		Percentage of population that identify as Muslim (Islam)	Objective	Percentage, persons
		Percentage of population that identify as having no religion	Objective	Percentage, persons
		Percentage of population that identify as having other faiths or unknown	Objective	Percentage, persons
	Ethnic group of usual resident population	Percentage of population whose ethnicity is white	Objective	Percentage, persons
		Percentage of population whose ethnicity is mixed/multiple	Objective	Percentage, persons

		Percentage of population whose ethnicity is Asian or Asian British	Objective	Percentage, persons
		Percentage of population whose ethnicity is Black, African, Caribbean or Black British	Objective	Percentage, persons
		Percentage of population whose ethnicity is none of the above ('other')	Objective	Percentage, persons
These data are available from the Citizenship Survey at city scale via a special license: http://discover.ukdataservice.ac.uk/catalogue/?sn=7403&type=Data%20catalogue	Racial and religious harassment	Percentage of people who feel that racial or religious harassment is a problem in the local area		
Data unavailable at the city scale	Religiously-, ethnically- or racially-motivated crimes	Percentage of religiously-, ethnically-, racially- or other prejudice- motivated (hate) crimes		
	Nationality:			
	Nationality of usual resident population	Percentage of population who are not British nationals	Objective	Percentage, persons

Birmingham's demographic data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of population that are children (0-14)	21.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that are youth (15-24)	16.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that are adult (25-64)	49.5	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that are senior citizens (65+)	12.9	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	

Mean age	35.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Median age	32	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Male to female ratio	97	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Usual resident population of city/area as a percentage of UK's usual resident population	1.7	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	% = (city population * 100) / UK population = (1,073,045 * 100) / 63,182,178
Usual resident population density	40.1	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Total usual resident population	1,073,045	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that identify as Christian	46.1	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that identify as Muslim (Islam)	21.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that identify as having no religion	19.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population that identify as having other faiths or unknown	12.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population whose ethnicity is white	57.9	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population	4.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	

whose ethnicity is mixed/multiple								
Percentage of population whose ethnicity is Asian or Asian British	26.6	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population whose ethnicity is Black, African, Caribbean or Black British	8.9	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of population whose ethnicity is none of the above ('other')	2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who feel that racial or religious harassment is a problem in the local area								
Percentage of religiously-, ethnically-, racially- or other prejudice-motivated (hate) crimes								
Percentage of population who are not British nationals	12.12	Birmingham	2011	ONS	Secondary	NA	Public	

Where you live tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Indicator units
	Duration of residence			
More recent data are available from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Sense of belonging	Percentage of people who feel very or fairly strongly that they belong to their neighbourhood	Subjective	Percentage, persons
	Duration of residence	Average (mean) duration of living in city/area	Objective	Count, years
		Median duration of living in city/area	Objective	Count, years
		Mode duration of living in city/area	Objective	Count, years
	Expectation of future residence	Percentage of people who think they are very or quite likely to be living in city/area in 10 years time	Subjective	Percentage, persons
	Urban form			
	Area	City/area land area	Objective	Count, hectares
	Land use	Percentage area of domestic buildings	Objective	Percentage, land area
		Percentage area of domestic gardens	Objective	Percentage, land area
		Percentage area of non-domestic buildings	Objective	Percentage, land area
		Percentage area of road	Objective	Percentage, land area
		Percentage area of paths	Objective	Percentage, land area
		Percentage area of rail	Objective	Percentage, land area
		Percentage area of greenspace	Objective	Percentage, land area
		Percentage area of water	Objective	Percentage, land area
	Density	Dwelling density	Objective	Count, dwellings per hectare
	Vacant dwellings	Percentage of vacant dwelling units	Objective	Percentage, dwelling units
Data unavailable at city scale	Jobs/housing ratio	Jobs/housing ratio		

	Household characteristics			
	Number of households	Number of households	Objective	Count, households
	Household composition	Percentage of one person households	Objective	Percentage, households
		Percentage of one family households	Objective	Percentage, households
		Percentage of households that are neither one person nor one family	Objective	Percentage, households
	Household size	Average household size	Objective	Count, persons
	Occupancy rating of households	Percentage of households with more rooms than required	Objective	Percentage, households
		Percentage of households with fewer rooms than required	Objective	Percentage, households
	Tenure of households	Percentage households owned	Objective	Percentage, households
		Percentage households shared ownership	Objective	Percentage, households
		Percentage households social rented	Objective	Percentage, households
		Percentage households private rented	Objective	Percentage, households
		Percentage households rent free	Objective	Percentage, households
	Housing characteristics			
	Type of accommodation	Percentage accommodation type: whole house or bungalow	Objective	Percentage, accommodation
		Percentage accommodation type: flat, maisonette or apartment	Objective	Percentage, accommodation
Indicator being developed by the Liveable Cities team	Energy saving attributes of households	Average (mean) EPC rating of housing stock: CO_2		
Indicator being developed by the Liveable Cities team		Average (mean) EPC rating of housing stock: energy		
	Main heating types of households	Percentage of households without central heating	Objective	Percentage, households
		Percentage of households with gas as primary central heating	Objective	Percentage, households
		Percentage of households with electric as primary central heating	Objective	Percentage, households

		Percentage of households with oil as primary central heating	Objective	Percentage, households
		Percentage of households with solid fuel as primary central heating	Objective	Percentage, households
		Percentage of households with 'other' as primary central heating	Objective	Percentage, households
	Quality			
	Deprivation	Percentage of households not deprived in any dimension	Objective	Percentage, households
These data are available from the English Housing Survey and require a special license to access at the city level (http://discover.ukdataservice.ac.uk/catalogue/?sn=6923&type=Data%20catalogue)	Substandard/unfit housing	Percentage of total population/households living in substandard/unfit housing		
Data unavailable	Homelessness	Number of homeless per 100 000 of the population		
	Sustainably-classified buildings	Number of BREEAM certified assessments of Good, Very Good, Excellent and Outstanding	Objective	Count, assessments
Data unavailable at city scale	Housing SAP ratings	Mean SAP rating of existing housing		
Data unavailable at city scale		Mean SAP rating of new housing		
These data are available from the Citizenship Survey at city scale only via a special license: http://discover.ukdataservice.ac.uk/catalogue/?sn=7403&type=Data%20catalogue	Satisfaction with the quality of city/area	Percentage of people who are very or somewhat satisfied with their city/area as a place in which to live		
These data are from the English Housing Survey and require a special license to access at the city level (http://discover.ukdataservice.ac.uk/Catalogue/?sn=6923&type=Data%20catalogue)	Satisfaction with the quality of accommodation	Percentage of people who are very or fairly satisfied with their accommodation		
		Percentage of people who wished they lived in a different house	Subjective	Percentage, persons

Birmingham's where you live data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of people who feel very or fairly strongly that they belong to their neighbourhood	49.7	Birmingham Metropolitan District	2008	Data.gov.uk	Secondary	NA	Public	
Average (mean) duration of living in city/area	38.42	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Median duration of living in city/area	36	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Mode duration of living in city/area	55	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who think they are very or quite likely to be living in city/area in 10 years time	73	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
City/area land area	26779	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage area of domestic buildings	8.8	Birmingham	2005	ONS	Secondary	NA	Public	
Percentage area of domestic gardens	29.3	Birmingham	2005	ONS	Secondary	NA	Public	
Percentage area of non-domestic buildings	5.1	Birmingham	2005	ONS	Secondary	NA	Public	
Percentage area of road	12.4	Birmingham	2005	ONS	Secondary	NA	Public	
Percentage area of paths	0.9	Birmingham	2005	ONS	Secondary	NA	Public	

Percentage area of rail	0.8	Birmingham	2005	ONS	Secondary	NA	Public	
Percentage area of greenspace	34.2	Birmingham	2005	ONS	Secondary	NA	Public	
Percentage area of water	1.2	Birmingham	2005	ONS	Secondary	NA	Public	
Dwelling density	15.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of vacant dwelling units	3	Birmingham	2006	ONS	Secondary	NA	Public	
Jobs/housing ratio								
Number of households	410736	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of one person households	31.9	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of one family households	56.6	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of households that are neither one person nor one family	11.4	Birmingham	2011	ONS	Secondary	NA	Public	
Average household size	2.6	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of households with more rooms than required	65.4	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of households with fewer rooms than required	12.4	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage households owned	55.2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage household	1	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	

s shared ownership								
Percentage household s social rented	24.2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage household s private rented	17.9	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage household s rent free	1.7	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage accommodation type: whole house or bungalow	75	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage accommodation type: flat, maisonette or apartment	25	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Average (mean) EPC rating of housing stock: CO_2								
Average (mean) EPC rating of housing stock: energy								
Percentage of household s without central heating	4.1	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of household s with gas as primary central heating	77.6	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of household s with electric as primary central heating	10.2	Birmingham	2011	ONS	Secondary	NA	Public	

Percentage of households with oil as primary central heating	0.1	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of households with solid fuel as primary central heating	0	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of households with 'other' as primary central heating	3.5	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of households not deprived in any dimension	33.6	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of total population /households living in substandard/unfit housing								
Number of homeless per 100 000 of the population								
Number of BREEAM certified assessments of Good, Very Good, Excellent and Outstanding	67	Birmingham	2008 - 2015	BRE	Secondary	NA	Public	
Mean SAP rating of existing housing								
Mean SAP rating of new housing								
Percentage of people who are very or								

somewhat satisfied with their city/area as a place in which to live								
Percentage of people who are very or fairly satisfied with their accommodation								
Percentage of people who wished they lived in a different house	32.8	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Green & blue space tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Access			
	Access of to natural environment	Percentage of people who access the natural environment at least once a week / visited public gardens, parks, commons or other green spaces at least once a week	Objective	Percentage, persons
		Percentage of residents living in locations with high bee biodiversity potential (where the number of bee species is predicted to be at least 50% of the city maximum).	Objective	Percentage, persons
Indicator being developed by the Liveable Cities team	Proximity to blue and green space	Percentage of the population with easy access to green spaces		
	Ease of access to parks	Percentage of people who rate as very or quite good the access to parks within a 5 minute walk of where they live	Subjective	Percentage, persons
	Ease of access to waterways	Percentage of people who rate as very or quite good the access to waterways within a	Subjective	Percentage, persons

		5 minute walk of where they live		
	Ease of access to green spaces	Percentage of people who rate as very or quite good the access to green spaces within a 5 minute walk of where they live	Subjective	Percentage, persons
	Quality			
Data unavailable at city scale	Protected areas	Total area of protected areas		
		Number of conservation areas per 100 000 of the population	Objective	Count, conservation areas
	Quality of parks	Percentage of people who rate as very or quite good the quality of parks within a 5 minute walk of where they live	Subjective	Percentage, persons
	Quality of waterways	Percentage of people who rate as very or quite good the quality of waterways within a 5 minute walk of where they live	Subjective	Percentage, persons
		Number of major or significant pollution incidents made to water or air	Objective	Count, pollution incidents
Data unavailable at city scale	Ecological status of rivers	Percentage of river length classified as having high or good ecological status		
	Quality of green spaces	Percentage of people who rate as very or quite good the quality of green spaces within a 5 minute walk of where they live	Subjective	Percentage, persons

Birmingham's green & blue space data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of people who access the natural environment at least once a week / visited public	66.7	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

gardens, parks, commons or other green spaces at least once a week								
Percentage of residents living in locations with high bee biodiversity potential (where the number of bee species is predicted to be at least 50% of the city maximum).	46.6	Birmingham	2011	Liveable Cities	Secondary	Using data collected by Bates *et al*. (2011) (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0023459) a Generalized Linear Model (GLM) was created which predicted bee species richness as a function of broad vegetation and tree cover within 100m of the survey sites.	Forthcoming, academic paper in review	
Percentage of the population with easy access to green spaces				Liveable Cities				
Percentage of people who rate as very or quite good the access to parks within a 5 minute walk of where they live	70.9	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who rate as very or quite good the access to waterways	37.5	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

within a 5 minute walk of where they live								
Percentage of people who rate as very or quite good the access to green spaces within a 5 minute walk of where they live	60.5	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Total area of protected areas								
Number of conservation areas per 100 000 of the population	2.8	Birmingham	2013	Birmingham City Council	Secondary	NA	Public	
Percentage of people who rate as very or quite good the quality of parks within a 5 minute walk of where they live	35.4	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who rate as very or quite good the quality of waterways within a 5 minute walk of where they live	25	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Number of major or significant pollution incidents made to water or air	23	Birmingham	1 January - 17 September 2015	Environment Agency	Secondary	NA	Public	

Percentage of river length classified as having high or good ecological status								
Percentage of people who rate as very or quite good the quality of green spaces within a 5 minute walk of where they live	33.3	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Energy tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Energy flows			
	Energy flows	Energy entering the city/area from outside the city/area	Objective	Count, Mtoe/year
		Energy generated within the city/area	Objective	Count, Mtoe/year
		Energy exported from the city/area	Objective	Count, ktoe/year
		Energy lost as heat		
Indicator being developed by the Liveable Cities team		Potential electricity generation from rooftop solar PV panels		
	Electrical energy use	Mean electricity consumption: domestic	Objective	Count, KWh
		Mean electricity consumption: non-domestic	Objective	Count, KWh
	Energy saving			
Indicator being developed by the Liveable Cities team	Energy saving from retrofitting households	Percentage reduction in energy demand through retrofitting loft or roof insulation		
Indicator being developed by the Liveable Cities team		Percentage reduction in energy demand through retrofitting cavity wall insulation		

Indicator being developed by the Liveable Cities team		Percentage reduction in energy demand through retrofitting heating type and controls		
Indicator being developed by the Liveable Cities team		Percentage reduction in energy demand through retrofitting double glazing		
Indicator being developed by the Liveable Cities team		Percentage reduction in energy demand through retrofitting under-floor insulation		
	Energy use awareness	Percentage of people who strongly or tend to agree that they don't think about saving energy in their home	Subjective	Percentage, persons
Data unavailable	Appetite for sustainable energy	Percentage of people who strongly or somewhat agree that they want to use more energy that is kinder to the environment		
Data unavailable	Appetite for local energy	Percentage of people who strongly or somewhat agree they want to access locally-produced energy (such as energy from wind farms and solar panels)		

Birmingham's energy data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Energy entering the city/area from outside the city/area	1.65	Birmingham	2011	Gov.uk	Secondary	NA	Public	Energy entering the city and energy consumption by the city are assumed to be equal.
Energy generated within the city/area	0.044	Birmingham	Various : 2012-2016	See 'calculation' cell	Secondary	NA	Public	217 GWh/year - Energy from Waste in Tyseley. Veolia Environmental Services. Annual performan

								ce report for VESB Tyseley ERF. Permit No. WP3239SJ Year 2012. http://tinyurl.com/pvpajgg. 1 ktoe = 11.63 GWh (see http://www.iea.org/statistics/resources/unitconverter/); 217 GWh = 18.66 ktoe. + 18.83 GWh/year - Solar PV. 2015. Renewable electricity generation: (MWh) at Local Authority Level + 46.78 GWh/year - Sewage gas. 2015. Renewable electricity generation: (MWh) at Local Authority Level + 4.91 GWh/year - Anaerobic Digestion. 2015. Renewable electricity generation: (MWh) at Local Authority Level + 218.79 GWh/year - CHP (at large heat load sites in Birmingha

								m). 2016. = 506 GWh/year = 0.044 Mtoe/year
Energy exported from the city/area	0	Birmingham						It is assumed that the energy that the city generates + energy it demands from external sources is fully used within the city.
Energy lost as heat								
Potential electricity generation from rooftop solar PV panels								
Mean electricity consumption: domestic	3982	Birmingham	2011	Gov.uk	Secondary	NA	Public	
Mean electricity consumption: non-domestic	75779	Birmingham	2011	Gov.uk	Secondary	NA	Public	
Percentage reduction in energy demand through retrofitting loft or roof insulation								
Percentage reduction in energy demand through retrofitting cavity wall insulation								
Percentage reduction in energy demand through retrofitting heating								

type and controls								
Percentage reduction in energy demand through retrofitting double glazing								
Percentage reduction in energy demand through retrofitting under-floor insulation								
Percentage of people who strongly or tend to agree that they don't think about saving energy in their home	20.9	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who strongly or somewhat agree that they want to use more energy that is kinder to the environment								
Percentage of people who strongly or somewhat agree they want to access locally-produced energy (such as energy from wind								

farms and solar panels)								

Waste tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Waste flows			
	Waste flows	Solid waste entering the city/area from outside the city/area	Objective	Count, kt/year
		Wastewater entering the city/area from outside the city/area	Objective	Count, Mt/year
		Solid waste created within the city/area	Objective	Count, Mt/year
		Wastewater created by the city/area	Objective	Count, Ml/year
Data unavailable		Solid waste exported from the city/area		
		Wastewater leaving the city/area	Objective	Count, Mt/year
	Repurposing, reusing and recycling			
	Waste recycling	Percentage of household waste that is recycled	Objective	Percentage, household waste
		Percentage to household waste that goes to landfill	Objective	Percentage, household waste
Data unavailable	Waste awareness	Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of waste they produce at home		
Data unavailable	Recycling behaviour	Percentage of people who say they recycle always or most of the time		
	Attitudes to recycling	Percentage of people who strongly or somewhat agree that people have a duty to recycle	Subjective	Percentage, persons

Birmingham's waste data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Solid waste entering the city/area from outside the city/area	0	Birmingham						Waste flows into the city are likely to be very small given that there is no active landfill site within the city. Some waste processors may import waste for their operations, but these figures are unknown.
Wastewater entering the city/area from outside the city/area	103.5	Birmingham	Undisclosed	Severn Trent Water	Secondary	NA	Public	The total volume of sewage collected by STW for 2011/12 was estimated to be 544,406.42 Ml/yr for the whole region (7,496,800 customers). Using these data, the per capita amount of sewage collected equates to 0.07 Ml/yr. The amount of sewage treated at Minworth is 182,500 Ml/yr (year not known). This site processes sewage from Birmingha

								m as well as parts of the Black Country (Sandwell, Dudley, Walsall, Wolverhampton) and Solihull which covers a population of 1.7 million. In addition, sewage sludge from smaller sites is brought in by tanker to be treated. In total the sewage from 2.5 million people is treated. Using the company per capita value and the city's population, the amount of sewage from Birmingham only is estimated to be 77,992 Ml/yr. An additional 45,459 Ml/yr comes from parts of the Black Country and Solihull with further sludge from 0.8 million people outside Birmingham, providing

								a total of 58,095 Ml/yr. In total, 103, 554 Ml/yr of sewage sludge is supplied from outside the city. Converted to Mt/year by dividing by 1000. The total amount of all sewage is 181,546 Ml/yr. The difference of 954 Ml/yr between this figure and the amount recorded at Minworth could be due to yearly differences, or wastewater from other sources e.g. leakage or rainfall within the city boundaries.
Solid waste created within the city/area	3.2	Birmingham	2008	Birmingham City Council	Secondary	NA	Public	
Wastewater created by the city/area	77992	Birmingham	Data not available	Minworth	Secondary	NA	Public	Total volume of sewage collected for Minworth (544406Ml/Year) / number of Minworth customer (7496800) * Birmingham population (1.074M)

Solid waste exported from the city/area								
Wastewater leaving the city/area	0	Birmingham						
Percentage of household waste that is recycled	29.5	Birmingham	2011/12	Gov.uk	Secondary		Public	
Percentage to household waste that goes to landfill	4.9	Birmingham	2011/12	Gov.uk	Secondary		Public	
Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of waste they produce at home								
Percentage of people who say they recycle always or most of the time								
Percentage of people who strongly or somewhat agree that people have a duty to recycle	81.3	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Water tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Water flows			
	Water flows	Raw water entering the city/area from outside the city/area (excluding rainfall)	Objective	Count, Mt/year
		Raw water stored within the city/area at any one time (maximum reservior capacity)	Objective	Count, Mt
		Potable water exported from the city/area	Objective	Count, Mt/year
		Water wasted through distribution losses	Objective	Count, Mt/year
	Water demand	Domestic potable water demand	Objective	Count, Litres/person/day
	Water saving and recycling			
	Water use awareness	Percentage of people to strongly or tend to agree that they don't pay much attention to the amount of water they use at home	Subjective	Percentage, persons
Data unavailable	Appetite for sustainable water	Percentage of people to strongly or somewhat agree that they want to use recycled water for some of their water usage (such as rainwater harvesting to flush the toilet)		

Birmingham's water data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Raw water entering the city/area from outside the city/area	120.4	Birmingham	2009/10	Severn Trent Water	Secondary	NA	Public	Water available for use = 329.9Ml/day. Converted to Mt/year using *365

(excluding rainfall)								(days per year) /1000 (converting litres to tonnes).
Raw water stored within the city/area at any one time (maximum reservior capacity)	3.3	Birmingham	2016	Severn Trent Water	Secondary	NA	Public	0.9 Mt of water are stored in Frankley reservoir + 2.4 Mt in Bartley Reservoir
Potable water exported from the city/area	2.24	Birmingham	2009/10	Severn Trent Water	Secondary	NA	Public	Water is exported to the Severn Zone at Norton (2.2 Mt/yr) + to South Staffordshire Water (0.04 Mt/yr)
Water wasted through distribution losses	23.6	Birmingham	2011/12	Severn Trent Water	Secondary	NA	Public	
Domestic potable water demand	142	Birmingham	2006/7	Severn Trent Water	Secondary	NA	Public	The value often given for Birmingham is 164 l/p/d, arising from Severn Trent Water's (STW) calculation for the Birmingham zone: 164.47 Ml/d (2006/7 data) consumed by households in the Birmingham zone (from the Severn Trent Management Plan 2010: http://s3-eu-west-1.amazonaws.com/m

								edia.aws.stwater.co.uk/upload/pdf/Final_WRMP_2010.pdf). This figure comes from the total of measured (i.e. metered) and unmeasured water for the Birmingham zone 2006/07 = 23.61 + 140.86 = 164.47 Ml/d (see Figure 8.8). Dividing this by 1 million people (the population of Birmingham) returns 164.47 l/p/d, but this was not entirely correct. The population of the Birmingham zone (according to STW for this area) is 1,156,200 (slightly more than Birmingham's actual population). To convert to l/d for the population of 1.156 million gives 142 l/p/d (not 164 l/p/d). This assumes that the whole of

								the Birmingham population is in a household (this is not strictly true because of old people's homes, hostels the homeless, etc.) so even this figure is slightly inaccurate. The general consensus is that average per capita consumption is not very informative as it can vary greatly across any given geography.
Percentage of people to strongly or tend to agree that they don't pay much attention to the amount of water they use at home	33.4	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people to strongly or somewhat agree that they want to use recycled water for some of their water usage (such as rainwater harvesting								

to flush the toilet)								

Food tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Food flows			
	Food flows	Food consumed within the city/area	Objective	Count, kt/year
		Food grown within the city/area	Objective	Count, kt/year
Data unavailable		Food exported from the city/area		
		Food waste	Objective	Count, kt/year
	Food saving and recycling			
Data unavailable	Food consumption awareness	Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of food they use at home		
Data unavailable	Food recycling/composting behaviour	Percentage of people who say they recycle/compost food always or most of the time		
Data unavailable	Attitudes to recycling/composting food	Percentage of people who strongly or somewhat agree that people have a duty to recycle/compost food		
Data unavailable	Appetite for sustainable food	Percentage of people who strongly or somewhat agree that they want to buy more food that is kinder to the environment		
	Appetite for locally-sourced food	Percentage of people who strongly or somewhat agree that they want to buy more local food from local businesses	Subjective	Percentage, persons
	Food flows	Percentage of people who always or often buy their food from supermarkets	Objective	Percentage, persons

		Percentage of people who always or often buy locally-produced food	Objective	Percentage, persons
		Percentage of people who always or often grow their own food	Objective	Percentage, persons

Birmingham's food data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Food consumed within the city/area	685	Birmingham	2013	Gov.uk	Secondary	NA	Public	Assuming a Birmingham citizen consumes similar amounts to a West Midlands citizen, it can be estimated that Birmingham citizens buy 402 kt of food and 283 Ml (283 kt) of drink (excluding water) per year, giving a total of 685 kt of food and drink.
Food grown within the city/area	0.0075	Birmingham	2013	Gov.uk	Secondary	NA	Public	Defra estimates that 3.5% of all fresh fruit and vegetables came from free sources, namely gardens and allotments .
Food exported from the city/area								
Food waste	139	Birmingham	2013-2014	Birmingham City Council	Secondary	NA	Public	38% of 366 kt (amount collected

				and Gov.uk				and not recycled) (292KT (household) + 74kt (not household))
Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of food they use at home								
Percentage of people who say they recycle/compost food always or most of the time								
Percentage of people who strongly or somewhat agree that people have a duty to recycle/compost food								
Percentage of people who strongly or somewhat agree that they want to buy more food that is kinder to the environment								
Percentage of people who	85.4	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

strongly or somewhat agree that they want to buy more local food from local businesses								
Percentage of people who always or often buy their food from supermarkets	81.2	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who always or often buy locally-produced food	31.9	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who always or often grow their own food	12.5	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Materials tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Materials flows			
	Material flows	Goods imported into the city/area from outside the city/area	Objective	Count, kt/year
		Materials consumed within the city/area	Objective	Count, Mt/year
		Goods exported from the city/area	Objective	Count, kt/year
		Materials waste	Objective	Count, Mt/year
	Material saving and recycling			
Data unavailable	Materials consumption awareness	Percentage of people to strongly or somewhat agree that they don't pay much attention to the amount of materials they use at home (e.g.		

		paper, plastics, metals, rare earth elements)		
Data unavailable	Appetite for sustainable goods	Percentage of people who strongly or somewhat agree that they want to buy more goods that are kinder to the environment		
Data unavailable	Appetite for locally-sourced goods	Percentage of people who strongly or somewhat agree that they want to buy goods containing more local materials from local businesses		
Data unavailable	Material flows	Percentage of people who buy locally produced goods more than half the time		

Birmingham's materials data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Goods imported into the city/area from outside the city/area	29,857	Birmingham	2010-2011	DfT	Secondary	NA	Public	This is calculated by downscaling based upon population. Goods coming into Birmingham by road from the rest of the UK = 1.1/5.6 * 68 (where 68=152-84) = 13.36 million tonnes. Goods within the West Midlands estimated as going to Birmingham (based on

								population) = 1.1/5.6*84 = 16.5 Mt. Total UK Imports to Birmingham = 13.36+16.5=29.86 Mt.
Materials consumed within the city/area	9.88	Birmingham	2011	Eurostat	Secondary	NA	Public	Pop of UK = 63.3 MILLION Pop of WM = 5.6 MILLION Pop of Brum = 1.1 MILLION For WM divide by 11.285 For Brum divide by 58.9
Goods exported from the city/area	26,620	Birmingham	2011	Eurostat	Secondary	NA	Public	65 Mt exports from WM to rest of UK (2010). Goods going out of Birmingham by road to the rest of the UK = 1.1/5.6 * 65 (where 65=149-84) = 12.77 million tonnes. Goods within the West Midlands estimated as coming from Birmingham (based on population) = 1.1/2.7*34 = 13.85 Mt. Total UK Exports from Birmingham = 12.77+13.85=26.62 Mt. Note

								Former West Midlands Metropolitan County population = 2711900 (2010).
Materials waste	3.2	Birmingham	2008	Birmingham City Council	Secondary	NA	Public	Municipal waste management arisings 2010/11 (0.509) + Commercial and Industrial wastes 2008 (0.923) + Construction, Demolitiion and Excavation waste (1.704)
Percentage of people to strongly or somewhat agree that they don't pay much attention to the amount of materials they use at home (e.g. paper, plastics, metals, rare earth elements)								
Percentage of people who strongly or somewhat agree that they want to buy more goods that are kinder to the environment								

Percentage of people who strongly or somewhat agree that they want to buy goods containing more local materials from local businesses								
Percentage of people who buy locally produced goods more than half the time								

Emissions tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	CO_2 emissions			
	CO_2 emissions	CO_2 emissions per capita	Objective	Count, tonnes
		CO_2 emissions from energy flows	Objective	Count, ktCO_2 per year
Data unavailable		CO_2 emissions from waste flows		
		CO_2 emissions from water flows	Objective	Count, ktCO_2e per year
		CO_2 emissions from the transport of food consumed within city/area	Objective	Count, ktCO_2 per year
		CO_2 emissions from materials flows	Objective	Count, ktCO_2 per year
		CO_2 emissions from personal vehicle flows	Objective	Count, ktCO_2 per year
	Air quality			
	Air quality management areas	Air quality management area(s) pollutant	Objective	Pollutant
		Air quality management area(s) geographic extent	Objective	Geographic extent/area

Birmingham's emissions data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
CO_2 emissions per capita	5.1	Birmingham	2011	Gov.uk	Secondary	NA	Public	
CO_2 emissions from energy flows	5504.8	Birmingham	2011	DECC	Secondary	NA	Public	
CO_2 emissions from waste flows								
CO_2 emissions from water flows	66	Birmingham	1 April 2011 - 31 March 2012	Severn Trent Water	Secondary	NA	Public	
CO_2 emissions from the transport of food consumed within city/area	620	Birmingham	2012	Gov.uk	Secondary	NA	Public	
CO_2 emissions from materials flows	2400	Birmingham	2012	DECC	Secondary	NA	Public	
CO_2 emissions from personal vehicle flows	995	Birmingham	2012	DECC	Secondary	NA	Public	First,calculate the percentage of personal fuel consumption of total fuel consumption. Total personal fuel consumption = 278.9 kt fuel; total freight fuel consumption: 96.6 kt fuel. Percentage freight of total fuel consumption =96.6/375.5 =

								25.72%. Percentage personal of total fuel consumption =278.9/375.5 = 74.28%. From Local CO_2 emission estimates full dataset (2012) data C02 emissions from road transport only (excluding rail & other transport) = 375.4+192.3+772.5= 1340.2 $ktCO_2$ Assumed the percentage of CO_2 emissions from personal transport is the same percentage as of fuel consumption. Therefore, 74.28% * 1340.2 $ktCO_2$ = 995.47 $ktCO_2$
Air quality management area(s) pollutant	NO2	Birmingham	2007	ONS	Secondary	NA	Public	
Air quality management area(s) geographic extent	Whole city	Birmingham	2007	ONS	Secondary	NA	Public	

Mobilities & transport tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Access			
	Driving	Percentage of households with no car or van	Objective	Percentage, households
		Average journey times (flow-weighted) during the weekday morning peak on locally managed 'A' roads	Objective	Minutes per mile
Data unavailable		Percentage of people who strongly or somewhat agree that driving in city/area is easy		
Data unavailable	Bicycling	Number of bicycles per capita		
		Percentage of people who strongly or somewhat agree that they are satisfied with the facilities for cycling in and around city/area	Subjective	Percentage, persons
Data unavailable		Percentage of people who strongly or somewhat agree that cycling in city/area is easy		
	Walking	Percentage of people who strongly or somewhat agree that walking in city/area is easy and safe	Subjective	Percentage, persons
		Percentage of people who feel very or fairly safe walking alone in city/area at night	Subjective	Percentage, persons
	Accessibility of public transport	Percentage of people who are strongly or somewhat satisfied with the quality and accessibility of public transport in city/area	Subjective	Percentage, persons
	Modal choice			
	Appetite for alternative means of transport	Percentage of people who strongly or somewhat agree that they want to increase their use of alternative means of transport - including car sharing	Subjective	Percentage, persons
	Modal choice	Percentage of people who strongly or somewhat agree that most of the journeys they make by car could also be made on	Subjective	Percentage, persons

		foot, on the bus, train, metro or by cycling		
		Percentage of people who work mainly at or from home	Objective	Percentage, persons
		Percentage of people who travel to work by underground, metro, light rail, tram	Objective	Percentage, persons
		Percentage of people who travel to work by train	Objective	Percentage, persons
		Percentage of people who travel to work by bus, minibus or coach	Objective	Percentage, persons
		Percentage of people who travel to work by taxi	Objective	Percentage, persons
		Percentage of people who travel to work by motorcycle, scooter or moped	Objective	Percentage, persons
		Percentage of people who travel to work by driving a car or van	Objective	Percentage, persons
		Percentage of people who travel to work as a passenger in a car or van	Objective	Percentage, persons
		Percentage of people who travel to work by bicycle	Objective	Percentage, persons
		Percentage of people who travel to work on foot	Objective	Percentage, persons
	Form			
Data unavailable	Kilometres of bicycles paths and lanes	Kilometres of bicycle paths and lanes per 100 000 of the population		
Data unavailable	Kilometres of high capacity public transport system	Kilometres of high capacity public transport system per 100 000 of the population		
Data unavailable	Kilometres of light passenger public transport system	Kilometres of light passenger public transport system per 100 000 of the population		
	Miles of roads	Miles of roads	Objective	Count, miles
	Transport access to key services or work	Households with good transport access to key services or work	Objective	Index, England 2011 = 100
	People flows (commuting)			
	People flows (commuting)	Percentage of commuters who live outside and commute into the city/area	Objective	Percentage, persons

		Percentage of commuters who live in the city/area and commute out of the city/area	Objective	Percentage, persons
		Percentage of commuters who live and work in city/area	Objective	Percentage, persons
	Annual population change	Inwards annual, internal migration	Objective	Count, persons
		Outwards annual, internal migration	Objective	Count, persons
	Reducing carbon-intensive mobilities and transport			
Data unavailable	Travelling awareness	Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of travelling they undertake		
Data unavailable	Appetite for sustainable travel	Percentage of people who strongly or somewhat agree that they want to travel more often in ways that are kinder to the environment		

Birmingham's mobilities & transport data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of households with no car or van	35.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Average journey times (flow-weighted) during the weekday morning peak on locally managed 'A' roads	3.21	Birmingham	2011/12	ONS	Secondary	NA	Public	
Percentage of people who strongly or somewhat agree that driving in								

city/area is easy								
Number of bicycles per capita								
Percentage of people who strongly or somewhat agree that they are satisfied with the facilities for cycling in and around city/area	52.1	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who strongly or somewhat agree that cycling in city/area is easy								
Percentage of people who strongly or somewhat agree that walking in city/area is easy and safe	54.3	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who feel very or fairly safe walking alone in city/area at night	45.2	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who are strongly or somewhat satisfied with the quality and accessibility of public transport in city/area	62.5	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Percentage of people who strongly or somewhat agree that they want to increase their use of alternative means of transport - including car sharing	62.5	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who strongly or somewhat agree that most of the journeys they make by car could also be made on foot, on the bus, train, metro or by cycling	58.3	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who work mainly at or from home	4.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work by underground, metro, light rail, tram	0.2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work by train	2.5	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work by bus, minibus or coach	9.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	

Percentage of people who travel to work by taxi	0.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work by motorcycle, scooter or moped	0.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work by driving a car or van	29.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work as a passenger in a car or van	2.9	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work by bicycle	0.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who travel to work on foot	5.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Kilometres of bicycle paths and lanes per 100 000 of the population								
Kilometres of high capacity public transport system per 100 000 of the population								
Kilometres of light passenger public transport system per 100 000 of								

the population								
Miles of roads	1570	Birmingham	2011	Gov.uk	Secondary	NA	Public	
Households with good transport access to key services or work	126	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of commuters who live outside and commute into the city/area	33	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of commuters who live in the city/area and commute out of the city/area	14	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of commuters who live and work in city/area	53	Birmingham	2011	ONS	Secondary	NA	Public	
Inwards annual, internal migration	42,338	Birmingham	Year ending June 2012	ONS	Secondary	NA	Public	
Outwards annual, internal migration	45,499	Birmingham	Year ending June 2012	ONS	Secondary	NA	Public	
Percentage of people who strongly or somewhat agree that they don't pay much attention to the amount of travelling they undertake								

Percentage of people who strongly or somewhat agree that they want to travel more often in ways that are kinder to the environment								

Life satisfaction tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Life			
	Life satisfaction	Percentage of people who rate their overall life satisfaction as very high	Subjective	Percentage, persons
	Worth			
	Sense of worth	Percentage of people who rate how worthwhile the things they do in their life are as very high	Subjective	Percentage, persons
	Happiness			
	Happiness	Percentage of people who rated their happiness yesterday as very high	Subjective	Percentage, persons
	Anxiety			
	Anxiety	Percentage of people who rated their anxiety yesterday as very low	Subjective	Percentage, persons
	Optimism			
	Optimism	Percentage of people who feel very optimistic about the next 12 months	Subjective	Percentage, persons

Birmingham's life satisfaction data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of people who rate their	21.98	Birmingham	2014	ONS	Secondary	NA	Public	

overall life satisfaction as very high								
Percentage of people who rate how worthwhile the things they do in their life are as very high	26.30	Birmingham	2014	ONS	Secondary	NA	Public	
Percentage of people who rated their happiness yesterday as very high	29.59	Birmingham	2014	ONS	Secondary	NA	Public	
Percentage of people who rated their anxiety yesterday as very low	38.35	Birmingham	2014	ONS	Secondary	NA	Public	
Percentage of people who feel very optimistic about the next 12 months	21.20	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Environmental & climate change tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Impacts			
	Ecological footprint of city/area	Ecological footprint	Objective	Number, planets (Earth) needed to support consumption rate
		Ecological footprint per capita	Objective	Global hectares (gha)

	Characteristics			
	Temperature	Annual average temperature	Objective	Count, degrees Celsius
		Percentage of people living in locations where evening outdoor air temperature is less than 20 degrees C during a moderate heatwave.	Objective	Percentage, persons
	Rainfall	Average annual rain	Objective	Percentage of the 1971 to 2000 average rainfall
Indicator being developed by the Liveable Cities team	Ecosystem service access	Access of vulnerable groups to ecosystem services (cooling, green spaces and potential biodiversity)		
		Percentage of people within 300m of a publically accessible green space that is greater than 2 hectares	Objective	Percentage, persons
Data for this indicator are not included due to the difficulty in obtaining them. Defra noise maps are one possible source of data, but the data are separated by noise source. The data are geocoded by noise source. See noisemapping.defra.gov.uk	Noise pollution	Noise pollution		
Indicator being developed by the Liveable Cities team	Light emissions	Light emissions		
	Behaviour			
	Difficulty in being more environmentally friendly	Percentage of people who strongly or tend to agree that they find it hard to change their habits to be more environmentally friendly	Subjective	Percentage, persons
Data unavailable	Appetite for doing more to help the environment	Percentage of people who want to do more to help the environment		
Data unavailable	Degree of environmentally friendly behaviour	Percentage of people who are environmentally friendly in most or all of the things they do		

Data unavailable	Confidence in reducing carbon footprint	Percentage of people who strongly or somewhat agree that they feel well informed about way in which they can reduce their carbon footprint		
	Beliefs about climate and environmental change			
Data unavailable	Degree of belief in human-induced climate change	Percentage of people who strongly or somewhat agree that human induced climate change is happening		
	Perception of the urgency of change required to prevent climate change	Percentage of people who strongly or tend to agree that the effects of climate change are too far in the future to really worry them	Subjective	Percentage, persons

Birmingham's environmental & climate change data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Ecological footprint	2.9	Birmingham	2007	WWF	Secondary	NA	Public	
Ecological footprint per capita	5.22	Birmingham	2007	WWF	Secondary	NA	Public	
Annual average temperatu re	10.6	Midlands	2014	Met Office	Secondary	NA	Public	
Percentag e of people living in locations where evening outdoor air temperatu re is less than 20 degrees C during a moderate heatwave.	51.2	Birmingham	2013	Liveable Cities	Secondary	A model to estimate spatial air temperatu re variation as a function of vegetation cover was developed for this analysis.	Private	The model used temperatu re data for Birmingha m at 10pm on the 23rd July 2013. This date was chosen because during this period the UK was experienci ng anticycloni c and hot conditions,

								with a wind speed of just 1km/hour over Birmingham. Maximum daytime temperature was 26 degrees centigrade, so whilst not representing a particularly extreme event, it was a day where impacts of heat on wellbeing would have been expected. We chose to use data from 10pm as this is a time we would expect the majority of residents to be at home, and because the UHI effect is typically greatest at night. Air temperature data were obtained from a network of 37 sensors, managed by the Birmingham Urban Climate Laboratory. This was then modelled against a variety of land-cover datasets.

								The best model was found to be the percentage of vegetation cover within 100m of the sensor. This model was therefore applied to a GIS vegetation layer to generate a 100m resolution raster of predicted air temperature across the entire city at 10pm. This raster was then intersected with resident address point layer that had been attributed with 2011 census data. This allowed a conservative estimation of the number of people living in locations with high evening air temperatures during heatwaves. Choosing a threshold for measuring temperature impacts on wellbeing is challenging, as this

								varies with humidity, and between individuals in terms of psychological, physiological and behavioural responses. We therefore selected an arbitrary threshold value of 20oC. This indicator could be further developed to include averaged models for air temperature under the range of climatic conditions experienced within a particular summer.
Average annual rain	74	Severn Trent	2011	ONS	Secondary	NA	Public	
Access of vulnerable groups to ecosystem services (cooling, green spaces and potential biodiversity)								
Percentage of people within 300m of a publically accessible green space that is greater than 2 hectares	50	Birmingham	2011	Liveable Cities	Secondary	Spatial model	Private	Location were identified that are no more than 300m away from public open spaces > 2 ha in size, which are dominated by vegetation

								or open water. This metric was developed from the Accessible Natural Greenspace Standards (ANGST) promoted by Natural England, the government's advisor on the natural environment. Accessible greenspaces were identified using digital maps supplied by Birmingham City Council (BCC) and EcoRecord (the biological record centre for Birmingham and the Black Country). Their boundaries were expanded by 300m within a Geographical Information System (GIS), which were then intersected with resident address point layer that had been attributed with 2011 census data. This

								allowed the estimation of the number of people living in locations within 300m of a public green space. It should be noted that whilst these green spaces are technically accessible to the public, more subtle definitions of accessibility include factors such as perceptions of safety and path quality. In addition, it is clear that linear distance to a green space is in some cases a poor indicator of the distance that must be walked to a park entrance. This indicator would therefore benefit from development to take advantage of path network data, allowing the measurement of walking

								routes from residential locations to park entrances.
Noise pollution								
Light emissions								
Percentage of people who strongly or tend to agree that they find it hard to change their habits to be more environmentally friendly	14.6	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who want to do more to help the environment								
Percentage of people who are environmentally friendly in most or all of the things they do								
Percentage of people who strongly or somewhat agree that they feel well informed about way in which they can reduce their carbon footprint								

Percentage of people who strongly or somewhat agree that human induced climate change is happening								
Percentage of people who strongly or tend to agree that the effects of climate change are too far in the future to really worry them	4.2	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Crime & safety tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Crime			
	Notifiable offences recorded by the police per 100 000 of the population	Number of notifiable offences recorded by the police	Objective	Count, notifiable offences
	Emergency services			
Data unavailable at city scale	Number of firefighters	Number of firefighters per 100 000 of the population		
Data unavailable at city scale	Number of police officers	Number of police officers per 100 000 of the population		
Data unavailable at city scale	Response time for emergency response services from initial call	Response time for emergency response services from initial call		
	Fear of crime			
	Feelings of safety	Percentage of people who feel very or fairly safe in city/area	Subjective	Percentage, persons
		Percentage of people who feel that their neighbourhood is safe for children to play outside	Subjective	Percentage, persons

Birmingham's crime & safety data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Number of notifiable offences recorded by the police	5520	Birmingham Metropolitan District	2011-2012	ONS	Secondary	NA	Public	
Number of firefighters per 100 000 of the population								
Number of police officers per 100 000 of the population								
Response time for emergency response services from initial call								
Percentage of people who feel very or fairly safe in city/area	34.2	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Percentage of people who feel that their neighbourhood is safe for children to play outside	29.2	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	

Social support & cohesion tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Social cohesion			
	Belief that people in the city/area who are from different backgrounds get on well together	Percentage of people who believe that people in their city/area who are from different backgrounds get on well together	Subjective	Percentage, persons
Data unavailable	Feelings of social cohesion	Percentage of people who strongly or somewhat feel close to the people in their local area		
Data unavailable		Percentage of people who visit with their neighbours at least once a month		
	Social vibrancy	Percentage of people who strongly or somewhat agree that they enjoy meeting up in the city/area.	Subjective	Percentage, persons
	Volunteering and activism			
	Participation rates in the most recent national election	Voter turnout in most recent national election	Objective	Percentage, persons
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Levels of volunteering	Percentage of people engaging in volunteering activity more than once in the last year		
		Percentage of people engaging in volunteering activity at least once a month in the last year	Objective	Percentage, persons
	Social support			
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Those in city/area who have a partner, family member or friend to rely on if they have a serious problem	Percentage of people who have a partner, family member or friend to rely on if they have a serious problem		

	Regularity of face-to-face conversations	Percentage of people who have a face-to-face conversation with a close friend, relative or someone else close to them (apart from your spouse or partner) at least once a week	Objective	Percentage, persons
	Social services			
Data unavailable at city scale	Quality of childcare services	Rating of childcare services in the last independent review		
Data unavailable	Satisfaction with the quality of childcare services	Percentage of people who rate as very or fairly satisfactory the quality of state childcare services in city/area		
Data unavailable at city scale	Quality of services for the elderly	Rating of services for the elderly in the last independent review		
Data unavailable	Satisfaction with the quality of services for the elderly	Percentage of people who rate as very or fairly satisfactory the quality of care services for the elderly in city/area		

Birmingham's social support & cohesion data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of people who believe that people in their city/area who are from different backgrounds get on well together	72.2	Birmingham Metropolitan District	2008	Data.gov.uk	Secondary	NA	Public	
Percentage of people who strongly or somewhat feel close to the people in their local area								

Percentage of people who visit with their neighbours at least once a month								
Percentage of people who strongly or somewhat agree that they enjoy meeting up in the city/area.	68.8	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Voter turnout in most recent national election	58.73	Birmingham	2010	UK Political Info	Secondary	NA	Public	
Percentage of people engaging in volunteering activity more than once in the last year								
Percentage of people engaging in volunteering activity at least once a month in the last year	16.7	Birmingham Municipal District	2008	Data.gov.uk	Secondary	NA	Public	
Percentage of people who have a partner, family member or friend to rely on if they have a serious problem								

Percentage of people who have a face-to-face conversation with a close friend, relative or someone else close to them (apart from your spouse or partner) at least once a week	58.4	Birmingham	2014	Liveable Cities	Primary	Questionnaire	Confidential	
Rating of childcare services in the last independent review								
Percentage of people who rate as very or fairly satisfactory the quality of state childcare services in city/area								
Rating of services for the elderly in the last independent review								
Percentage of people who rate as very or fairly satisfactory the quality of care services for the elderly in city/area								

Health tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Lifestyle			
	Physical activity	Percentage of adults (16+) who participate in sport and active recreation for at least 30 minutes on at least 12 days out of the last 4 weeks	Objective	Percentage, persons
	Recreation space	Number of publicly accessible sports halls	Objective	Count, sports halls
		Number of publicly accessible grass pitches	Objective	Count, grass pitches
Data unavailable at city scale	Time each week the people have for sleeping	Time/week for sleeping (hours)		
Data unavailable at city scale	Time each week the people have for leisure	Time/week for leisure (hours)		
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Satisfaction with amount of leisure time	Percentage of people who are somewhat, mostly or completely satisfied with the amount of leisure time they have		
More recent data available from the Taking part survey, UK Data archive, special license: https://discover.ukdataservice.ac.uk/Catalogue/?sn=7223&type=Data%20catalogue	Time spent on cultural activities	Percentage of people who have engaged with, or participated in, the arts or cultural activity at least 3 times in the last year	Objective	Percentage, persons
	Satisfaction with sports provision in local area	Percentage of adults who are satisfied with sports provision in their local area (defined as responding very or fairly satisfied)	Subjective	Percentage, persons
	Health overall			
	Healthy life expectancy	Healthy life expectancy at birth of the male population	Objective	Count, years
		Healthy life expectancy at birth of the female population	Objective	Count, years
	Life expectancy	Life expectancy at birth of the male population	Objective	Count, years

		Life expectancy at birth of the female population	Objective	Count, years
	Overall health	Percentage of people whose overall health is very good or good	Objective	Percentage, persons
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Satisfaction with health	Percentage of people who are somewhat, mostly or completely satisfied with their health in general		
	Long-standing impairment	Percentage of people with a long-standing physical or mental impairment, illness or disability.	Objective	Percentage, persons
	Physical health			
	Obese adults	Percentage of adults who are obese	Objective	Percentage, persons
	Obese children	Percentage of children (Year 6) who are obese	Objective	Percentage, persons
	Psychological health			
	Suicide rates	Suicide rate per 100 000 of the population	Objective	Count, persons
	Mental health of population	Percentage of people who are mental health service users	Objective	Percentage, persons
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.		Mental wellbeing of the population		
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.		Percentage of people with some evidence indicating depression or anxiety		
	Health system			
Data for this indicator are not included due to the difficulty in obtaining them (the	Number of hospital beds	Average daily available hospital beds per 100 000 of the population		

number of beds must be manually compiled and the areas covered by hospitals cross city political boundaries).				
Data for this indicator are not included due to the difficulty in obtaining them (the number of physicians must be manually compiled and the areas covered by hospitals cross city political boundaries).	Number of physicians	Number of physicians per 100 000 of the population		
Data for this indicator are not included due to the difficulty in obtaining them (the number of nursing and midwifery personnel must be manually compiled and the areas covered by hospitals cross city political boundaries).	Number of nurses and midwifes	Number of nursing and midwifery personnel per 100 000 of the population		
Data for this indicator are not included due to the difficulty in obtaining them (the number of mental health practitioners must be manually compiled and the areas covered by hospitals cross city political boundaries).	Number of mental health practitioners	Number of mental health practitioners per 100 000 of the population		
Data unavailable	Perceived quality of public health services	Percentage of people who rate a good or very good the quality of public health services in city/area		
	Mortality			
	Transportation fatalities	Number of transportation fatalities (fatal road casualties)	Objective	Number, count
	Avoidable mortality	Mortality from deaths considered avoidable (per 100 000 of the population)	Objective	Count, persons
		Premature deaths	Objective	Ranking out of 324 Local Authorities (1 performs best, 324 performs worst)

Birmingham's health data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of adults (16+) who participate in sport and active recreation for at least 30 minutes on at least 12 days out of the last 4 weeks	19.5	Birmingham	October 2009 - October 2011	Sport England	Secondary	NA	Public	
Number of publicly accessible sports halls	123	Birmingham	Unknown	Active Places Power	Secondary	NA	Public	
Number of publicly accessible grass pitches	398	Birmingham District	Unknown	Active Places Power	Secondary	NA	Public	
Time/week for sleeping (hours)								
Time/week for leisure (hours)								
Percentage of people who are somewhat, mostly or completely satisfied with the amount of leisure time they have								
Percentage of people who have engaged with, or participated in, the arts or cultural activity at least 3 times in	36.7	Birmingham Metropolitan District	2009	Data.gov.uk	Secondary	NA	Public	

the last year								
Percentage of adults who are satisfied with sports provision in their local area (defined as responding very or fairly satisfied)	60.8	Birmingham	2009/10	Sport England	Secondary	NA	Public	
Healthy life expectancy at birth of the male population	58.9	Birmingham	2009-2011	ONS	Secondary	NA	Public	
Healthy life expectancy at birth of the female population	59.5	Birmingham	2009-2011	ONS	Secondary	NA	Public	
Life expectancy at birth of the male population	77.3	Birmingham	2009-2011	ONS	Secondary	NA	Public	
Life expectancy at birth of the female population	82	Birmingham	2009-2011	ONS	Secondary	NA	Public	
Percentage of people whose overall health is very good or good	79.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of people who are somewhat, mostly or completely satisfied with their health in general								

Percentage of people with a long-standing physical or mental impairment, illness or disability.	18.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of adults who are obese	26.2	Birmingham UA	2011	Public Health England	Secondary	NA	Public	
Percentage of children (Year 6) who are obese	23.1	Birmingham UA	2011	Public Health England	Secondary	NA	Public	
Suicide rate per 100 000 of the population	5.3	Birmingham	1998-2004	ONS	Secondary	NA	Public	
Percentage of people who are mental health service users	2.52	Birmingham	2010/2011	ONS	Secondary	NA	Public	
Mental wellbeing of the population								
Percentage of people with some evidence indicating depression or anxiety								
Average daily available hospital beds per 100 000 of the population								
Number of physicians per 100 000 of the population								
Number of nursing and midwifery								

personnel per 100 000 of the population								
Number of mental health practitioners per 100 000 of the population								
Percentage of people who rate a good or very good the quality of public health services in city/area								
Number of transportation fatalities (fatal road casualties)	27	Birmingham	2011	Gov.uk	Secondary	NA	Public	
Mortality from deaths considered avoidable (per 100 000 of the population)	165.11	Birmingham	2011-13	Public Health England	Secondary	NA	Public	
Premature deaths	295	Birmingham	2011-13	Public Health England	Secondary	NA	Public	

Finance (households) tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Income			
	Income of households	Gross disposable household income per head	Objective	Index, UK 2011 = 100
		Average weekly earnings	Objective	Count, GBP

These data are from the Family Resources Survey and require a special license to access at the city level (https://www.google.co.uk/search?q=Households+below+average+income+birmingham&ie=utf-8&oe=utf-8&gws_rd=cr&ei=BXaWVf25Dsz6Uuq8h8gO).		Percentage of households with less than 60% of median income after housing costs (low income)		
These data are from the Wealth and Assets Survey, ONS, and require a special license to access at the city level.		Median wealth per household, including pension wealth		
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Satisfaction of households in city/are with their income	Percentage of people who are somewhat, mostly or completely satisfied with the income of their household		
	Key out of work benefits claimed	Percentage of the working age population that is claiming key out of work benefits	Objective	Percentage, persons
	Fuel poverty	Percentage of households in fuel poverty [Low income / high cost definition]	Objective	Percentage, households
	Standard of living			
Data unavailable	Satisfaction with overall standard of living	Percentage of people who are completely or somewhat satisfied with their present standard of living		
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Satisfaction with financial standard of living	Percentage of people who report finding it quite or very difficult to get by financially		
	Housing affordability	Housing affordability ratio	Objective	Ratio, house prices to earnings

Birmingham's finance (households) data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Gross disposable household income per head	78.4	Birmingham	2011	ONS	Secondary	NA	Public	
Average weekly earnings	492.4	Birmingham	2011	ONS	Secondary	NA	Public	
Percentage of households with less than 60% of median income after housing costs (low income)								
Median wealth per household, including pension wealth								
Percentage of people who are somewhat, mostly or completely satisfied with the income of their household								
Percentage of the working age population that is claiming key out of work benefits	22	Birmingham	2010	ONS	Secondary	NA	Public	
Percentage of households in fuel poverty [Low income / high cost definition]	15.5	Birmingham	2011	ONS	Secondary	NA	Public	

Percentage of people who are completely or somewhat satisfied with their present standard of living								
Percentage of people who report finding it quite or very difficult to get by financially								
Housing affordability ratio	6.6	Birmingham	2014	ONS	Secondary	NA	Public	

Finance (city) tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Expenditure and investment			
Data unavailable	Satisfaction with how city/area spends its money	Percentage of people who strongly or somewhat agree that city/area spends its resources in a responsible way		
Data unavailable	R&D spend	Expenditure on R&D performed in business [in real terms and in cash terms]		
Data unavailable	Environmental R&D spend	Expenditure on R&D related to environmental protection expenditure [in real terms and in cash terms]		
	Council spending	Spending for central services to the public per capita	Objective	GBP
		Spending for cultural and related facilities per capita	Objective	GBP
		Spending for environmental and regulatory services per capita	Objective	GBP
		Spending for planning services per capita	Objective	GBP

		Spending for children's and education services per capita	Objective	GBP
		Spending for highways and transport services per capita	Objective	GBP
		Spending for Local Authority housing per capita	Objective	GBP
		Spending for adult social care per capita	Objective	GBP

Birmingham's finance (city) data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of people who strongly or somewhat agree that city/area spends its resources in a responsible way								
Expenditure on R&D performed in business [in real terms and in cash terms]								
Expenditure on R&D related to environmental protection expenditure [in real terms and in cash terms]								
Spending for central services to the public per capita	126	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	
Spending for cultural and related facilities per capita	234	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	

Spending for environmental and regulatory services per capita	118	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	
Spending for planning services per capita	62	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	
Spending for children's and education services per capita	1921	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	
Spending for highways and transport services per capita	203	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	
Spending for Local Authority housing per capita	217	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	
Spending for adult social care per capita	496	Birmingham	2011/12	Birmingham City Council	Secondary	NA	Public	

Economy tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Economy			
	GVA	GVA per capita	Objective	Count, GBP
		GVA per hour worked	Objective	Index, UK = 100
		GVA per filled job	Objective	Index, UK = 100
	Number of businesses	Number of businesses per 10,000 of the population	Objective	Count, businesses
	Business enterprise births and deaths	Business enterprise births	Objective	Percentage, businesses
		Business enterprise deaths	Objective	Percentage, businesses
		Business churn rate	Objective	Churn rate
	Industrial structure	Percentage of agriculture, forestry and fishing services	Objective	Percentage, business services
		Percentage of production services	Objective	Percentage, business services

		Percentage of construction services	Objective	Percentage, business services
		Percentage of motor trades services	Objective	Percentage, business services
		Percentage of wholesale services	Objective	Percentage, business services
		Percentage of retail services	Objective	Percentage, business services
		Percentage of transport and storage (including postal)	Objective	Percentage, business services
		Percentage of accommodation and food services	Objective	Percentage, business services
		Percentage of information and communication services	Objective	Percentage, business services
		Percentage of finance and insurance services	Objective	Percentage, business services
		Percentage of property services	Objective	Percentage, business services
		Percentage of professional, scientific and technical services	Objective	Percentage, business services
		Percentage of business administration and support services	Objective	Percentage, business services
		Percentage of public administration and defence services	Objective	Percentage, business services
		Percentage of education services	Objective	Percentage, business services
		Percentage of health services	Objective	Percentage, business services
		Percentage of arts, entertainment, recreation and other services	Objective	Percentage, business services
		Ratio of expanding to contracting SMEs	Objective	Ratio, expanding to contracting SMEs
	Age of businesses	Enterprises less than 2 years old	Objective	Percentage, enterprises
		Enterprises 2 to 3 years old	Objective	Percentage, enterprises
		Enterprises 4 to 9 years old	Objective	Percentage, enterprises
		Enterprises 10 or more years old	Objective	Percentage, enterprises
	Employment size	Enterprises employing 0-4 people	Objective	Percentage, enterprises

		Enterprises employing 5-9 people	Objective	Percentage, enterprises
		Enterprises employing 10-19 people	Objective	Percentage, enterprises
		Enterprises employing 20-49 people	Objective	Percentage, enterprises
		Enterprises employing 50-99 people	Objective	Percentage, enterprises
		Enterprises employing 100-249 people	Objective	Percentage, enterprises
		Enterprises employing 250+ people	Objective	Percentage, enterprises
	Public/private status of businesses	Percentage of publicly-owned business units	Objective	Percentage, businesses
		Percentage of privately-owned business units	Objective	Percentage, businesses
	Commercial and industrial property vacancies	Commercial and industrial property vacancies	Objective	Percentage, properties
	New patents	Number of new patents per year per 100 000 of the population	Objective	Count, patents/year
Data unavailable	Environmental sector value	Value of environmental goods and services sector		

Birmingham's economy data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
GVA per capita	19,685	Birmingham	2011	ONS	Secondary	NA	Public	
GVA per hour worked	96	Birmingham	2002-2011	ONS	Secondary	NA	Public	
GVA per filled job	97.7	Birmingham	2002-2011	ONS	Secondary	NA	Public	
Number of businesses per 10,000 of the population	283	Birmingham	2011	ONS	Secondary	NA	Public	Total active businesses enterprises 2011 / (Birmingham population 2011 / 10,000) = 30380/(1073045/10000)

Business enterprise births	12.1	Birmingham	2011	ONS	Secondary	NA	Public	(Business enterprise births 2011 * 100) / total active business enterprises 2011 = (3675*100)/30380
Business enterprise deaths	11.8	Birmingham	2011	ONS	Secondary	NA	Public	(Business enterprise deaths 2011 * 100) / total active business enterprises 2011 = (3575*100)/30380
Business churn rate	11.7	Birmingham	2011	ONS	Secondary	NA	Public	(Business enterprise deaths in 2011 / total active businesses at end of 2010) * 100 = (3575/30675) * 100
Percentage of agriculture, forestry and fishing services	0.14	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (45/32870)*100
Percentage of production services	7.3	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (2405/32870)*100
Percentage of construction services	7.9	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (2605/32870)*100
Percentage of motor trades services	2.9	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (945/32870)*100
Percentage of wholesale services	5.7	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*10

								0 = (1885/32870)*100
Percentage of retail services	13.8	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (4535/32870)*100
Percentage of transport and storage (including postal)	2.9	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (960/32870)*100
Percentage of accommodation and food services	5.7	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (1885/32870)*100
Percentage of information and communication services	4.9	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (1615/32870)*100
Percentage of finance and insurance services	3.3	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (1080/32870)*100
Percentage of property services	3.8	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (1255/32870)*100
Percentage of professional, scientific and technical services	12.8	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (4195/32870)*100
Percentage of business administration and support services	6.8	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (2235/32870)*100
Percentage of public administration and defence services	4.0	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (1305/32870)*100

Percentage of education services	4.0	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (1315/32870)*100
Percentage of health services	7.8	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (2580/32870)*100
Percentage of arts, entertainment, recreation and other services	6.2	Birmingham	2011	ONS	Secondary	NA	Public	(sector count/total count)*100 = (2025/32870)*100
Ratio of expanding to contracting SMEs	1.4	Birmingham PUA	2010-2013	Centre for Cities	Secondary	NA	Public	
Enterprises less than 2 years old	17.6	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business <2 yrs old / total Birmingham businesses)*100 = (4230/24045)*100
Enterprises 2 to 3 years old	14.2	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business 2-3 yrs old / total Birmingham businesses)*100 = (3405/24045)*100
Enterprises 4 to 9 years old	27.9	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business 4-9 yrs old / total Birmingham businesses)*100 = (6720/24045)*100
Enterprises 10 or more years old	40.1	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business 10+ yrs old / total Birmingham businesses)*100 = (9690/24045)*100
Enterprises	73.3	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business

employing 0-4 people								employing 0-4 people / total Birmingham businesses)*100 = (17630/24045)*100
Enterprises employing 5-9 people	13.9	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business employing 5-9 people / total Birmingham businesses)*100 = (3335/24045)*100
Enterprises employing 10-19 people	6.7	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business employing 10-19 people / total Birmingham businesses)*100 = (1620/24045)*100
Enterprises employing 20-49 people	3.5	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business employing 20-49 people / total Birmingham businesses)*100 = (840/24045)*100
Enterprises employing 50-99 people	1.2	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business employing 50-99 people / total Birmingham businesses)*100 = (300/24045)*100
Enterprises employing 100-249 people	0.8	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business employing 100-249 people / total Birmingham businesses)*100 = (190/24045)*100

Enterprises employing 250+ people	0.5	Birmingham	2011	ONS	Secondary	NA	Public	(Birmingham business employing 250+ people / total Birmingham businesses)*100 = (130/24045)*100
Percentage of publicly-owned business units	4.1	Birmingham	2009	ONS	Secondary	NA	Public	
Percentage of privately-owned business units	95.9	Birmingham	2009	ONS	Secondary	NA	Public	
Commercial and industrial property vacancies	19	Birmingham	2004/2005	ONS	Secondary	NA	Public	
Number of new patents per year per 100 000 of the population	2.4	Birmingham PUA	2013	Centre for Cities	Secondary	NA	Public	
Value of environmental goods and services sector								

Governance tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Structure and characteristics			
	Political leanings	Political leanings	Objective	Political party affiliation
	Governance model	Governance model (e.g., elected mayor, leader of the council, etc.)	Objective	Governance model

	Government structure	Type of local authority (non-metropolitan district, metropolitan district, Unitary Authority (England), Council Area (Scotland), District Council (N. Ireland), Greater London (and the London Boroughs), Unitary Authority (Wales)	Objective	Local authority type
		LEP affiliation	Objective	LEP affiliation
	Policies, strategies and services			
	Smart city initiative	Presence of a smart city initiative	Objective	Binary, yes/no
	Sustainability / green city initiative	Presence of a sustainability / green city initiative	Objective	Binary, yes/no
	City networks	Membership in a national or international governance network (e.g., core cities, key cities)?	Objective	Binary, yes/no
Data unavailable	Satisfaction with local authority-provided basic services	Percentage of people who are very or fairly satisfied with the basic services offered by their local authority		
Data unavailable	Satisfaction with how the local authority is doing its job	Percentage of people who are very or fairly satisfied with the way their local authority is doing its job		
Data unavailable	Perceptions of the local authority's commitment to reducing climate change	Percentage of people who strongly or somewhat agree that the city/area is committed to the fight against climate change		
Data unavailable	Level of trust in national government	Percentage of people who have trust in the national Government		

Birmingham's governance data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Political leanings	Labour	Birmingham	2011	BBC	Secondary	NA	Public	
Governanc e model (e.g., elected mayor, leader of the	Leader of council	Birmingham City Council	2011	Birmingha m City Council	Secondary	NA	Public	

council, etc.)								
Type of local authority (non-metropolitan district, metropolitan district, Unitary Authority (England), Council Area (Scotland), District Council (N. Ireland), Greater London (and the London Boroughs), Unitary Authority (Wales)	Unitary authority	Birmingham City Council	2011	Birmingham City Council	Secondary	NA	Public	
LEP affiliation	Greater Birmingham and Solihull LEP	Birmingham City Council	2011	Gov.uk	Secondary	NA	Public	
Presence of a smart city initiative	No	Birmingham City Council	2011	Birmingham City Council	Secondary	NA	Public	
Presence of a sustainability / green city initiative	No	Birmingham City Council	2011	Birmingham City Council	Secondary	NA	Public	
Membership in a national or international governance network (e.g., core cities, key cities)?	Yes (Core Cities)	Birmingham City Council	2011	Core Cities	Secondary	NA	Public	
Percentage of people who are very or fairly satisfied with the basic services offered by their local authority								

Percentage of people who are very or fairly satisfied with the way their local authority is doing its job								
Percentage of people who strongly or somewhat agree that the city/area is committed to the fight against climate change								
Percentage of people who have trust in the national Government								

Education tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Qualifications			
	Qualifications	Percentage of the population that achieved level 2 as highest level of qualification (includes GCSEs A*-C)	Objective	Percentage, persons
		Percentage of the population that achieved above level 4 as highest level of qualification (above A and AS levels and HNC)	Objective	Percentage, persons
		Percentage of the population aged 16 to 64 with no qualifications	Objective	Percentage, persons

		Percentage of 16 year olds with five or more GCSEs A* to C including English and Mathematics	Objective	Percentage, persons
		Percentage of the population aged 16 to 64 that achieved a qualification at NVQ4 or above	Objective	Percentage, persons
	Quality and satisfaction			
Data for this indicator are not included due to the difficulty in obtaining them (the number of students and teachers must be manually compiled and averaged) and the its changeability over short time frames (academic year to academic year).	Student/teacher ratio in primary education	Average primary education student/teacher ratio		
Data for this indicator are not included due to the difficulty in obtaining them (individual school Ofstead reports must be manually compiled and scores extracted) and the variability of the report time frames and foci.	The rating of schools in their last independent review	The rating of schools in their last independent review		
		Average amount of time schools spend in special measures	Objective	Count, months
Data unavailable	Quality perception of local education services	Percentage of people who rate as very or fairly good the quality of their local education services		
Data unavailable	Happiness at school	Percentage of students who are very or fairly happy about the school that they go to		

Birmingham's education data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentag e of the population that achieved level 2 as	13.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	

highest level of qualification (includes GCSEs A*-C)								
Percentage of the population that achieved above level 4 as highest level of qualification (above A and AS levels and HNC)	6.6	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of the population aged 16 to 64 with no qualifications	28.2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of 16 year olds with five or more GCSEs A* to C including English and Mathematics	47.7	Birmingham District Council	2008/09	Data.gov.uk	Secondary	NA	Public	
Percentage of the population aged 16 to 64 that achieved a qualification at NVQ4 or above	3.6	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	30195*100 / 828,363
Average primary education student/teacher ratio								
The rating of schools in their last independent review								
Average amount of time schools spend in special measures	21	Birmingham Municipal District	2008/09	Data.gov.uk	Secondary	NA	Public	

Percentage of people who rate as very or fairly good the quality of their local education services								
Percentage of students who are very or fairly happy about the school that they go to								

Employment tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	Un/employment rate			
	Employment	Percentage of the working-age population in employment	Objective	Percentage, persons
	Unemployment	Unemployment rate	Objective	Percentage, persons
	Occupation			
	NS-SES	Percentage of National Statistics Socioeconomic Classification (NS-SES): Higher managerial, administrative and professional occupations	Objective	Percentage, persons
		Percentage of National Statistics Socioeconomic Classification (NS-SES): Lower managerial, administrative and professional occupations	Objective	Percentage, persons
		Percentage of National Statistics Socioeconomic Classification (NS-SES): Intermediate occupations	Objective	Percentage, persons
		Percentage of National Statistics Socioeconomic Classification (NS-SES): Small employers and own account workers	Objective	Percentage, persons

		Percentage of National Statistics Socioeconomic Classification (NS-SES): Lower supervisory and technical occupations	Objective	Percentage, persons
		Percentage of National Statistics Socioeconomic Classification (NS-SES): Semi-routine occupations	Objective	Percentage, persons
		Percentage of National Statistics Socioeconomic Classification (NS-SES): Routine occupations	Objective	Percentage, persons
	Working hours			
	Working hours	Average paid hours worked per week	Objective	Count, hours
	Full-time and part-time workers	Percentage part-time workers	Objective	Percentage, persons
		Percentage full-time workers	Objective	Percentage, persons
	Job satisfaction			
These data are from the Understanding Society Survey and require a special license to access at the local authority scale (http://discover.ukdataservice.ac.uk/catalogue/?sn=6666). A special license has been requested.	Job satisfaction	Percentage of the employed population who are somewhat, mostly or completely satisfied with their job		

Birmingham's employment data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of the working-age population in employment	52.7	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Unemployment rate	13.5	Birmingham	2011	ONS	Secondary	NA	Public	

Percentage of National Statistics Socioeconomic Classification (NS-SES): Higher managerial, administrative and professional occupations	7.8	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of National Statistics Socioeconomic Classification (NS-SES): Lower managerial, administrative and professional occupations	16.2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of National Statistics Socioeconomic Classification (NS-SES): Intermediate occupations	11.3	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of National Statistics Socioeconomic Classification (NS-SES): Small employers and own account workers	6.9	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of National Statistics Socioeconomic	6.1	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	

Classification (NS-SES): Lower supervisory and technical occupations								
Percentage of National Statistics Socioeconomic Classification (NS-SES): Semi-routine occupations	14.2	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of National Statistics Socioeconomic Classification (NS-SES): Routine occupations	11.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Average paid hours worked per week	33.8	Birmingham	2014	ONS	Secondary	NA	Public	
Percentage part-time workers	31.4	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage full-time workers	68.7	Birmingham	2011	ONS, 2011 Census	Secondary	NA	Public	
Percentage of the employed population who are somewhat, mostly or completely satisfied with their job								

IT tab

Data availability notes	Metric chosen for UK City LIFE$_1$	Related indicators chosen for UK City LIFE$_1$	Indicator type (objective/ subjective)	Units
	IT			
	Internet and broadband access	Percentage of internet users	Objective	Percentage, access
		Broadband quality available speed	Objective	1-5 scale where 1 is highest and fastest and 5 is lowest and slowest
	Mobile 'phone access	Level of outdoor mobile 'phone coverage	Objective	Percentage, coverage

Birmingham's IT data

Indicators	Birmingham perfor-mance	Geographic area	Perfor mance year	Data available from	Data type	Collection method if primary data	Data availability	Calcu-lation
Percentage of internet users	78-83	Birmingham	2011/2013	Oxford Internet Institute	Secondary	NA	Public	
Broadband quality available speed	1	Birmingham	2013	Ofcom	Secondary	NA	Public	
Level of outdoor mobile 'phone coverage	Greater than 95%	Birmingham	2013	Ofcom	Secondary	NA	Public	

APPENDIX G. PAPER 3 CIRCULAR PLOT CALCULATIONS

This appendix contains the calculations for the Figure 5, which were compiled by Dr Susan Lee, who led the Liveable Cities' study on material and energy flows. All figures are informed annual estimates for demonstrating the circular plot visualisation technique.

Kt = kiloton.

Ktoe = kilotons of oil equivalent.

Food flows

- Birmingham's food consumption is 368kt, made up of 350kt consumed within households and 18kt consumed whilst eating out.
- Of the food that enters households, 147kt enters the municipal waste stream and, of this, 1/3rd is composted.
- Of the food that enters eating establishments, 8kt enters the municipal waste steam.

Waste flows

- Birmingham's municipal waste is 508kt.
- 137kt of waste is recycled/composted
- 25kt of waste is sent to landfill
- 346kt of waste is sent to the city's energy from waste plant

Energy flows

Birmingham's energy is comprised of the following elements.

- 371ktoe comes in the form of electricity, of which 44ktoe comes from its energy from waste plant and 327ktoe comes from the national grid. 15% of electricity lost during transmission (i.e., wasted). 145ktoe is consumed by the domestic sector. 226ktoe is consumed by the non-domestic sector.
- 770ktoe comes in the form of natural gas. 486 ktoe is consumed by the domestic sector. 284ktoe is consumed by the non-domestic sector.
- 547ktoe comes in the form of petroleum oil. 1.7ktoe is consumed by the domestic sector (not including transport). 54ktoe is consumed by the non-domestic sector (not including transport). 491ktoe is consumed by the transport sector.
- 1.4ktoe comes in the form of manufactured fuels, all of which is consumed by the non-domestic sector.

APPENDIX H. PAPER 3 SUPPLEMENTARY INFORMATION

This appendix contains the supplementary information for Paper 3.

Calculations for Birmingham's livability scores and coupling measures

Following are the calculations of Birmingham's livability scores and coupling measures. They are largely for illustrative purposes, as it is beyond the scope of this paper to expand upon the distillation process, the calculations or their implications for interpretation. The underpinning data, including all data sources and dates, can be found in Leach *et al*. (2017).

Birmingham's livability scores

Wellbeing score

The following five indicators, equally weighted and averaged to produce an overall score.

Source for 1-4: ONS (http://www.ons.gov.uk/ons/rel/wellbeing/measuring-national-well-being/personal-well-being-in-the-uk--three-year-data-2011-2014/rft-table-1.xls).

Source for 5: Wellbeing survey.

1. Percentage of usual resident population in city/area who rate their overall life satisfaction as very high = 21.98%
2. Percentage of usual resident population in city/area who rate how worthwhile the things they do in their life are as very high = 26.30%
3. Percentage of usual resident population in city/area who rated their happiness yesterday as very high = 29.59%
4. Percentage of usual resident population in city/area who rated their anxiety yesterday as very low = 38.35%

5. Percentage of the usual resident population of city/area who feel very optimistic about the next 12 months = 21.20%

21.98 + 26.30 + 29.59 + 38.35 + 21.20 = 137.42

137.42 ÷ 5 = 27.48

Carbon emissions score

A city's carbon emissions performance can be expressed as the percentage change from 2005 levels. Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322822/20140624_Full_Dataset.xlsx

1. Birmingham's current (2011) carbon emissions = 5505 $ktCO_2$
2. Birmingham's 2005 baseline = 6,710 $ktCO_2$

(6710 – 5505) = 1205

1205 ÷ 6710 * 100 = 17.96

Resource efficiency score (Energy, Water and materials)

Resource efficiency (the relationship between a city's demand for resources and its waste of the same resources) can be expressed as the percentage a given resource's demand that is wasted. Waste is defined as any amount of the resource that is not consumed, reused or recycled (resource circularity).

These calculations do not include energy, water or materials used 'unnecessarily' in homes and elsewhere. For example, additional energy used by running older white goods, leaving appliances on standby or watching 'too much' TV (for a summary of this type of energy 'waste' see http://www.dailymail.co.uk/news/article-2164803/Families-

waste-86-year-electricity-bills-don-t-switch-televisions-gadgets.html), by not having low flush toilets and taps, by not reusing water (greywater recycling) or using rainwater (rainwater harvesting), by purchasing items in excessive packaging, owning multiple identical items or owning items that are never used. These are the potential areas for engineering and social interventions.

Each resource is measured as the percentage waste of the resource that is consumed by the city. The percentages for each resource are then averaged to produce an overall score.

Energy:

- Energy consumption = 1.65 Mtoe/year
- Energy waste (electricity distribution (not transmission) losses (there are no gas losses)) = 5.2% of demand (see https://www.ofgem.gov.uk/ofgem-publications/43516/distribution-units-and-loss-percentages-summary.pdf) = (5.2 * 1.65) / 100 = 0.086 Mtoe/year

Energy waste as a percentage of consumption = (0.086 * 100) ÷ 1.65 = 5.21

Water:

- Water distribution input (the amount of water distributed to consumers, see https://www.severntrent.com/about-us/future-plans/water-resource-management/final-wrmp-documents/, and https://www.severntrent.com/content/dam/stw/ST_Corporate/About_us/Docs/Appendix-A-How-much-water-do-we-have-available.pdf) = 96.28 Mt/year
- Water waste (distribution losses + USPL, between the treatment works and households) = 23.60 Mt/year + 77,992 Ml/year (wastewater) = 23.60 Mt/year + 77.99 Mt/year = 101.59 Mt/year

Water waste as a percentage of consumption = (101.59 * 100) ÷ 96.28 = 105.52

Materials:

- Materials demand = 9.88 Mt/year
- Materials waste = 3.2 Mt/year (total solid waste) – 0.14 Mt/year (food waste) – 0.119 Mt/year local authority-collected waste sent for recycling/composting/reuse = 2.94 Mt/year

Materials waste as a percentage of consumption = (2.94 * 100) ÷ 9.88 = 29.76

5.21 + 105.52 + 29.76 = 140.49 ÷ 3 = 46.83

Inverted to make 100% the least percentage waste.

100 – 46.83 = 53.17

Resource security score (Energy and food)

Resource security can be directly measured as the city's consumption of resources as a percentage of its ability to supply them. Each resource is measured as the percentage of the demand for the resource that is supplied from within the city. The percentages for each resource are then averaged to produce an overall score.

Energy:

- Energy consumption = 1.65 Mtoe/year
- Energy generation within the city = 506 GWh/year = 0.044 Mtoe/year

Energy supply as a percentage of demand = (0.044 * 100) ÷ 1.65 = 2.67

Food:

- Food consumption = 0.685 Mt/year
- Food grown within the city = 0.000,007,5 Mt/year

Food supply as a percentage of demand = (0.000,007,5 * 100) ÷ 0.685) = 0.0011

2.67 + 0.0011 = 2.67 ÷ 2 = 1.35

Birmingham's Coupling Measures

The coupling measures are calculated as the distance between the coupled scores (not their degree of dependence). This distance is represented in the following equation.

Coupling measure = (100 – Score 1) + (100 – Score 2)

- Birmingham's wellbeing score = 27.48
- Birmingham's carbon emissions reduction score = 17.96
- Birmingham's resource efficiency score = 53.17
- Birmingham's resource security score = 1.35

Carbon emissions and wellbeing coupling measure:

(100 – 17.96) + (100 – 27.48) = 154.56

Carbon emissions and resource security coupling measure:

(100 – 17.96) + (100 – 1.35) = 180.69

Carbon emissions and resource efficiency coupling measure:

(100 – 17.96) + (100 – 53.17) = 128.87

Wellbeing and resource efficiency coupling measure:

(100 – 27.48) + (100 – 53.17) = 119.35

Wellbeing and resource security coupling measure:

(100 – 27.48) + (100 – 1.35) = 171.17

Resource efficiency and resource security coupling measure:

(100 – 53.17) + (100 – 1.35) = 145.48

In order for the uncoupling relationships to be visualised in a 3d space where the furthest point away from 0, 0, 0 is the most uncoupled the coupling scores must be subtracted from 200.

Uncoupling measure = 200 – coupling measure

Carbon emissions and wellbeing uncoupling measure:

200 – 154.56 = 45.44

Carbon emissions and resource security uncoupling measure:

200 – 180.69 = 19.31

Carbon emissions and resource efficiency uncoupling measure:

200 – 128.87 = 71.13

These values can then be plotted in a 3d space (box). Each plane of the box has a range of 0 to 200.

The coupling measures can be represented in a Venn diagram where the centre of each circle is the distance between the three scores in question: wellbeing, resource security and resource efficiency. That is to say, the distances are the coupling measures for wellbeing and resource efficiency; wellbeing and resource security; and, resource efficiency and resource security. The radii are arbitrarily selected.

References

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APPENDIX I. HAY MILLS NEIGHBOURHOOD SURVEYS

This appendix contains the surveys conducted in the Hay Mills neighbourhood of Birmingham.

Household survey

This survey is part of the Liveable Cities project conducted at the University of Birmingham, examining how Hay Mills, Birmingham, is performing with regard to resource use, the wellbeing of its residents and overall sustainability. The results of this research will help to inform future policy and practice in cities generally, and in Birmingham specifically, on how to combine low-carbon living and resource security with wellbeing.

This survey has received ethical approval from the University of Birmingham Ethics Committee. The data from this survey will be analysed using statistical methods and the results from this research may be published through presentations, reports and journal articles. Your responses will ***always*** be anonymised in all of our outputs and your identity and contact details will ***never*** be shared with third parties. Aggregated data will be made publically available. This data is the combined, anonymised data for all respondents. For example, the average age of the survey respondents. All efforts will be made to ensure no individual is identifiable from the aggregated data.

You have the right to withdraw from this study at any time, without penalty to you. Should you withdraw, you will be asked if you are happy for the data collected from you up to that point to continue to be included in the study. If you indicate that you do not wish for your data to be included then your data will be destroyed.

If you have any questions about this survey or the wider research project please contact

Joanne Leach

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07785 792 187

Many thanks for your time and participation

Please tick the following boxes to indicate that:	
1. you have passed your 17th birthday	☐
2. you have read and understood the above information	☐
3. you consent to taking part in this survey	☐

Section 1: Participant and Interviewer ID

TO THE INTERVIEWERS:

Please enter the participant's ID as agreed previous to the interview.
Please ensure that you have entered the ID on the participant information sheet before entering it here.

The ID has the following three elements.

1. The three-digit household ID we have given to the household
2. A '1' for the household representative (this survey should be filled in by the hh representative)
3. The last 4 digits of the participant's personal mobile phone number or, if they don't have a mobile, the day and month of their birthday (e.g. "0905" for the 9th of May).

Please connect these elements with dashes. An example ID looks like this: 350-1-9765

Participant ID: _____ - 1 - _____

For interviewers, please enter the initials of your first and last name as your interviewer ID

Interviewer 1 ID: _____ _____

Interviewer 2 ID: _____ _____

Please enter the date the interview is/was conducted

Date of survey: DD MM YYYY

Section 2: demographics

2.1 Please enter the **number** of members of your household (including yourself) of each age group below.

0-4_____

5-7_____

8-9_____

10-14____

15_____

16-17____

18-19____

20-24____

25-29____

30-44____

45-59____

60-64____

65-74____

75-84____

85-89____

90+_____

Don't know ☐

I'd rather not say ☐

2.2 Please enter the **number** of members of your household (including yourself) of each gender designation below.

Male_____

Female_____

Indeterminate/intersex/unspecified_____

Other (please specify) _____

Don't know ☐

I'd rather not say ☐

2.3 Please enter the **number** of members of your household (including yourself) for each residential designation below.

Me, this is my permanent or family home_____

Family members including partners, children, and babies born on or before 27 March 2015 _____

Students and/or schoolchildren who live away from home during term time_

Housemates, tenants or lodgers_____

People who usually live outside the UK who are staying in the UK for 3 months or more_____

People who work away from home within the UK, or are members of the armed forces, if this is their permanent or family home_____

People who are temporarily outside the UK for less than 12 months_

People staying temporarily who usually live in the UK but do not have another UK address, for example, relatives, friends_____

Other people who usually live here, including anyone temporarily away from home _____

No-one usually lives here, for example, this is a second address or holiday home_

Other (please specify) _____

Don't know ☐

I'd rather not say ☐

2.4 Please enter the **number** of members of your household (including yourself) of each religious designation below.

Buddhist_____

Christian_____

Hindu_____

Jewish_____

Muslim_____

Sikh_____

No religion_____

Other (please specify) _____

Don't know ☐

I'd rather not say ☐

2.5 Please enter the **number** of members of your household (including yourself) of each ethnic designation below.

Asian/Asian British:

Bangladeshi_____

Indian_____

Pakistani_____

Chinese_____

Other Asian_____

Black/African/Caribbean/Black British:

African_____

Caribbean_____

Other Black_____

Mixed/multiple ethnic group:

White and Black Caribbean_____

White and Black African_____

White and Asian_____

Other Mixed_____

Other ethnic group:

Arab_____

Any other ethnic group_____

White:

English/Welsh/Scottish/Northern Irish/British_____

Irish_____

Gypsy or Irish Traveller_____

Other White_____

Don't know ☐

I'd rather not say ☐

2.6 Please enter the **number** of members of your household (including yourself) of each national designation below.

British national_____

Other national_____

2.7 Please indicate the familial composition of your household.

One person household ☐

One family household:

Married couple:

No children ☐

One dependent child ☐

Two or more dependent children ☐

All children non-dependent ☐

Same-sex civil partnership:

No children ☐

One dependent child ☐

Two or more dependent children ☐

All children non-dependent ☐

Cohabiting couple:

No children ☐

One dependent child ☐

Two or more dependent children ☐

All children non-dependent ☐

Lone parent:

One dependent child ☐

Two or more dependent children ☐

All children non-dependent ☐

Other household type:

No children ☐

One dependent child ☐

Two or more dependent children ☐

All children non-dependent ☐

Don't know ☐

I'd rather not say ☐

2.8 Please enter the **number** of members of your household (including yourself) of each national designation below.

Foreign born and UK citizen_____

Foreign born but not a UK citizen_____

UK born and UK citizen_____

UK born but not a UK citizen_____

Other (please specify) _____

Don't know ☐

I'd rather not say ☐

Section 3: where you live

3.1 What is your home postcode? _____

We are interested in proximity to transport links, green space and mapping demographics in the area in which you live. We will NOT use this information to contact you.

Please leave blank if you don't know or would rather not say.

3.2 Please enter the total **number** of members of your household (including yourself). ___

A household as one person living alone or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room or sitting room or dining area (definition taken from the 2011 census).

Please leave blank if you don't know or would rather not say.

3.3 What best describes the residential status of your household?

Owned outright ☐

Owned with a mortgage or loan ☐

Shared ownership (part owned and part rented) ☐

Social Rented: Rented from council (Local Authority) ☐

Social rented: Other ☐

Private rented: Private landlord or letting agency ☐

Private rented: Other ☐

Living rent free ☐

Other (please specify)_

Don't know ☐

I'd rather not say ☐

3.4 Which best describes the property in which you live (please tick all that apply)?

Whole house or bungalow:

Detached ☐

Semi-detached ☐

Mid-terraced ☐

End-terrace ☐

Flat, maisonette or apartment:

Purpose-built block of flats or tenement ☐

Part of a converted or shared house ☐
(including bed-sits)

In a commercial building ☐

Caravan or other mobile or temporary structure ☐

Other (please specify)

Don't know ☐

I'd rather not say ☐

3.5 What is the main source of heating in your home?

Do not have central heating ☐

Gas ☐

Electric (including storage heaters) ☐

Oil ☐

Solid fuel central heating (e.g., wood, coal) ☐

Solar hot water ☐

Other (please specify)

Don't know ☐

I'd rather not say ☐

3.6 Do you know the SAP rating of your household? If so, please enter it here.

_____

The SAP rating (Standard Assessment Procedure) measures the energy and environmental performance of dwellings. Please leave blank if you don't know or would rather not say

Section 4: green and blue space

4.1 Is your household within a 5-minute walk of a natural 'blue space' (e.g., lake, canal) or 'green space' (e.g., park, garden)?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Section 5: energy

5.1 Does your household have a gas meter?

Yes ☐

See questions 5.1.1 and 5.1.2, below

No ☐

Don’t know ☐

I’d rather not say ☐

5.1.1 If yes, who is your gas supplier?

_____

Please leave blank if this question does not apply to you, you don’t know or you would rather not say.

5.1.2 If yes, please provide from your latest gas bill the amount of gas used and the dates the usage covers. Please do not use amounts from estimated meter readings. If your latest gas bill uses estimated readings, please go back to the most recent bill that does not use estimated readings.

Amount of gas used_____

units_____

Dates the usage covers _____

Please leave blank if this question does not apply to you, you don’t know or you would rather not say.

5.2 Does your household have an electricity meter?

Yes ☐

If yes, see questions 5.2.1 and 5.2.2, below

No ☐

Don't know ☐

I'd rather not say ☐

5.2.1 If yes, who is your electricity supplier?

_____

Please leave blank if this question does not apply to you, you don't know or you would rather not say.

5.2.2 If yes, please provide from your last electricity bill the amount of electricity used and the dates the usage covers. Please do not use amounts from estimated meter readings. If your last electricity bill uses estimated readings, please go back to the most recent bill that does not use estimated readings.

Amount of electricity used units_____

Dates the usage covers _____

Please leave blank if this question does not apply to you, you don't know or you would rather not say.

5.3 Does your household use solid fuel used for energy or heating (e.g., wood, coal)?

Yes ☐

If yes, see question 5.3.1, below

No ☐

Don't know ☐

I'd rather not say ☐

5.3.1 If yes, how much solid fuel would you say you used last year? Please complete a separate line for each different solid fuel type you used.

Solid fuel type:_____

Amount used last year:_____

Solid fuel type:_____

Amount used last year:_____

Solid fuel type:_____

Amount used last year:_____

Solid fuel type:_____

Amount used last year:_____

Solid fuel type:_____

Amount used last year:_____

Please leave blank if this question does not apply to you, you don't know or you would rather not say.

5.4 If you generate energy at home, how much did you generate last year?

Amount of energy generated_____

units_____

Please leave blank if this question does not apply to you, you don't know or you would rather not say.

Section 6: water

6.1 Does your household have a water meter?

Yes ☐

No ☐

Don't know ☐

I'd rather not say ☐

6.2 Do you collect water at home for use (for example, in water butts, greywater recycling systems, rainwater harvesting systems)?

Yes ☐
If yes, see question 6.2.1, below

No ☐

Don’t know ☐

I’d rather not say ☐

6.2.1 If yes, please describe how you collect water and the capacity of the associated systems or tanks.

_____

Section 7: food

7.1 Please indicate how often your household buys its food from supermarkets.

Always ☐

Often ☐

Sometimes ☐

Never ☐

Don't know ☐

I'd rather not say ☐

7.2 Please indicate how often your household buys locally-produced food.

Always ☐

Often ☐

Sometimes ☐

Never ☐

Don't know ☐

I'd rather not say ☐

7.3 Please indicate how much of the food you eat has been grown by you or members of your household.

All ☐

More than half ☐

Half ☐

Less than half ☐

None ☐

Don't know ☐

I'd rather not say ☐

Section 8: mobilities and transport

8.1 How many vehicles (e.g., car, van, motorbike) does your household own or long-term lease (by long-term, I mean for more than a few weeks)? _____

Please leave blank if you don't know or you would rather not say.

8.2 How many bicycles (including electric bicycles but not including child's bicycles) does your household own or long-term lease (by long-term, I mean for more than a few weeks)? ___

Please leave blank if you don't know or you would rather not say.

Section 9: household finances

9.1 Which of the following categories represents the total income per year of your household from all sources before tax?

Please note that information on income will help us analyse the data as a whole. It will be fully anonymised in any outputs and information on individuals will never be disclosed the third parties

Up to £5,199 ☐

£5,200 - £7,799 ☐

£7,800 - £12,499 ☐

£12,500 - £16,599 ☐

£16,600 - £19,999 ☐

£20,000 - £23,999 ☐

£24,000 - £29,999 ☐

£30,000 - £34,999 ☐

£35,000 - £44,999 ☐

£45,000 or more ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

Section 10: employment

10.1 For each person in this household under the age of 17, how many are unemployed (not in school and not employed)?

_____

Section 11: IT

11.1 Does your household have access to a computer?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

11.2 Does your household have access to broadband, superfast broadband or fibreoptic?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Individual survey

This survey is part of the Liveable Cities project conducted at the University of Birmingham, examining how Tyseley, Birmingham, is performing with regard to resource use, the wellbeing of its residents and overall sustainability. The results of this research will help to inform future policy and practice in cities generally, and in Birmingham specifically, on how to combine low-carbon living and resource security with wellbeing.

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If you have any questions about this survey or the wider research project please contact

Joanne Leach

j.leach@bham.ac.uk

07785 792 187

Many thanks for your time and participation

Please tick the following boxes to indicate that:	
1. you have passed your 17th birthday	☐
2. you have read and understood the above information	☐
3. you consent to taking part in this survey	☐

Section 1: Participant and Interviewer ID

TO THE INTERVIEWERS:

Please enter the participant's ID as agreed previous to the interview.
Please ensure that you have entered the ID on the participant information sheet before entering it here.

The ID has the following three elements.

4. The three-digit household ID we have given to the household
5. A ‘1’ for the household representative, a ‘0’ for everyone else
6. The last 4 digits of the participant’s personal mobile phone number or, if they don't have a mobile, the day and month of their birthday (e.g. "0905" for the 9th of May).

Please connect these elements with dashes. An example ID looks like this: 350-1-9765

Participant ID: _____ - - _____

For interviewers, please enter the initials of your first and last name as your interviewer ID

Interviewer 1 ID: _____ _____

Interviewer 2 ID: _____ _____

Please enter the date the interview is/was conducted

Date of survey: DD MM YYYY

Section 2: demographics

2.1 Do you feel that racial or religious harassment is a problem in Hay Mills?

Yes ☐

No ☐

No opinion ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

Section 3: where you live

3.1 Please indicate to what extent you agree or disagree with the following statement:

I feel like I belong in Hay Mills.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

3.2 How long have you lived in Hay Mills? _____

months/years

Please leave blank if you don’t know or would rather not say.

3.3 Do you think you will be living in Hay Mills in 10 years' time?

Very likely ☐

Likely ☐

Somewhat likely ☐

Neither likely nor unlikely ☐

Somewhat unlikely ☐

Unlikely ☐

Very unlikely ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

3.4 How satisfied are you with the quality of the area in which you live?

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐

Somewhat dissatisfied ☐

Dissatisfied ☐

Very dissatisfied ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

3.5 How satisfied are you with your accommodation?

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐

Somewhat dissatisfied ☐

Dissatisfied ☐

Very dissatisfied ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

3.6 Please indicate to what extent you agree or disagree with the following statement:

I wish I lived in a different house.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 4: green and blue space

4.1 How often do you visit public gardens, parks, commons or other green spaces?

6-7 days a week ☐

3-5 days a week ☐

1-2 days a week ☐

Once a fortnight ☐

Once a month ☐

Several times a year ☐

Once a year ☐

Less often ☐

Never ☐

Don’t know ☐

I'd rather not say ☐

Not applicable ☐

4.2 How do you rate the ***access*** to ***parks*** within a 5 minute walk of where you live?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

4.3 How do you rate the ***access*** to ***waterways*** within a 5 minute walk of where you live?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

4.4 How do you rate the ***access*** to ***green spaces*** within a 5 minute walk of where you live?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

4.5 How do you rate the ***quality*** of ***parks*** within a 5 minute walk of where you live?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

4.6 How do you rate the ***quality*** of ***waterways*** within a 5 minute walk of where you live?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

4.7 How do you rate the ***quality*** of ***green spaces*** within a 5 minute walk of where you live?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 5: energy

5.1 Please indicate to what extent you agree or disagree with the following statement:

I don't really give much thought to saving energy in my home.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

5.2 Please indicate to what extent you agree or disagree with the following statement:

I want to use more energy that is kinder to the environment.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

5.3 Please indicate to what extent you agree or disagree with the following statement:

I want to access locally-produced energy (such as energy from wind farms and solar panels).

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 6: waste

6.1 Please indicate to what extent you agree or disagree with the following statement:

I don't pay much attention to the amount of waste I produce at home.

Strongly agree ☐
Agree ☐
Somewhat agree ☐
Neither agree nor disagree ☐
Somewhat disagree ☐
Disagree ☐
Strongly disagree ☐
No opinion ☐
Don't know ☐
I'd rather not say ☐
Not applicable ☐

6.2 How often, on average, in the previous 12 months have you engaged in recycling?

Always ☐
More than half the time ☐
Half the time ☐
Less than half the time ☐
Never ☐
Don't know ☐
I'd rather not say ☐
Not applicable ☐

6.3 Please indicate to what extent you agree or disagree with the following statement:

People have a duty to recycle.

Strongly agree ☐
Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 7: water

7.1 Please indicate to what extent you agree or disagree with the following statement:

I don't pay much attention to the amount of water I use at home.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

7.2 Please indicate to what extent you agree or disagree with the following statement:

I want to use recycled water for some of my water usage (such as rainwater harvesting to flush the toilet).

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 8: food

8.1 Please indicate to what extent you agree or disagree with the following statement:

I don't pay much attention to the amount of food I use at home.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

8.2 How often, on average, in the previous 12 months have you engaged in recycling/composting of food?

Always ☐

More than half the time ☐

Half the time ☐

Less than half the time ☐

Never ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

8.3 Please indicate to what extent you agree or disagree with the following statement:

People have a duty to recycle/compost food.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

8.4 Please indicate to what extent you agree or disagree with the following statement:

I want to buy more food that is kinder to the environment.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

8.5 Please indicate to what extent you agree or disagree with the following statement:

I want to buy more local food from local businesses.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 9: Materials

9.1 Please indicate to what extent you agree or disagree with the following statement:

I don't pay much attention to the amount of materials I use at home (e.g., paper, plastics, metals, rare earth elements).

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

9.2 Please indicate to what extent you agree or disagree with the following statement:

I want to buy more goods that are kinder to the environment.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

9.3 Please indicate to what extent you agree or disagree with the following statement:

I want to buy goods containing more local materials from local businesses.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

9.4 How often, on average, in the previous 12 months have you bought locally produced goods?

Always ☐

More than half the time ☐

Half the time ☐

Less than half the time ☐

Never ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 10: Mobilities and transport

10.1 Please indicate to what extent you agree or disagree with the following statement:

Driving in Hay Mills is easy.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.2 Please indicate to what extent you agree or disagree with the following statement:

I am satisfied with the facilities for cycling in and around Hay Mills.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.3 Please indicate to what extent you agree or disagree with the following statement:

Cycling in Hay Mills is easy.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.4 Please indicate to what extent you agree or disagree with the following statement:

Walking in Hay Mills is easy.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.5 How satisfied are you with the accessibility of public transport in Hay Mills?

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐

Somewhat dissatisfied ☐

Dissatisfied ☐

Very dissatisfied ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.6 Please indicate to what extent you agree or disagree with the following statement:

I want to increase my use of alternative means of transport - including car sharing.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.7 Please indicate to what extent you agree or disagree with the following statement:

Most of the journeys I make by car could also be made on foot, on the bus, train, metro or by cycling.

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Disagree ☐
- Strongly disagree ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

10.8 How do you typically travel to work?

Please select one mode of travel only.

- by underground, metro, light rail, tram ☐
- by train ☐
- by bus, minibus or coach ☐
- by taxi ☐
- by motorcycle, scooter or moped ☐
- by driving a car or van ☐
- as a passenger in a car or van ☐
- by bicycle ☐
- on foot ☐
- I work mainly at or from home ☐

10.9 If you travel to work, do you commute to a workplace located…

Within Hay Mills ☐

Outside Hay Mills ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.10 Have you moved into Hay Mills within the last 12 months?

Yes ☐

No ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.11 Please indicate to what extent you agree or disagree with the following statement:

I don't pay much attention to the amount of travelling I undertake.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

10.12 Please indicate to what extent you agree or disagree with the following statement:

I want to travel more often in ways that are kinder to the environment.

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Disagree ☐
- Strongly disagree ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

Section 11: life satisfaction

11.1 Overall, how satisfied are you with your ***life*** nowadays?

- Very satisfied ☐
- Satisfied ☐
- Somewhat satisfied ☐
- Neither satisfied nor dissatisfied ☐
- Somewhat dissatisfied ☐
- Dissatisfied ☐
- Very dissatisfied ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

11.2 Overall, how satisfied are you with your ***family life*** nowadays?

- Very satisfied ☐
- Satisfied ☐
- Somewhat satisfied ☐
- Neither satisfied nor dissatisfied ☐
- Somewhat dissatisfied ☐
- Dissatisfied ☐
- Very dissatisfied ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

11.3 Overall, how satisfied are you with your ***social life*** nowadays?

- Very satisfied ☐
- Satisfied ☐
- Somewhat satisfied ☐
- Neither satisfied nor dissatisfied ☐
- Somewhat dissatisfied ☐
- Dissatisfied ☐
- Very dissatisfied ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

11.4 Overall, to what extent do you feel that the things you do in your life are worthwhile?

- Very worthwhile ☐
- Worthwhile ☐
- Somewhat worthwhile ☐
- Neither worthwhile nor not worthwhile ☐
- Somewhat not worthwhile ☐
- Not worthwhile ☐

Very not worthwhile ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

11.5 Overall, how ***happy*** did you feel yesterday?

Very happy ☐

Happy ☐

Somewhat happy ☐

Neither happy nor unhappy ☐

Somewhat unhappy ☐

Unhappy ☐

Very unhappy ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

11.6 How ***anxious*** did you feel yesterday?

Very anxious ☐

Anxious ☐

Somewhat anxious ☐

Neither anxious nor unanxious ☐

Somewhat unanxious ☐

Unanxious ☐

Very unanxious ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

11.7 Overall, how ***optimistic*** do you feel about the next 12 months?

- Very optimistic ☐
- Optimistic ☐
- Somewhat optimistic ☐
- Neither optimistic nor unoptimistic ☐
- Somewhat unoptimistic ☐
- Unoptimistic ☐
- Very unoptimistic ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

Section 12: environmental and climate change

12.1 Please indicate to what extent you agree or disagree with the following statement:

I find it hard to change my habits to be more environmentally friendly.

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Disagree ☐
- Strongly disagree ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

12.2 Which one of the following options best describes how you feel about your current lifestyle and the environment (select one):

I'd like to do a lot more to help the environment ☐

I'd like to do a bit more to help the environment ☐

I'm happy with what I do at the moment ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

12.3. Which of the following best describes your current lifestyle (select one)?

I'm environmentally friendly in everything I do ☐

I'm environmentally friendly in most things I do ☐

I do quite a few things that are environmentally friendly ☐

I do one or two things that are environmentally friendly ☐

I don't really do anything that is environmentally friendly ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

12.4 Please indicate to what extent you agree or disagree with the following statement:

I feel well informed about ways in which I can reduce my carbon footprint.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

12.5 Please indicate to what extent you agree or disagree with the following statement:

Human-induced climate change is happening.

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Disagree ☐
- Strongly disagree ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

12.6 Please indicate to what extent you agree or disagree with the following statement:

The effects of climate change are too far in the future to really worry me.

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Disagree ☐
- Strongly disagree ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

Section 13: safety

13.1 How safe do you feel in Hay Mills?

- Very safe ☐
- Safe ☐
- Somewhat safe ☐
- Neither safe nor unsafe ☐
- Somewhat unsafe ☐
- Unsafe ☐
- Very unsafe ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

13.2 How safe do you feel walking alone in Hay Mills after dark?

- Very safe ☐
- Safe ☐
- Somewhat safe ☐
- Neither safe nor unsafe ☐
- Somewhat unsafe ☐
- Unsafe ☐
- Very unsafe ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

13.3 Please indicate to what extent you agree or disagree with the following statement:

It is safe for children to play outside in my neighbourhood.

- Strongly agree ☐
- Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 14: social support and cohesion

14.1 Please indicate to what extent you agree or disagree with the following statement:

I believe that people from different backgrounds get on well together in my local area.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

14.2 Please indicate to what extent you agree or disagree with the following statement:

I feel close to the people in my local area.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

14.3 About how often do you visit with any of your neighbours, either at their homes or at your own?

At least once a week ☐

At least once a month ☐

Several times a year ☐

Once a year or less ☐

Never / almost never ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

14.4 Please indicate to what extent you agree or disagree with the following statement:

I enjoy meeting up with my friends in Hay Mills.

Strongly agree ☐

Agree ☐

Somewhat agree ☐

Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

14.5 Are you registered to vote?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

14.6 Did you vote in the most recent election (whether local or national)?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

14.7 How frequently do you do unpaid voluntary work?

At least once a week ☐

At least once a month ☐

Several times a year ☐

Once a year or less ☐

Never / almost never ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

14.8 Do you have a spouse, family member or friend to rely on if you have a serious problem?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

14.9 Roughly, how often do you have a face-to-face conversation with a close friend, relative or someone else close to you (apart from your spouse or partner), about how you are feeling or just to catch up?

- At least once a week ☐
- At least once a month ☐
- Several times a year ☐
- Once a year or less ☐
- Never / almost never ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

14.10 In general, how would you rate the quality of state childcare services in Hay Mills?

- Very good ☐
- Good ☐
- Somewhat good ☐
- Neither good nor bad ☐
- Somewhat bad ☐
- Bad ☐
- Very bad ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

14.11 In general, how would you rate the quality of care services for the elderly in Hay Mills?

- Very good ☐
- Good ☐
- Somewhat good ☐
- Neither good nor bad ☐
- Somewhat bad ☐
- Bad ☐
- Very bad ☐
- No opinion ☐
- Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 15: health

15.1 Have you participated in sport, at moderate intensity, for at least 30 minutes on at least 4 days out of the last 4 weeks?

This does not include recreational walking or recreational cycling.

It does include the following more organised and intense/strenuous walking activities: Backpacking, Hill trekking, Cliff Walking, Gorge Walking, Hill walking, Rambling, Power walking and sport ‘walking’. It includes the following light intensity activities for those aged 65 and over: yoga, pilates, indoor and outdoor bowls, archery and croquet.

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

15.2 Please indicate if you smoke.

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

15.3 On average, how much time would you say you spend sleeping in a 24 hour period?

_____

Please leave blank if you don’t know or you would rather not say.

15.4 On average, how much time would you say you spend in leisure pursuits in a 24 hour period?

_____

Please leave blank if this question does not apply to you, you don't know or you would rather not say.

15.5 How satisfied are you with the amount of leisure time you have.

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐

Somewhat dissatisfied ☐

Dissatisfied ☐

Very dissatisfied ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

15.6 Have you engaged with, or participated in, arts or cultural activity at least 3 times in the last year?

Yes ☐

No ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

15.7 How satisfied are you with the sports provision of your local area.

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐
Somewhat dissatisfied ☐
Dissatisfied ☐
Very dissatisfied ☐
No opinion ☐
Don't know ☐
I'd rather not say ☐
Not applicable ☐

15.8 How would you describe your overall health?

Very good ☐
Good ☐
Somewhat good ☐
Neither good nor bad ☐
Somewhat bad ☐
Bad ☐
Very bad ☐
No opinion ☐
Don't know ☐
I'd rather not say ☐

15.9 How satisfied are you with your health in general?

Very satisfied ☐
Satisfied ☐
Somewhat satisfied ☐
Neither satisfied nor dissatisfied ☐
Somewhat dissatisfied ☐
Dissatisfied ☐
Very dissatisfied ☐
No opinion ☐
Don't know ☐
I'd rather not say ☐
Not applicable ☐

15.10 Do you have any long-standing physical or mental impairment, illness or disability?

By 'long-standing' I mean anything that has troubled you over a period of at least 12 months or that is likely to trouble you over a period of at least 12 months.

Yes ☐

No ☐

Don't know ☐

I'd rather not say ☐

15.11 If you know your Body Mass Index (BMI) please write it here. If not, please write your height and weight.

_____

Please leave blank if you don't know or you would rather not say.

15.12 Have you accessed NHS mental health services at any time in the last 12 months?

Yes ☐

No ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

15.13 Below are some statements about feelings and thoughts. Please tick the box that best describes your experience of each over the last two weeks.

	Always	More than half the time	Half the time	Less than half the time	Never	Don't know	I'd rather not say	Not applicable
I've been feeling optimistic about the future	☐	☐	☐	☐	☐	☐	☐	☐
I've been feeling useful	☐	☐	☐	☐	☐	☐	☐	☐
I've been feeling relaxed	☐	☐	☐	☐	☐	☐	☐	☐
I've been dealing with problems well	☐	☐	☐	☐	☐	☐	☐	☐
I've been thinking clearly	☐	☐	☐	☐	☐	☐	☐	☐
I've been feeling close to other people	☐	☐	☐	☐	☐	☐	☐	☐
I've been able to make up my own mind about things	☐	☐	☐	☐	☐	☐	☐	☐

15.14 In general, how would you rate the quality of public health services in Hay Mills?

Very good ☐

Good ☐

Somewhat good ☐

Neither good nor bad ☐

Somewhat bad ☐

Bad ☐

Very bad ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 16: household finances

16.1 What are your average weekly or monthly earnings (before tax)?

Weekly earnings £_____

Monthly earnings £_____

Don't know ☐

I'd rather not say ☐

Not applicable ☐

16.2 How satisfied are you with the income of your household?

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐

Somewhat dissatisfied ☐

Dissatisfied ☐

Very dissatisfied ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

16.3 Are you claiming a key out of work benefit (such as Jobseeker's Allowance, Income Support, Employment and Support Allowance, Incapacity Benefit, Severe Disablement Allowance and Carer's Allowance)?

Yes ☐

No ☐

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

16.4 How satisfied are you with your present standard of living?

- Very satisfied ☐
- Satisfied ☐
- Somewhat satisfied ☐
- Neither satisfied nor dissatisfied ☐
- Somewhat dissatisfied ☐
- Dissatisfied ☐
- Very dissatisfied ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

16.5 How well would you say you yourself are managing financially these days? Would you say you are.... ?

- Living comfortably ☐
- Doing alright ☐
- Just about getting by ☐
- Finding it quite difficult ☐
- Finding it very difficult ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

Section 17: city finances

17.1 Please indicate to what extent you agree or disagree with the following statement:

The local authority spends its resources in a responsible way.

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐

Somewhat disagree ☐

Disagree ☐

Strongly disagree ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

Section 18: governance

18.1 Broadly speaking, what are your political leanings?

Conservative ☐

Labour ☐

Liberal Democrat ☐

Green ☐

Other (please specify) _

I don’t have political leanings ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

18.2 How satisfied are you with the basic services offered by your local authority?

Very satisfied ☐

Satisfied ☐

Somewhat satisfied ☐

Neither satisfied nor dissatisfied ☐

Somewhat dissatisfied ☐

Dissatisfied ☐

Very dissatisfied ☐

No opinion ☐

Don't know ☐

I'd rather not say ☐

Not applicable ☐

18.3 In general, how satisfied are you with the way your local authority is doing its job?

- Very satisfied ☐
- Satisfied ☐
- Somewhat satisfied ☐
- Neither satisfied nor dissatisfied ☐
- Somewhat dissatisfied ☐
- Dissatisfied ☐
- Very dissatisfied ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

18.4 Please indicate to what extent you agree or disagree with the following statement:

My local authority is committed to the fight against climate change (e.g., reducing energy consumption in housing).

- Strongly agree ☐
- Agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Disagree ☐
- Strongly disagree ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

18.5 Please tick the box that best describes your feelings towards of each level of government.

	National government	City government	Neighbourhood government
Tend to trust it	☐	☐	☐
Tend not to trust it	☐	☐	☐
Have no opinion	☐	☐	☐
Don't know	☐	☐	☐
Would rather not say	☐	☐	☐
Not applicable	☐	☐	☐

Section 19: education

19.1 Please indicate your highest qualification.

O level/GCSE ☐

(please state number and grades, e.g., A*, A, B, C, etc.) _____

_____

_____

_____

_____

A level / A/S level or equivalent ☐

(please state number obtained)_____

First degree e.g., BSc or equivalent ☐

Vocational qualification ☐

(please state type and level)_____

Degree/Professional Equivalent ☐

Postgraduate degree ☐

No formal qualification ☐

Other (please specify)_____

Don't know ☐

I'd rather not say ☐

Not applicable ☐

19.2 In general, how would you rate the quality of local education services in Hay Mills?

- Very good ☐
- Good ☐
- Somewhat good ☐
- Neither good nor bad ☐
- Somewhat bad ☐
- Bad ☐
- Very bad ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

19.3 Answering on behalf of each of the children in this household that are currently in school, how happy are they about the school that they go to?

	Child 1	Child 2	Child 3	Child 4
Very happy	☐	☐	☐	☐
Happy	☐	☐	☐	☐
Fairly happy	☐	☐	☐	☐
Neither happy nor unhappy	☐	☐	☐	☐
Fairly unhappy	☐	☐	☐	☐
Unhappy	☐	☐	☐	☐
Very unhappy	☐	☐	☐	☐
Don’t know	☐	☐	☐	☐
No opinion	☐	☐	☐	☐
I’d rather not say	☐	☐	☐	☐

	Child 5	Child 6	Child 7	Child 8
Very happy	☐	☐	☐	☐
Happy	☐	☐	☐	☐
Fairly happy	☐	☐	☐	☐
Neither happy nor unhappy	☐	☐	☐	☐
Fairly unhappy	☐	☐	☐	☐
Unhappy	☐	☐	☐	☐
Very unhappy	☐	☐	☐	☐
Don’t know	☐	☐	☐	☐
No opinion	☐	☐	☐	☐
I’d rather not say	☐	☐	☐	☐

Section 20: employment

20.1 What best describes your current situation?

Employed full time (including maternity) ☐

Employed part time (including maternity) ☐

Self-employed full time ☐

Self-employed part time ☐

Unemployed and seeking work ☐

Unemployed and not seeking work ☐

Student ☐

Retired ☐

In full-time higher education ☐

In part-time higher education ☐

Other (please specify)_

Don’t know ☐

I’d rather not say ☐

Not applicable ☐

20.2 What best describes your situation 1, 2, 3, 4 and 5 years ago?

	1 year ago	2 years ago	3 years ago	4 years ago	5 years ago
Employed full time (including maternity)	☐	☐	☐	☐	☐
Employed part time (including maternity)	☐	☐	☐	☐	☐
Self-employed full time	☐	☐	☐	☐	☐
Self-employed part time	☐	☐	☐	☐	☐
Unemployed and seeking work	☐	☐	☐	☐	☐
Unemployed and not seeking work	☐	☐	☐	☐	☐
Student	☐	☐	☐	☐	☐
Retired	☐	☐	☐	☐	☐
In full-time higher education	☐	☐	☐	☐	☐
In part-time higher education	☐	☐	☐	☐	☐
Other (please specify)					
Don’t know	☐	☐	☐	☐	☐
I’d rather not say	☐	☐	☐	☐	☐
Not applicable	☐	☐	☐	☐	☐

20.3 Which of the following best describes your occupation?

Higher managerial, administrative and professional occupations ☐
(such as finance manager or chief executive)

Lower managerial, administrative and professional occupations ☐
(such as secretary, personal assistant, clerical worker, office clerk, call centre agent, nursing auxiliary, nursery nurse)

Intermediate occupations ☐
(such as office manager, retail manager, bank manager, restaurant manager, warehouse manager, publican)

Small employers and own account workers ☐

Lower supervisory and technical occupations ☐
(such as motor mechanic, fitter, inspector, plumber, printer, tool maker, electrician, gardener, train driver)

Semi-routine occupations ☐
(such as postal worker, machine operative, security guard, caretaker, farm worker, catering assistant, receptionist, sales assistant)

Routine occupations ☐
(such as HGV driver, van driver, cleaner, porter, packer, sewing machinist, messenger, labourer, waiter/waitress, bar staff)

20.4 On average, how much time would you say you spend working in a 24 hour period?

_____

Please leave blank if this question does not apply to you, you don't know or you would rather not say.

20.5 Do you work…

Part-time ☐

Full-time ☐

Both part-time and full-time ☐

I don't work ☐

Other (please specify)_

Don't know ☐

I'd rather not say ☐

20.6 If you are eligible to join your employer's workplace pension scheme, have you?

- Yes ☐
- No ☐
- Don’t know ☐
- I’d rather not say ☐
- Not applicable ☐

20.7 How satisfied are you with your job (if in employment)?

- Very satisfied ☐
- Satisfied ☐
- Somewhat satisfied ☐
- Neither satisfied nor dissatisfied ☐
- Somewhat dissatisfied ☐
- Dissatisfied ☐
- Very dissatisfied ☐
- No opinion ☐
- Don't know ☐
- I'd rather not say ☐
- Not applicable ☐

Section 21: IT

21.1 Have you accessed the internet in the last year?

- Yes ☐
- No ☐
- Don’t know ☐
- I’d rather not say ☐
- Not applicable ☐

APPENDIX J. AUTHOR CONTRIBUTIONS

This appendix contains the author contributions for each paper and co-author statements of my contributions.

Author contributions

1. Joanne Leach and Christopher Boyko wrote the paper. Rachel Cooper, Anna Woodeson, Jim Eyre, and Christopher Rogers contributed to writing the manuscript. Joanne Leach and Christopher Boyko conceived, designed, and undertook the semi-structured interviews. Joanne Leach and Christopher Boyko analysed the data.
2. Joanne Leach and Chris Rogers wrote the paper. Peter Braithwaite, Susan Lee, Christopher Bouch, and Dexter Hunt contributed to writing the manuscript. Joanne Leach and Peter Braithwaite conceived the lens framework. Joanne Leach undertook the case study.
3. Joanne Leach wrote the paper. Susan Lee, Dexter Hunt, and Chris Rogers contributed to writing the manuscript. Joanne Leach conceived, designed, and implemented the visualisation technique. Chris Rogers provided substantial feedback on its implementation.
4. Joanne Leach wrote the paper. Christoper Boyko, Claire Coulton, Rachel Cooper, Nicholas Smith, Hélène Joffe, Milena Büchs, James Hale, Jon Sadler, Peter Braithwaite, Luke Blunden, Valeria De Laurentiis, Dexter Hunt, AbuBakr Bahaj, Katie Barnes, Christopher Bouch, Leonidas Bourikas, Marianna Cavada, Andrew Chilvers, Stephen Clune, Brian Collins, Ellie Cosgrave, Nick Dunn, Jane Falkingham, Philip James, Corina Kwami, Martin Locret-Collet, Francesca

Medda, Adriana Ortegon, Serena Pollastri, Cosmin Popan, Katerina Psarikidou, Nick Tyler, John Urry, Phil Wu, Victoria Zeeb, and Chris Rogers provided substantial feedback on UK City LIFE$_1$ and conducted the primary data collection. Joanne Leach conducted the secondary data collection.

5. Joanne Leach and Rachel Mulhall wrote the paper. Chris Rogers and John Bryson contributed to writing the manuscript. Joanne Leach conceived, designed, and undertook the evidence mapping. John Bryson conceived the Principal Components Analysis and Rachel Mulhall undertook it. Joanne Leach and Rachel Mulhall analysed the data.
6. Joanne Leach and Rachel Mulhall wrote the paper. John Bryson and Chris Rogers and contributed to writing the manuscript. Joanne Leach conceived, designed, and undertook the evidence mapping. John Bryson conceived the Principal Components Analysis and Rachel Mulhall undertook it. Joanne Leach and Rachel Mulhall analysed the data.
7. Joanne Leach and Chris Rogers wrote the paper. Adriana Ortegon-Sanchez and Nick Tyler provided feedback on the manuscript and contributed the ideal city model. Joanne Leach and Chris Rogers conceived and designed the method and Joanne Leach undertook the analysis.

Co-author statements

AbuBakr Bahaj

From: Bahaj A.S. [A.S.Bahaj@soton.ac.uk]
Sent: 16 May 2018 17:39
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Dear Joanne

I agree with the statement in the email below.

Please let me know needs further info.

Regards
AbuBakr S. Bahaj
www.energy.soton.ac.uk
Sent from a mobile device.....

From: Joanne Leach
Sent: 16 May 2018 16:21
To: AbuBakr Bahaj (A.S.Bahaj@soton.ac.uk)
Subject: Request for paper contribution statement

Dear 'Bakr,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. AbuBakr Bahaj, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as

measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Katie Barnes

From: k.l.barnes.88@cantab.net <k.l.barnes.88@cantab.net>
Sent: 18 May 2018 22:23
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: Re: Request for paper contribution statement

Hello Joanne

Yes, very happy to provide confirmation of your lead author role:

I, Katie Barnes, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

Very best of luck with the PhD submission.

Kind regards

Katie

On Wed, 16 May 2018 18:20 Joanne Leach, <J.Leach@bham.ac.uk> wrote:
Dear Katie,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Katie Barnes, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Luke Blunden

From: Blunden L.S. [lsb1@soton.ac.uk]
Sent: 16 May 2018 23:55
To: Joanne Leach
Subject: RE: Request for paper contribution statement

Hi Joanne,

I'm totally happy with the text of your statement. Hope all goes well with wrapping up the PhD.

Best wishes,

Luke

From: Joanne Leach [mailto:J.Leach@bham.ac.uk]
Sent: 16 May 2018 18:05
To: Blunden L.S.
Subject: Request for paper contribution statement

Dear Luke,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Luke Blunden, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Christopher Bouch

From: Christopher Bouch (School of Engineering)
Sent: 17 May 2018 09:04
To: Joanne Leach
Subject: STATEMENT OF FIRST AUTHOR CONTRIBUTION

Hi Joanne

I, Chris Bouch, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
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Regards

Chris

Mr Chris Bouch
Senior Research Fellow
Liveable Cities project (http://liveablecities.org.uk/)
iBUILD project (https://research.ncl.ac.uk/ibuild/)
School of Civil Engineering
University of Birmingham
B15 2TT
United Kingdom
Tel: 075 8717 5535

Leonidas Bourikas

From: Bourikas L. [L.Bourikas@soton.ac.uk]
Sent: 17 May 2018 10:33
To: Joanne Leach
Subject: RE: Request for paper contribution statement

Dear Joanne,

I agree with the statement below.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Leonidas Bourikas, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

Congratulations for finishing your PhD study. Wish you have a good submission and a good viva and I am sure that you will succeed. Good luck!

Best Wishes,

Leo

Dr Leo Bourikas, MEng, MSc, PhD
Research Fellow
Sustainable Energy Research Group
Energy and Climate Change
Faculty of Engineering and the Environment
Civil, Maritime and Environmental Engineering and Science
Room 5013, Building 7
University of Southampton

T: 00 44 2380 593940
W: www.energy.soton.ac.uk
E: L.Bourikas@soton.ac.uk
Twitter @lbourik | Skype lbourik

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 16 May 2018 18:07
To: Bourikas L. <L.Bourikas@soton.ac.uk>
Subject: Request for paper contribution statement

Dear Leo,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Leonidas Bourikas, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Christopher Boyko

From: Boyko, Christopher [c.boyko@lancaster.ac.uk]
Sent: 17 May 2018 09:41
To: Joanne Leach
Subject: Re: Request for paper contribution statement

Hi Joanne,

I agree with the statement you drafted and have nothing else to add... other than to say GOOD LUCK with submitting your PhD by publication! :)

Hope you're doing well!

Kind regards,
Chris

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 17 May 2018 06:58:05
To: Boyko, Christopher
Subject: Request for paper contribution statement

Dear Chris,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Christopher Boyko, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Leach JM, Boyko CT, Cooper R, Woodeson A, Eyre J, Rogers CDF (2014). Do sustainability measures constrain urban design creativity? Proceedings of the ICE: Urban Design and Planning. 168(1): 30-41. DOI: 10.1680/udap.13.00034. Winner of the Reed & Mallik Prize.

Kind regards, Joanne

Peter Braithwaite

From: Peter Braithwaite
Sent: 05 June 2018 09:14
To: Joanne Leach
Subject: RE: Request for paper contribution statement

Joanne,

Sorry for the tardiness in responding to you, afraid ARLI has overtaken my University life lately!

Yes, I'm happy for you to include the draft statement in your thesis – and am pleased to hear that you are almost at the end of the process, quite an achievement considering your PM commitments!

Best wishes

Peter

Peter Braithwaite
Director of Engineering Sustainability
Birmingham Centre for Resilience Research and Education
School of Engineering
University of Birmingham
Edgbaston
Birmingham
B15 2TT
Tel: 0121 414 3143

Senior Technical Officer
Alternative Resources with Low Impact (ARLI) Research Project

E: ARLI@contacts.bham.ac.uk
Web: ARLI

From: Joanne Leach
Sent: 17 May 2018 07:03
To: Peter Braithwaite (p.braithwaite@bham.ac.uk) <p.braithwaite@bham.ac.uk>
Subject: Request for paper contribution statement

Dear Peter,

I hope this email finds you well.

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Peter Braithwaite, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Leach, JM, Braithwaite, PA, Lee, SE, Bouch, CJ, Hunt, DVL and Rogers, CDF (2016). Measuring urban sustainability and liveability performance: the City Analysis Methodology, Int. J. Complexity in Applied Science and Technology. 1(1): 86-106.

Kind regards, Joanne

John Bryson

From: John Bryson
Sent: 17 May 2018 09:54
To: Joanne Leach
Subject: RE: Request for paper contribution statement
Dear Joanne,

I am happy with this and wish you all the best with this.

Best wishes

John

From: Joanne Leach
Sent: 17 May 2018 06:40
To: John Bryson
Subject: Request for paper contribution statement

Dear John,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. John Bryson, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; is ensuring that all co-authors review and approve the manuscript before publication; and, is acting as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Mulhall RA, Rogers CDF and Bryson JR (at review). Urban Diagnostics and Identifying Integrated Urban Problems in the City of Birmingham, UK. Cities.

Kind regards, Joanne

Milena Büchs

From: Milena Buchs [M.M.Buchs@leeds.ac.uk]
Sent: 17 May 2018 08:11
To: Joanne Leach
Subject: RE: Request for paper contribution statement

Hi Joanne,

Thanks for checking, sure, that's absolutely fine. All the best for the submission!! ☺

Cheers, Milena

From: Joanne Leach [mailto:J.Leach@bham.ac.uk]
Sent: 16 May 2018 18:11
To: Milena Buchs <M.M.Buchs@leeds.ac.uk>
Subject: Request for paper contribution statement

Dear Milena,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Milena Buchs, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS,

Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Marianna Cavada

From: Marianna Cavada (Studying PhD Dept of Civil Eng FT)
Sent: 17 May 2018 18:28
To: Joanne Leach
Subject: RE: Request for paper contribution statement

Dear Joanne

Yes that is fine with me

All the best with the submission and viva!

Rgds

Marianna

_____

From: Joanne Leach
Sent: 17 May 2018 07:05
To: Marianna Cavada (Studying PhD Dept of Civil Eng FT)
Subject: Request for paper contribution statement

Dear Marianna,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include

a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Marianna Cavada, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695. http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Joanne Leach

Andrew Chilvers

From: Chilvers, Andrew [a.chilvers@ucl.ac.uk]
Sent: 23 May 2018 17:41
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Hi Joanne,

I agree with the statement in your email below and am happy for you to reproduce it in any documentation pertaining to your PhD submission(s).

Best wishes,

Andrew

Dr Andrew Chilvers

Honorary Lecturer
Department of Science, Technology, Engineering and Public Policy (STEaPP)
University College London (UCL)

+44 (0) 7944 100 161
Skype: andrew.chilvers

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 23 May 2018 16:39
To: Chilvers, Andrew
Subject: RE: Request for paper contribution statement

Hi Andrew,

Oops! I was pretty sure there would be at least one email containing an error as I sent somewhere in the region of 50 emails that were almost identical. I'm sorry it was yours that contained a mistake.

All I need from you is an email in response to mine stating that you agree with the statement, which I've corrected and is below. It would be best if you responded again – just for clarity. A simple 'I agree' will suffice.

Thanks in advance!

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Andrew Chilvers, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695. http://www.sciencedirect.com/science/article/pii/S2352340917305218

All the best, Joanne

From: Chilvers, Andrew <a.chilvers@ucl.ac.uk>
Sent: 21 May 2018 11:02
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: Re: Request for paper contribution statement

Joanne,

I am a little unsure what you need from me - is it just an email saying that I am happy with the statement you have copied into your email? If so, provided you use my name in place of Katie's name (the statement you have copied reads "I, Katie Barnes, ..."!), I am happy for you to recreate that statement in my name - in short, *I agree*. If you need something further from me then please do say.

Best of luck pulling together your PhD materials.

Andrew

Dr Andrew Chilvers

Honorary Lecturer

Department of Science, Technology, Engineering and Public Policy (STEaPP)
University College London (UCL)

+44 (0) 7944 100 161
Skype: andrew.chilvers

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 16 May 2018 18:16
To: Chilvers, Andrew
Subject: Request for paper contribution statement

Dear Andrew,

I hope this email finds you well.

As (I think...) you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Katie Barnes, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as

measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Stephen Clune

This statement was originally produced on letterhead as a pdf

06 June 2018

Re: JOANNE LEACH STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Stephen Clune, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Regards Stephen Clune

Director
Sustainability research and design
13 Centenary Avenue
Cootamundra, NSW 25
e: Stephen@s-rad.com
m: 0402 768 006
ABN 93 352 025 120

Brian Collins

From: Collins, Brian [brian.collins@ucl.ac.uk]
Sent: 16 May 2018 20:05
To: Joanne Leach
Subject: RE: Request for paper contribution statement

Joanne

I agree; that is an accurate statement of affairs; well done!!

Best wishes

Professor Brian Collins CB, FREng
Professor of Engineering Policy
Convenor of UKCRIC
Department of Civil, Environmental and Geomatic Engineering
UCL
Room 203, Chadwick Building
Gower Street
London
WC1E 6BT, UK

Email: Brian.collins@ucl.ac.uk
Tel: +442076797291
www.ucl.ac.uk/cege

http://www.ucl.ac.uk/steapp/isngi

https://www.youtube.com/watch?v=gVo6Sa2J5c4

https://www.youtube.com/channel/UCtVvFrBElD8rmZ3te6-sYmg?feature=g-high-f

http://www.youtube.com/watch?v=gVo6Sa2J5c4&index=5&list=PLsRNoUx8w3rNYPACQ4oxdeAcg8mjtpaFP

From: Joanne Leach [mailto:J.Leach@bham.ac.uk]
Sent: 16 May 2018 18:24
To: Collins, Brian <brian.collins@ucl.ac.uk>
Subject: Request for paper contribution statement

Dear Brian,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Brian Collins, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Rachel Cooper

From: Cooper, Rachel (LICA) <r.cooper@lancaster.ac.uk>
Sent: 21 May 2018 10:27
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: Re: Request for paper contribution statement

Dear Joanne

Of course I agree, I am looking forward to you getting your PhD!!!

Do you need me to do anything like put it on headed paper or anything?

Best wishes

Rachel Cooper OBE
Distinguished Professor: Design Management and Policy
Director: ImaginationLancaster http://imagination.lancs.ac.uk
Chair: Lancaster Institute for the Contemporary Arts http://www.lancaster.ac.uk/fass/lica/
Lancaster University
LA1 4YW

President: Design Research Society

PA: Ruth Templeton
01524 510873
e-mail: Ruth.Templeton@lancaster.ac.uk

Latest Liveable cities video: https://www.youtube.com/watch?v=OBtxQioczJw

Liveable cities final outcomes: http://liveablecities.org.uk/updates/liveable-cities-final-outcomes

From: Joanne Leach <J.Leach@bham.ac.uk>
Date: Thursday, 17 May 2018 at 07:08
To: Rachel Cooper <r.cooper@lancaster.ac.uk>
Subject: Request for paper contribution statement

Dear Rachel,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Rachel Cooper, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took

responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Leach JM, Boyko CT, Cooper R, Woodeson A, Eyre J, Rogers CDF (2014). Do sustainability measures constrain urban design creativity? Proceedings of the ICE: Urban Design and Planning. 168(1): 30-41. DOI: 10.1680/udap.13.00034. Winner of the Reed & Mallik Prize.

Kind regards, Joanne

Ellie Cosgrave

From: Cosgrave, Ellie [e.cosgrave@ucl.ac.uk]
Sent: 05 June 2018 17:16
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Dear Joanne,

huge apologies for the delayed reply on this, i had forgotten!

I agree with the below statement:

Ellie Cosgrave, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695. http://www.sciencedirect.com/science/article/pii/S2352340917305218

On 4 Jun 2018, at 10:18, Joanne Leach <j.leach@bham.ac.uk> wrote:

<LeachEtAl2017DatasetOfTheLivabilityPerformanceOfTheCityOfBirmingham.pdf>

Dr Ellie Cosgrave
Director, UCL City Leadership Laboratory
Lecturer in Urban Innovation and Policy
University College London

Department of Science, Technology, Engineering
and Public Policy (UCL STEaPP)
36-38 Fitzroy Square (2nd Floor)
London W1T 6EY

e.cosgrave@ucl.ac.uk
Tel: +44 (0)203 108 9434
Mob: +44 (0)7712452208

www.ucl.ac.uk/steapp
@elliecosgrave

Find out about our Master in Urban Innovation and Policy (MPA)
- http://www.ucl.ac.uk/steapp/study/masters/2018-19/urban-innovation-policy
Applications for 2018-19 now open.

Claire Coulton

From: Coulton, Claire [c.coulton2@lancaster.ac.uk]
Sent: 16 May 2018 19:32
To: Joanne Leach
Subject: Re: Request for paper contribution statement

Dear Joanne,

I agree with the statement below and confirm you are first author.

Best wishes,
Claire

Dr C Coulton
Lancaster University

Sent from my iPhone

On 16 May 2018, at 18:23, Joanne Leach <J.Leach@bham.ac.uk> wrote:

Dear Claire,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Claire Coulton, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon

emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Joanne Leach

Valeria De Laurentiis

From: valeria.delaurentiis@gmail.com [valeria.delaurentiis@gmail.com]
Sent: 04 June 2018 13:35
To: Joanne Leach
Subject: Re: FW: Request for paper contribution statement
Dear Joanne,

Sorry I must have missed the previous email.

Yes I am happy with the statement you wrote and I fully agree.

Good luck with your submission.

Kind regards,

Valeria

From: Joanne Leach
Sent: 17 May 2018 07:11
To: Valeria De Laurentiis (valeria.delaurentiis@gmail.com) <valeria.delaurentiis@gmail.com>
Subject: Request for paper contribution statement

Dear Valeria,

I hope this email finds you well.

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Valeria De Laurentiis, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Joanne Leach

Nick Dunn

From: Dunn, Nick [nick.dunn@lancaster.ac.uk]
Sent: 17 May 2018 08:36
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Dear Joanne,

Thanks for your email, just a quick note to confirm I completely agree with the statement below.

Very best wishes with getting everything together for your PhD by publication,

N.

Professor Nick Dunn
Chair of Urban Design

Executive Director: ImaginationLancaster

Associate Director: Institute for Social Futures
Lancaster Institute for the Contemporary Arts

Tel: +44 (0) 1524 510793
http://imagination.lancaster.ac.uk/

www.lancaster.ac.uk

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 16 May 2018 18:27:10
To: Dunn, Nick
Subject: Request for paper contribution statement

Dear Nick,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Nick Dunn, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F,

Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Joanne Leach

Jim Eyre

From: j.eyre@wilkinsoneyre.com [j.eyre@wilkinsoneyre.com]
Sent: 17 May 2018 09:06
To: Joanne Leach
Subject: Paper Contribution Statement

Dear Joanne

Please find below confirmation as requested

Kind Regards

Jim

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Jim Eyre, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Boyko CT, Cooper R, Woodeson A, Eyre J, Rogers CDF (2014). Do sustainability measures constrain urban design creativity? Proceedings of the ICE: Urban Design and Planning. 168(1): 30-41. DOI: 10.1680/udap.13.00034. Winner of the Reed & Mallik Prize.

Jim Eyre
Director

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Jane Falkingham

From: Falkingham J.C. [J.C.Falkingham@soton.ac.uk]
Sent: 17 May 2018 05:52
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Dear Joanne

Thank you for your email. I am very happy to confirm your role and responsibilities as stated as first author.

With best wishes
Jane

Sent from my iPhone

On 17 May 2018, at 01:29, Joanne Leach <J.Leach@bham.ac.uk> wrote:

Dear Jane,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Jane Falkingham, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Mike Goodfellow-Smith

From: Michael Goodfellow-Smith
Sent: 17 May 2018 08:48
To: Joanne Leach
Subject: RE: Request for paper contribution statement
I totally agree!

Mike Goodfellow-Smith
FRSA;MIIRSM;MSI;PIEMA;MSc;BA;DipEM

PhD Researcher - Civil Engineering
iBuild and Liveable Cities
University of Birmingham
07966 283280
https://uk.linkedin.com/in/mikegoodfellowsmith
skype: mike.g-smith

From: Joanne Leach
Sent: 17 May 2018 07:16
To: Michael Goodfellow-Smith
Subject: Request for paper contribution statement

Dear Mike,

I hope this email finds you well.

As you may be are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Michael Goodfellow-Smith, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; is ensuring that all co-authors review and approve the manuscript before publication; and, is acting as corresponding author with the journal, managing the article proofing process through to publication.

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Kind regards, Joanne

Nick Grayson

From: Nick Grayson [Nick.Grayson@birmingham.gov.uk]
Sent: 18 May 2018 09:24
To: Joanne Leach
Subject: RE: Request for paper contribution statement
Joanne,
Thankyou for sharing this paper.
Yes I agree!

We are in discussions with BCU (the other place!) about a Climate KIC proposal on Ecosystem Innovation- I have proposed using the 9 step LCM; they seemed very keen on the idea; (I hope that's OK?)

I am also planning to use it with the Corporate Management Team at BCC- once I can get over a couple of immediate hurdles; like getting my new post confirmed.

Best regards Nick

Many thanks
Nick Grayson,

Nick Grayson,
Climate Change and Sustainability Manager,
Birmingham City Council,
Council House Extension,
6 Margaret Street, Room 110,
Birmingham B3 3BU
Email: nick_grayson@birmingham.gov.uk
Tel: 0121-464-1045
Mobile: 07766-923-340
View us at www.birmingham.gov.uk/parks

Helping make Birmingham a cleaner, greener, smarter City.

http://biophiliccities.org/
http://www.birmingham.gov.uk/greenlivingspaces

For more information on the Birmingham Natural Capital Planning Tool see:-
http://www.rics.org/uk/knowledge/research/research-reports/natural-capital-tool-planning-/

Liveable Cities Research: http://liveablecities.org.uk/
Liveable Cities Summary Film (7mins.) https://www.youtube.com/watch?v=OBtxQioczJw;

The Little Book of Ecosystem Services in Cities:
http://liveablecities.org.uk/outcomes/little-book-series;

The value of Nature in Cities video
https://www.youtube.com/watch?v=NJXiuAMHlig&t=0s&list=PLRXpIU2lq6E6neFQy9Flam24Lc1nOvQUp&index=12;

From: Joanne Leach [mailto:J.Leach@bham.ac.uk]
Sent: Thursday, May 17, 2018 7:23 AM
To: Nick Grayson
Subject: Request for paper contribution statement

Dear Nick,

I hope this email finds you well.

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Nick Grayson, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; is ensuring that all co-authors review and approve the manuscript before publication; and, is acting as corresponding author with the journal, managing the article proofing process through to publication.

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Kind regards, Joanne

James Hale

From: James Hale (School of Geography Earth and Environmental Sciences)
Sent: 23 May 2018 11:29
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: RE: Request for paper contribution statement

Dear Joanne,

This is great news. Yes, of course I can confirm that you were the main author and that you contributed the majority of the content and intellectual base.

Good luck with the PhD!

James

p.s. can you use jamesdavidhale@yahoo.co.uk for future contact. UoB email will soon dissapear

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http://urban-futures.org/

From: Joanne Leach
Sent: 17 May 2018 07:30
To: James Hale (School of Geography Earth and Environmental Sciences)
Subject: Request for paper contribution statement

Dear James,

I hope this email finds you well.

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, James Hale, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Dexter Hunt

From: Dexter Hunt
Sent: 17 May 2018 10:01
To: Joanne Leach
Subject: RE: Request for paper contribution statement
Hi Joanne

This is absolutely fine - these are all an excellent contribution to knowledge. It will be great to see you get the PhD that you have long deserved.

Best wishes

Dex

Dr Dexter Hunt
Lecturer in Sustainable and Underground Construction
Room E6
School of Civil Engineering
University of Birmingham
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B15 2TT
t. (+44) 0121 414 5148
w. www.urban-futures.org
w. www.liveablecities.org.uk
w. http://bioregionbirmingham.org/protecting-the-commons-water-availability-in-our-bioregion/

Most recent publication: http://www.mdpi.com/2071-1050/8/1/95

From: Joanne Leach
Sent: 17 May 2018 07:34
To: Dexter Hunt
Subject: Request for paper contribution statement
Dear Dexter,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Dexter Hunt, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Leach, JM, Lee, SE, Hunt, DVL and Rogers, CDF (2017). Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK, Cities. 71: 80-87.

Leach, JM, Braithwaite, PA, Lee, SE, Bouch, CJ, Hunt, DVL and Rogers, CDF (2016). Measuring urban sustainability and liveability performance: the City Analysis Methodology, Int. J. Complexity in Applied Science and Technology. 1(1): 86-106.

Kind regards, Joanne

Patrick James

From: James P.A.B. <P.A.James@soton.ac.uk>
Sent: 19 May 2018 10:01
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: RE: Request for paper contribution statement

Joanne

I agree with the statement outlined below regarding author contributions to your paper.
regards

patrick.

Patrick James BSc PhD CEng FCIBSE SFHEA
Professor of Energy and Buildings
Sustainable Energy Research Group
Energy and Climate Change

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Civil, Maritime and Environmental Engineering and Science
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E paj1@soton.ac.uk
Twitter @pab_james
Skype pab_james

From: Joanne Leach [J.Leach@bham.ac.uk]
Sent: 16 May 2018 18:30
To: James P.A.B.
Subject: Request for paper contribution statement

Dear Patrick,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would

be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Patrick James, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Hélène Joffe

From: Joffe, Helene [h.joffe@ucl.ac.uk]
Sent: 17 May 2018 08:58
To: Joanne Leach
Subject: Joanne Leach

I, Prof. Helene Joffe, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Corina Kwami

From: Kwami, Corina <corina.kwami.14@ucl.ac.uk>
Sent: 23 May 2018 09:21
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: Re: Request for paper contribution statement

Hi Joanne!

Hope all is well and congrats on the upcoming submission.

"Yes" I agree to the statement.

Speak soon,
Corina

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: Wednesday, May 16, 2018 7:16:27 PM
To: Kwami, Corina
Subject: Request for paper contribution statement

Dear Corina,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Corina Kwami, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for

the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Susan Lee

From: Susan Lee (Department of Civil Engineering)
Sent: 17 May 2018 09:18
To: Joanne Leach
Subject: RE: Request for paper contribution statement
This all looks fine to me.

Will you be at the Clark Lecture? If so, let me know if you would like me to sign anything?

How are things going with the Southampton/Lancaster data?

Good luck with the Ph.D. submission - you certainly have plenty of material to talk about!

Hope to see you next week and to catch up with everyone else.

Best wishes,
Susan

Dr. Susan E. Lee
Honorary Research Fellow
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s.e.lee@bham.ac.uk
0121 414 3544
www.liveablecities.org.uk
Transforming Birmingham - a city system approach
https://tinyurl.com/y7evq5e6

From: Joanne Leach
Sent: 17 May 2018 07:38
To: Susan Lee (Department of Civil Engineering)
Subject: Request for paper contribution statement
Dear Susan,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Susan Lee, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

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Leach, JM, Lee, SE, Hunt, DVL and Rogers, CDF (2017). Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK, Cities. 71: 80-87.

Leach, JM, Braithwaite, PA, Lee, SE, Bouch, CJ, Hunt, DVL and Rogers, CDF (2016). Measuring urban sustainability and liveability performance: the City Analysis Methodology, Int. J. Complexity in Applied Science and Technology. 1(1): 86-106.

Kind regards, Joanne

Martin Locret-Collet

From: martinlocret@hotmail.com [martinlocret@hotmail.com]
Sent: 17 May 2018 13:53
To: Joanne Leach
Subject: Re: Request for paper contribution statement

I Martin Locret-Collet, agree.

--

Martin Locret-Collet, Ph.D

Email: martinlocret@hotmail.com
Academia: Martin Locret-Collet
Twitter: @martinlocret
From: Joanne Leach <J.Leach@bham.ac.uk>
Date: Thursday, 17 May 2018 at 08:42
To: "Martin Locret-Collet - The University of Birmingham (martinlocret@hotmail.com)" <martinlocret@hotmail.com>
Subject: Request for paper contribution statement

Dear Martin,

I hope this email finds you well.

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Martin Locret-Collet, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Francesca Medda

From: Medda, Francesca <f.medda@ucl.ac.uk>
Sent: 28 May 2018 17:05
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: RE: Request for paper contribution statement

Dear Joanne,

Please accept my apologies for this delay but I lost your email and I was travelling.
In relation to the publication (Dataset of the liveability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218)
Here is my statement:
I, Prof. Francesca Medda, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation

of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.
Please let me know if you need additional information.

Yours sincerely,
Francesca

_____

Francesca Romana Medda, FICE
Professor of Applied Economics and Finance
Director QASER Laboratory
University College London
Gower Street, London, WC1E 6BT
www.ucl.ac.uk/qaser
Tel. +020 76791557
@F_Medda

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 16 May 2018 19:18
To: Medda, Francesca <f.medda@ucl.ac.uk>
Subject: Request for paper contribution statement

Dear Francesca,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Francesca Medda, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed

the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Rachel Mulhall

From: rachel.a.mulhall@gmail.com <rachel.a.mulhall@gmail.com>
Sent: 21 May 2018 07:38
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: PhD submission

Dear Joanne,

Thank you for your hard work bringing the paper together. Please find below my statement for the PhD submission:

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Rachel Mulhall, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; is ensuring that all co-authors review and approve the manuscript before publication; and, is acting as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Mulhall RA, Rogers CDF and Bryson JR (at review). Urban Diagnostics and Identifying Integrated Urban Problems in the City of Birmingham, UK. Cities.

Kind regards,
Rachel

Timea Nochta

From: Timea Nochta (PhD Local Government FT)
Sent: 04 June 2018 11:13
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: RE: Request for paper contribution statement

Dear Joanne,

Thank you for the reminder and apologies for not getting back to you earlier.
Please find below the statement as requested:

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Timea Nochta, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; is ensuring that all co-authors review and approve the manuscript before publication; and, is acting as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Best regards,
Timea

Ps. Please let me know if you prefer the statement in a separate document / attached file.

Timea Nochta
Doctoral Researcher
Institute of Local Government Studies
University of Birmingham
Edgbaston
B15 2TT

Adriana Ortegon-Sanchez

From: Ortegon, Adriana [adriana.ortegon.10@ucl.ac.uk]
Sent: 04 June 2018 17:02
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Dear Joanne,

Many apologies for my belated reply.

First of all, congratulations! From a fellow Liveable Cities Researcher/Part-time PhD student, I can say that doing both things at the same time is a great challenge, therefore, reaching the final line is a great accomplishment! and best of luck for the remaining path!

I agree with the Statement of First Author Contribution on your email below.

Best regards,

Adriana

From: Joanne Leach
Sent: 17 May 2018 07:44
To: Adriana Ortegon (adriana.ortegon.10@ucl.ac.uk) <adriana.ortegon.10@ucl.ac.uk>
Subject: Request for paper contribution statement

Dear Adriana,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Adriana Ortegon-Sanchez, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Serena Pollastri

From: Pollastri, Serena [s.pollastri@lancaster.ac.uk]
Sent: 17 May 2018 10:00
To: Joanne Leach
Subject: Re: Request for paper contribution statement

Dear Joanne,

I wish you the best of luck with the last sprint of the PhD. I am sure you'll do great and it will be great deserved!

As for the papers, I am happy to confirm your effort in leading and managing this.

I, Serena Pollastri, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F,

Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695. http://www.sciencedirect.com/science/article/pii/S2352340917305218

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Serena Pollastri
International Lecturer in Design
ImaginationLancaster
Lancaster Institute for the Contemporary Arts,
Lancaster University

http://seremiru.com/

s.pollastri@lancaster.ac.uk
(+44)(0)15245 10518
@sere_miru

From: Joanne Leach <J.Leach@bham.ac.uk>
Date: Wednesday, 16 May 2018 at 19:19
To: "Pollastri, Serena" <s.pollastri@lancaster.ac.uk>
Subject: Request for paper contribution statement

Dear Serena,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Serena Pollastri, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Cosmin Popan

From: cosmin.popan@gmail.com [cosmin.popan@gmail.com]
Sent: 17 May 2018 10:55
To: Joanne Leach
Subject: Re: Request for paper contribution statement

Hi Joanne

This is fine with me! Good luck!

Cosmin Popan, PhD | Lancaster University | Liveable Cities | +4407460311013 | cosminpopan.co

On Wed, May 16, 2018 at 7:20 PM, Joanne Leach <J.Leach@bham.ac.uk> wrote:

Dear Cosmin,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Cosmin Popan, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved

the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Katerina Psarikidou

From: Psarikidou, Katerina [a.psarikidou@lancaster.ac.uk]
Sent: 04 June 2018 12:31
To: Joanne Leach
Subject: Co-author consent

To whom it may concern,

I, Katerina Psarikidou, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-
695. http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards,
Katerina Psarikidou

Dr Katerina Psarikidou | Senior Research & Knowledge Exchange Fellow | Centre for the Study of Environmental Change| Centre for Mobilities Research | Department of Sociology | Lancaster University, UK | Tel: 01524593493; 07942467314

HEFCE N8 AgriFood Resilience Programme - http://n8agrifood.ac.uk/
My profile - http://www.lancaster.ac.uk/sociology/about-us/people/katerina-psarikidou

Chris Rogers

From: Christopher Rogers
Sent: 04 June 2018 10:43
To: Joanne Leach <J.Leach@bham.ac.uk>
Subject: STATEMENT OF FIRST AUTHOR CONTRIBUTION

Dear Joanne

Please find my statement below.

I, Professor Chris Rogers, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for carrying out the research and made substantial intellectual contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Lee SE, Bouch CJ, Ortegon-Sanchez A, Tyler N (on the point of submission). The Liveable Cities Method: Establishing the Case for Transformative Change. Proceedings of the ICE – Engineering Sustainability.

Leach JM, Mulhall RA, Rogers CDF and Bryson JR (at review). Urban Diagnostics and Identifying Integrated Urban Problems in the City of Birmingham, UK. Cities.

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F, Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.
http://www.sciencedirect.com/science/article/pii/S2352340917305218

Leach, JM, Lee, SE, Hunt, DVL and Rogers, CDF (2017). Improving city-scale measures of livable sustainability: A study of urban measurement and assessment through application to the city of Birmingham, UK, Cities. 71: 80-87.

Leach, JM, Braithwaite, PA, Lee, SE, Bouch, CJ, Hunt, DVL and Rogers, CDF (2016). Measuring urban sustainability and liveability performance: the City Analysis Methodology, Int. J. Complexity in Applied Science and Technology. 1(1): 86-106.

Leach JM, Boyko CT, Cooper R, Woodeson A, Eyre J, Rogers CDF (2014). Do sustainability measures constrain urban design creativity? Proceedings of the ICE: Urban Design and Planning. 168(1): 30-41. DOI: 10.1680/udap.13.00034. Winner of the Reed & Mallik Prize.

Yours sincerely

Chris Rogers

Professor C.D.F. Rogers
Director, UKCRIC National Buried Infrastructure Facility
School of Engineering
University of Birmingham
Edgbaston
Birmingham
B15 2TT
Tel. 0121 414 5066
c.d.f.rogers@bham.ac.uk
www.urban-futures.org
www.liveablecities.org.uk
www.mappingtheunderworld.ac.uk
For an introduction to Future Cities, follow 360° Walkthrough, turn left, find the Smart Cities Display and click the tag that says Future Cities next to the large screen.

Jon Sadler

From: Jonathan Sadler
Sent: 17 May 2018 09:24
To: Joanne Leach
Subject: Re: Request for paper contribution statement
That's great Joanne!!!

I have read this declaration and am a happy to support it.

All the best with the submission process and viva!

Regards
Jon

Jonathan P. Sadler
Professor of Biogeography

GEES (School of Geography, Earth and Environmental Sci), University of Birmingham
Birmingham B15 2TT
Email: j.p.sadler@bham.ac.uk
Tel: 0121 414 5776
http://www.birmingham.ac.uk/staff/profiles/gees/sadler-jon.aspx

Future cities: http://www.urban-futures.org/
Livable Cities: www.liveablecities.org.uk
Chief Editor: Journal of Biogeography

On 17 May 2018, at 07:47, Joanne Leach <J.Leach@bham.ac.uk> wrote:

Dear Jon,

I hope this email finds you well.

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Jon Sadler, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

LIST OF PAPERS

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Leach JM, Lee SE, Boyko CT, Coulton CJ, Cooper R, Smith N, Joffe H, Büchs M, Hale JD, Sadler JP, Braithwaite PA, Blunden LS, DeLaurentiis V, Hunt DVL, Bahaj AS, Barnes K, Bouch CJ, Bourikas L, Cavada M, Chilvers A, Clune SJ, Collins B, Cosgrave E, Dunn N, Falkingham J, James P, Kwami C, Locret-Collet M, Medda F,

Ortegon A, Pollastri S, Popan C, Psarikidou K, Tyler N, Urry J, Wu Y, Zeeb V, Rogers CDF (2017). Dataset of the livability performance of the city of Birmingham, UK, as measured by its citizen wellbeing, resource security, resource efficiency and carbon emissions. Data in Brief. 15: 691-695.http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Nick Smith

From: Nicholas Smith [N.Smith@westminster.ac.uk]
Sent: 16 May 2018 20:25
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Hi Joanne

Congrats on the near completion of the PhD! Yes that text is fine with me. Hope all going well!

Cheers,
Nick

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: 16 May 2018 19:24
To: Nicholas Smith
Subject: Request for paper contribution statement

Dear Nick,

As you may be aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Nick Smith, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as

corresponding author with the journal, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Nick Tyler

From: Tyler, Nick [n.tyler@ucl.ac.uk]
Sent: 04 June 2018 12:48
To: Joanne Leach
Subject: Re: Request for paper contribution statement

Dear Joanne,

I agree.

Yours,
Nick

Nick Tyler CBE FREng
Chadwick Professor of Civil Engineering
Centre for Transport Studies
UCL

From: Joanne Leach <J.Leach@bham.ac.uk>
Sent: Monday, June 4, 2018 10:27:34 AM
To: Tyler, Nick
Subject: FW: Request for paper contribution statement

Dear Nick,

A gentle reminder about the below email.

Kind regards, Joanne

From: Joanne Leach
Sent: 17 May 2018 07:46

To: Nick Tyler (n.tyler@ucl.ac.uk) <n.tyler@ucl.ac.uk>
Subject: Request for paper contribution statement

Dear Nick,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a number of papers on which I was first author and you were a co-author. In order to comply with submission regulations, I need a statement from you regarding my contribution to each paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Prof. Nick Tyler, confirm that Joanne M Leach was first author on the following papers, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journals, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Kind regards, Joanne

Jonathan Ward

From: Jonathan Ward
Sent: 17 May 2018 08:15

To: Joanne Leach
Subject: RE: Request for paper contribution statement

Dear Joanne,

That's absolutely fine with me. Where is the paper at now in terms of publishing?

Best wishes,

Jonathan

From: Joanne Leach
Sent: 17 May 2018 07:27
To: Jonathan Ward <JPW410@student.bham.ac.uk>
Subject: Request for paper contribution statement

Dear Jonathan,

As you are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Jonathan Ward, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; is ensuring that all co-authors review and approve the manuscript before publication; and, is acting as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Rogers CDF, Locret-Collet M, Grayson N, Hale JD, Sadler JP, Lee SE, Bouch CJ, Cavada M, Nochta T, Ward JP, Braithwaite PA, De Laurentiis V, Hunt DVL, Goodfellow-Smith M, Ortegon-Sanchez A, Tyler N (draft with Chris Rogers). A decision-making method for enhancing urban sustainability and liveability. Proceedings of the ICE – Engineering Sustainability.

Kind regards, Joanne

Anna Woodeson

From: aw@lts-architects.co.uk [aw@lts-architects.co.uk]
Sent: 17 May 2018 07:37
To: Joanne Leach
Subject: Re: Request for paper contribution statement
Joanne

Congratulations. Almost there.

Yes of course I agree. Do you need me to send that wording back to you?

Thanks

Anna

Sent from my iPhone

On 17 May 2018, at 06:46, Joanne Leach <J.Leach@bham.ac.uk> wrote:

Dear Anna,

I hope this email finds you well.

As you may be are aware, I have been studying part time for a PhD and I will be submitting my thesis, a PhD by Published Works, in early December of this year. The thesis will include a paper on which I was first author and you were a co-author (attached). In order to comply with submission regulations, I need a statement from you regarding my contribution to the paper. I've drafted this below and would be grateful if you could respond via email to say you agree – and if you don't please feel free to amend the text as you see fit.

If you have any questions, please don't hesitate to contact me. Thank you in advance for your time.

STATEMENT OF FIRST AUTHOR CONTRIBUTION

I, Anna Woodeson, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

PAPER

Leach JM, Boyko CT, Cooper R, Woodeson A, Eyre J, Rogers CDF (2014). Do sustainability measures constrain urban design creativity? Proceedings of the ICE: Urban Design and Planning. 168(1): 30-41. DOI: 10.1680/udap.13.00034. Winner of the Reed & Mallik Prize.

Kind regards, Joanne

Phil Wu

From: Wu Y. (Phil) [Phil.Wu@soton.ac.uk]
Sent: 17 May 2018 09:12
To: Joanne Leach
Subject: STATEMENT OF FIRST AUTHOR CONTRIBUTION

To Whom It May Concern,

I, Yue Wu, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As the first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

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http://www.sciencedirect.com/science/article/pii/S2352340917305218

Regards,
Yue (Phil)

Dr Yue Wu (Phil)

Research Fellow
Sustainable Energy Research Group / Energy and Climate Change Division
Faculty of Engineering and the Environment
University of Southampton

Tel: 023 8059 3940 (Ext 23940)
Web page: http://www.energy.soton.ac.uk/philwu/

Victoria Zeeb

From: Zeeb, Victoria [victoria.zeeb.14@ucl.ac.uk]
Sent: 16 May 2018 21:17
To: Joanne Leach
Subject: Re: Request for paper contribution statement

Hi Joanne,

Yes of course, I agree to this. Below is the confirmation as requested:

I, Victoria Zeeb, confirm that Joanne M Leach was first author on the following paper, on which I was a co-author. As first author, Joanne took responsibility for the study and made substantial contributions to the conception, design, and execution of the research study as well as the acquisition, analysis, and interpretation of data; had full access to all the data and took responsibility for its integrity and the accuracy of the data analysis; drafted and substantively reviewed the article, held the master copy, and critically synthesised co-author contributions; ensured that all co-authors reviewed and approved the manuscript before publication; and, acted as corresponding author with the journal, managing the article proofing process through to publication.

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Best wishes,
Victoria