RESEARCH ARTICLE

REVISED Exploring the smart-natural city interface; re-imagining and re-integrating urban planning and governance [version 2; peer review: 2 approved]

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Abstract

Globally, urban planners and decision makers are pursuing place-based initiatives to develop and enhance urban infrastructure to optimise city performance, competitiveness and sustainability credentials. New discourses associated with big data, Building Information Modelling, SMART cities, green and biophilic thinking inform research, policy and practice agendas to varying extents. However, these discourses remain relatively isolated as much city planning is still pursued within traditional sectoral silos hindering integration. This research explores new conceptual ground at the Smart – Natural City interface within a safe interdisciplinary opportunity space. Using the city of Birmingham UK as a case study, a methodology was developed championing co-design, integration and social learning to develop a conceptual framework to navigate the challenges and opportunities at the Smart-Natural city interface. An innovation workshop and supplementary interviews drew upon the insights and experiences of 25 experts leading to the identification of five key spaces for the conceptualisation and delivery at the Smart-Natural city interface. At the core is the space for connectivity; surrounded by spaces for visioning, place-making, citizen-led participatory learning and monitoring. The framework provides a starting point for improved discussions, understandings and negotiations to cover all components of this particular interface. Our results show the importance of using all spaces within shared narratives; moving towards 'silver-green' and living infrastructure and developing data in response to identified priorities. Whilst the need for vision has dominated traditional urban planning discourses we have identified the need for improved connectivity as a prerequisite. The use of all 5 characteristics collectively takes forward the literature

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on socio-ecological-technological relationships and heralds significant potential to inform and improve city governance frameworks, including the benefits of a transferable deliberative and co-design method that generates ownership with a real stake in the outcomes.

Keywords
Biophilic, Co-design, Conceptual Framework, Natural City, SMART, Urban Planning, Transdisciplinary.

This article is included in the Sustainable Cities gateway.

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REVISED **Amendments from Version 1**

The text has been revised in response to the comments we have received from our two peer reviews. This includes additional commentary on the relevance of the research for urban governance and in particular from the perspective of urban planners engaged in policy-making for green infrastructure. We have clarified the description of the databases we used for the literature search and the methodology section has been restructured to improve clarity on transferability and replication. The paper now includes additional tables and information on the selection of the 4 propositions and the semi-structured interview questions used for the deeper dives. Table 2 has been added that sets out the proforma used for the deep dives to demonstrate consistency.

Any further responses from the reviewers can be found at the end of the article

Introduction - smart and natural; two separate city discourses?

In recent decades, metropolitan planners and decision makers have employed place-based initiatives to improve cities performance, infrastructure, competitiveness, liveability and sustainability (de Jong *et al*., 2015; Nesta, 2015; UN, 2016). However, there are significant strategic challenges in reconciling how cities plan effectively for the competing resourcing demands of public health, water, housing, economic growth, biodiversity and climate change (Ravetz, 2018). Typically, these challenges are often addressed within separate sectoral "silos" leading to policy disintegration (Lennon, 2015; Scott *et al*., 2013).

The Smart City paradigm represents one of these silos, fuelling a significant research and policy agenda focussed on data-led solutions to urbanisation challenges (Buck & While, 2017; Viitanen & Kingston, 2014). The Natural or Biophilic city paradigm represents another silo, based on nature-based solutions to urbanisation challenges (Newman, 2014:47 see also Beatley, 2016; Reeve *et al*., 2015). Crucially, there is limited research that looks at the interface between these two areas of research activity, particularly that which has focussed on the role of the citizen-led approaches which have pervaded much urban policy and decision-making literatures (UN Habitat, 2016).

Our principle research challenge was to identify the added value and benefits for the environment and citizens from integrating these natural and smart city discourses. More specifically, the research aimed to show whether we could identify and mainstream the opportunities that arise from integrating knowledge flows and exchange across the Smart-Natural interface. By finding a method to de-construct the characteristics of the interface between these two hitherto disparate areas, could better policy and decision making processes and outcomes ensue? The research is part of a wider research project 'Urban Living Birmingham' which formed our principal case study (Leach *et al*., 2018). Significantly, the City Council had developed separate strategies towards achieving Smart and Natural cities (BCC, 2013; BCC, 2014a) and thus provided an excellent test bed for our research goal.

We proceed with a discussion of the core ingredients and evolution of the Natural and Smart City paradigms before explaining the development of a conceptual framework based on a convergence and synthesis of existing literatures. This framework is then used as a prompt for an innovation workshop and 'deeper dive' discussions with participants and key stakeholders in the city of Birmingham. The results were used to develop a set of characterisations to facilitate improved integration into future research, policy and practice. We then discuss the implications of this for new impact pathways in dealing with contemporary urban challenges globally.

The Natural City

In 2050, 68% of the world's population is projected to be urban (UN, 2018). The process of urbanisation globally is a key driver of significant declines in biodiversity (IPBES, 2018; WWF, 2018). This has shaped new agendas for cities to work with 'people and nature' together within changing models of urbanization to better respond to the challenges of inequality, climate change, informality, insecurity, and the unsustainable forms of urban expansion (Mace, 2017; UN Habitat, 2016; United Nations, 2015).

Distinctive approaches towards natural or green cities from the late 19th and early 20th centuries to today can be identified from the academic and practice literatures (Hou, 2013; Locke & Grace, 1993; Singapore Government, 2016). 'Urban ecology' and its potential as a means for integrated urban planning (Hough, 2004; Lord *et al*., 2003; Stefanovic & Scharper, 2011) and the opportunities for nature in cities (see for example, Barranco-León de las Nieves *et al*., 2016) have led others to recognise the importance that cities can potentially play in the conservation of global biodiversity (Aronson *et al*., 2017).

The recent emergence of 'Biophilic' cities extends the natural city concept to "*cities of abundant nature in close proximity to large numbers of urbanites…..value residents' innate connection and access to nature through abundant opportunities to be outside and to enjoy the multisensory aspects of nature by protecting and promoting nature within the city*" (Biophilic Cities Project, 2017; see also Beatley, 2010). Biophilic environments entail multi-sensory frequent contact with nature, and value, for instance, nurturing natural soundscapes and smellscapes in cities (Beatley, 2016; Porteous, 1985).

A network of cities, including Birmingham, have identified with Biophilia, recognising that it is conducive to comprehensive, intentional and strategic urban greening. Biophilic urbanism can be applied at multiple scales in urban environments through a range of multi-functional features including green and blue infrastructure providing multiple benefits for people (Reeve *et al*., 2015). Indeed, nature in the city is now topically viewed as part of urban green and blue infrastructure (GI), set often within the language of environmental protection, natural capital and ecosystem services designed to maximise their value to urban populations (NCC, 2017). Here GI as living infrastructure has been promulgated as the "glue" to help deliver multiple benefits in policy and practice (Alexandra *et al*., 2017; Metro Tunnel Living Infrastructure Plan, 2017) and is a rapidly growing area

of research (e.g. Connop *et al*., 2016; Hansen & Pauliet, 2014; Lennon & Scott, 2014; Mell, 2014). Nitoslawski *et al.*, 2019 in a review of current "smart urban forest" projects identify a focus on monitoring techniques involving sensors and Internet of Things (IoT) technologies, open data and citizen engagement via mobile devices, applications ("apps"), and open-source mapping platforms.

Much emphasis has also been on the economic valuation of GI (e.g. Foster *et al*., 2011; UK NEA, 2011). Sadler *et al*. (2018) argue that natural capital in urban GI, helps unlock the other four capitals: financial, human, social and manufactured, transforming hitherto negative associations with GI as a burden (Scott & Hislop, 2019) and places people at the centre of ecosystem service delivery (Gaston *et al*., 2013; Hansen & Pauliet, 2014). Despite this progress amidst calls to move towards more holistic assessment methods (Spash, 2008), GI has yet to achieve its full potential in mainstreaming endeavours (Scott, 2019).

The Smart or Digital City

The Smart city concept is underpinned by the extensive application of information and communications technology with traditional infrastructure but a single consensual definition still remains elusive (Batty *et al.*, 2012; Carter, 2017; Joss *et al.*, 2019; Stimmel, 2015). Albino *et al*. (2015) identify 24 definitions with a strong focus towards sustainability, focusing on people and community needs. Joss *et al.*, 2019 find in their work on 27 cities how a smart city consists of multiple dimensions beyond an infrastructure-technology focus. In particular, globalisation and governance act as integrating activities. However, the environmental dimension is less evident challenging whether smart is sustainable enough.

From the rapidly growing literature on Smart cities, a number of definitional groupings can be unearthed (Centre for Cities, 2014). Some are data-driven (Falconer & Mitchell, 2012, for Cisco); whilst others revolve around citizen-focused approaches, which are defined by approaches to governance and yet others towards city efficiency and performance and finally as prestige for the city and its leaders (Nesta, 2015).

Marsal-Llacuna *et al*. (2015) describe the evolution of the Smart Cities initiative over a decade at the start of the 21st century; from creative cities, to digital cities, to knowledge cities, to Intelligent Cities to then Smart Cities. They argue that the development has grown from a concern with measuring environmentally friendly and liveable cities. The 'Smart City' can therefore be positioned as a distinct category of urban modernization ambitions and initiatives, albeit with concerns about whether this type of smart growth can adequately cater for social equity and environmental progress (De Jong *et al*., 2015; Hernandez & Roberts, 2018).

Within the literature there is concern that SMART initiatives must move away from generating huge amounts of city-level data for its own sake and develop an improved understanding of cities as transboundary, multisectoral, multiscalar, social-ecological-infrastructural systems (Ramaswami *et al*., 2016). It is here that improved urban diagnostics and natural or biophilic- style ideas can help filter the data needed to address particular challenges (Leach *et al*., 2018).

Integrating smart and natural city discourses?

The approaches towards Smart(er) cities and Natural cities can be located within transition discourses; part of a range of alternatives with no single one providing all the answers for urban futures (Blaschke *et al*., 2011; Ravetz, 2016). However both claim to offer transformative models without sufficient scrutiny to the redundancy of existing governance structures and the virtue of "disruptive" innovation (Joss *et al.*, 2019). This issue of governance becomes crucial to both smart and natural conceptualisations yet the interactions between various actors in the city within a user-centered collaborative environment attracts less attention (Ben Yahia *et al.,* 2019). This was well illuminated in research assessing the evolution of 2011 Climate Contract that envisioned Hyllie as a model climate-neutral city district of Malmo using a smart grid (Parks, 2020). Despite initial progress the city with Eon to realise the vision it became bogged down in opposition, leading to both parties acknowledging that they lacked the resources need to make Hyllie climate-neutral.

Individually, neither the Smart nor the Natural city approach are currently sufficient to deliver a sustainable city and weaknesses have been identified in how they might converge into hybridised notions of a sustainable city (Hassan & Lee, 2015). Others are clear that being green must be a facet of being a smart city (Cavada *et al*., 2017; Colding & Barthel, 2017).

A number of authors have undertaken comprehensive reviews of smart city literature and reached similar conclusions. In China, Li *et al.* (2019) identified the importance of a smart environment alongside smart people and smart governance. Martin *et al.* (2018) identified five tensions between the smart city and the goals of sustainable urban development in Europe and North America. These tensions involve: (1) reinforcing neoliberal economic growth; (2) focusing on more affluent populations; (3) disempowering and marginalising citizens; (4) neglecting environmental protection; and, (5) failing to challenge prevailing consumerist cultures. A key finding is that the potential to empower and include citizens represents the key to unlocking forms of smart-sustainable urban development that emphasise environmental protection and social equity. They noted that scant attention is paid to ecosystems and that urban greenspace which improves quality of life and reduces environmental impacts tends to be neglected in visions of smart cities. Mora & Deakin (2019) exhaustive review considered smart city development in Asia, Australia and especially Europe and North America. They concluded that there is a need for a collaborative environment shaped by an open community whose actions serve the public interest and which are based on a holistic interpretation of smart city development.

Our case study of Birmingham reinforced the view that no single discourse could fully address current urban challenges. A city-wide diagnosis was undertaken within the ULB project (Leach *et al*., 2018) which assessed the key strategic issues

facing Birmingham and identified four interlinked critical challenges – health & wellbeing, energy, connectivity and the economy - all located within an overarching governance challenge which collectively formed the Birmingham 'nexus' (Bryson, 2017). The diagnosis also found a significant 'disconnect' between citizens and their place.

A number of authors have described new or alternative categories of sustainable city development that capture partial components of SMART and/or natural city principles in the same approach (Buizer *et al*., 2016; De Jong *et al*., 2015; Dhawan, 2017; Hassan & Lee, 2015; Hulme, 2017). In practice, these multiple terms often appear to be used uncritically and interchangeably by academics, policy makers, planners and developers, reflecting their relatively weak theoretical underpinnings (Caprotti *et al*., 2016). Indeed, De Jong *et al*. (2015) consider only six to be conceptually robust enough; 'sustainable city', 'smart city', 'eco city', 'low carbon city', 'resilient city' and 'knowledge city'.

Furthermore, it has been argued that the social, environmental and community aspects of the smart city have not been sufficiently integrated into the smart city research and policy agendas (Capdevila & Zarlenga, 2015; Colding & Barthel, 2017; Joss *et al*., 2019), which has underplayed the role of social and environmental capital and the resulting behaviours of its citizens (ERKC, 2014; Eurocities, 2018).

New digital techniques for informing better decisions are not yet systemic but are emerging and Arts *et al*. (2015) have identified a number of categories of data alongside risks and problems that accompany digital conservation. Others have identified specific applications for urban landscapes, remote and human sensing (see for example; Blaschke *et al*., 2011; Hill, 2016; IWUN, 2017; Roberts *et al*., 2018; Seresinhe *et al*., 2017 and Tu *et al*., 2018). Carton & Ache (2017) have specifically explored the rise of citizen-sensor-networks, combining civic engagement and ICT. The appropriation of digital technologies by citizens can also be an important integrating mechanism for the governance of a Smart and Natural city, though, crucially there is a significant lack of understanding as to how these benefits are transferred to, and received, by urban populations (Roberts, 2017).

Achieving integration in practice is, however, not so straightforward. There are a plethora of economic, political, institutional and financial barriers to overcome and working across disciplinary and professional boundaries is challenging and time consuming (see, for example, Boon & Baarlen, 2019; Tress *et al*., 2005). This requires significant behaviour change, consideration of citizen-led perspectives and development of new tools for decision makers (Grace & Proverbs, 2017; Naylor *et al*., 2018; Scott *et al*., 2018). Indeed, whilst Colding *et al.* (2019) note that the assumption that ICT can pave the way for more democratic forms of urban planning and governance, this proposition has limitations given it is dealing with 'wicked' problems that lack simplistic solutions.

This critique of the literature highlights the need for more holistic and robust theoretical frameworks that can better conceptualise and measure the contribution towards sustainability and SMART goals. It is here that social ecological thinking has started to dominate the discourse (Ahvenniemi *et al*., 2017; Bruckmeier, 2016; Cumming & Allen, 2017 and Ramaswami *et al*., 2016). Furthermore, Ramaswami *et al*. (2016) identify eight principles to help reconnect contemporary urban infrastructure within the social ecological system of the city. Here infrastructure is positioned as a key integrative tool allowing connections to be made across grey, green and blue infrastructure components (Lennon, 2015; Mell, 2014) with access for all across sectors and scales.

Both the Smart and Natural city paradigms argue for new investment, capacity building and delivery models concomitant with a change in culture and behaviours and there is clear added value from exploring mechanisms that facilitate their integration (Cowell & Lennon, 2014). This also ties in with a need to move 'from industrial to network-age designs for institutions' as part of a shift toward smarter governance that recognises the importance of the citizen at the heart of this behavioural change (Noveck, 2015a). The smartness in Smart cities is realized only when the system adapts itself to the user needs (Albino *et al*., 2015) and, we suggest, this is a key element where the integration of people with nature and with digital technology can occur.

The main themes from the literature review are summarised in Table 1. These 4 propositions have directly informed our research questions and helped shape the conceptual approach that has evolved through this research.

Research methods

Our research method takes a deliberative approach set within a wider social learning agenda. Here, Roger's (2003) contribution on the diffusion of innovation provides a useful theoretical catalyst for conceptualising how new innovation or knowledge progresses through its various stages (see also Scott *et al*., 2018). Our method can be described as having 4 significant steps and these are shown in Figure 1.

1. **The 4 key Smart-Natural Propositions:** The sophisticated diagnostic of the case study city, Birmingham UK (Leach *et al*., 2018), considered a range of statistical and policy documents and, as we have noted, this identified key challenges facing the city. Our literature review used a rapid evidence assessment (Collins *et al*., 2014) to explore the interface between Smart and Natural City futures discourses and explored whether a Natural Capital could be a part of a Smart City. The review process principally used Summon (Birmingham City University's discovery tool) which accesses multiple databases and electronic resources including Web of Science, Scopus, Ethos (UK) and JStor. In addition, Google Scholar was used as well as researcher-led searches of grey literature including conference papers, technical reports, discussion papers and working papers as well as suggestions from the experts within the ULB 'Touchstone Group'. 4 key propositions arose from the literature review and, with the associated research challenges, are summarised in Table 1.

Table 1. Summary of key themes and challenges arising from the Smart-Natural City literature (Source – authors).

Thematic propositions	Research challenges
Taking a 'whole city' approach	This steers us toward identifying a place-making and place-keeping approach. How do we bring together the capabilities needed to address a wide range of challenges from infrastructure and environment to smart cities and big urban data?
The value of green and the rise of smart	An influential and substantial body of evidence now exists that emphasises the important role of Green Infrastructure provision in cities in enhancing the health and wellbeing of citizens. How to merge this with the Smart City discourse that is for a more efficient city and services to its citizens; addressing the challenges of low economic performance, unemployment and skills gap; tackling health and wellbeing inequalities; the need for seamless and effective mobility and establishing a low carbon society?
People and their connection with the city	The diagnostic of our case study city, Birmingham, highlighted the disconnect between citizen and city. Approaches are required for the resolution of the tensions between both managing for different goods and services and the frequent differences between the needs or expectations of urban dwellers and the reality of urban landscapes. How to address governance issues to look at the bigger strategic picture including the large numbers of land managers?
Infrastructure and a systems perspective	Delivering a concept of Green Infrastructure that is part of a more holistic narrative for the city came to the fore. How to integrate with other critical systems that provide energy, water, food, houses, public health, employment, transportation, communication, waste management and recreational spaces for economic development and societal benefit? Understanding the city ecosystem so that green infrastructure, biodiversity and climate change agendas can be planned and managed to evolve as part of a smart city? This has to recognise a complex management environment.

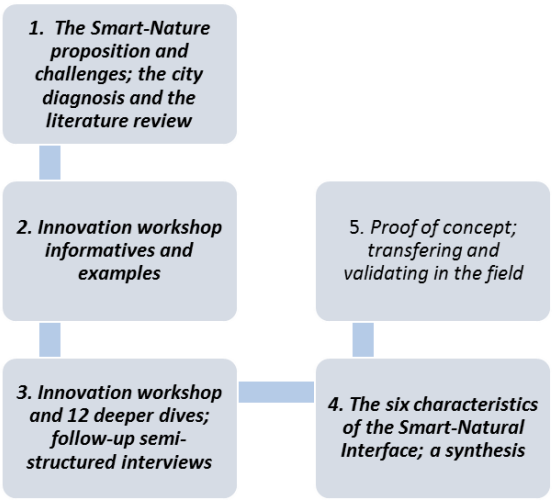

Figure 1. Research methodology.

An initial search identified +40 items which were assessed for relevance and used to further refine the evidence assessment. We set out a number of sub-questions; what was meant by a smart city, how has nature been described within cities, how are technologies being applied to measure nature and what indicators of future policy are there? The key terms were, alone or in combination; smart city, natural or biophilic or green city, natural capital, future cities, technology and nature, digital conservation, co-design. This generated +80 references which were additionally reviewed for relevance by questions on whether there was systematic practice of joining smart and green, how smart data (remote and people sensing) is utilised to enhance green outcomes and people's interaction with green in cities and citizen-led approaches.

Our method then took on an iterative process which added substantially to the findings in the review. This process of adding value has its roots in good practice for urban place-making (see for example, AlWaer *et al.*, 2018) and the value added of each stage is

indicated in Figure 2. The deliberative nature of the process is important in validating the outcomes within a heavily co-produced space.

2. **The Innovation Workshop:** 25 senior managers with city, regional and national expertise were invited to an Innovation Workshop. The experts were primarily selected using the project teams' extensive networks and knowledge both of the region and its informed actors and organisations and others who could bring a non-local external view, Selection was based on capturing a range of highly relevant interests from private, public and NGO sectors concerned with the delivery of benefits and services across and within Smart city and Natural city approaches. This deliberately sought to bring in multiple and varied disciplines and included senior representatives from the fields of health, development and regeneration, green infrastructure and natural capital, smart and wider city policy and strategy development, business representative bodies, academics, individual business organisations, built environment consultancies, national and local government agencies. To avoid unintended pre-determination, selection deliberately invited individuals not otherwise engaged in the wider ULB project alongside those who already had some knowledge of this context.

   The workshop was informed by a pre-circulated briefing document setting out the four themes (see extended data (Grace *et al.*, 2019)) and the day was introduced with several 'vignettes' from selected attendees that described current challenges and their specific ideas and approaches: establishing a city-wide environmental observatory; designing new garden village urban settlements with integrated digital and natural components; and seizing opportunity spaces within major redevelopment projects. Facilitated discussions in groups addressed one of the four themes per table. These discussions had been further primed and framed by comments and questions put forward by attendees in response to the briefing document; these included additional perspectives on 'green commercial' opportunities, governance and connecting citizens to the city. The workshop culminated in the group developing and justifying a set of recommendations and actions. Key to the design of the workshop was holding the discussions within a managed and "safe" confidential space within a neutral academic location.

   Post-workshop, the intelligence and ideas gathered were then combined with the findings of the literature review and translated by the project team into a set of principles with associated characterisations. These were initially reviewed through a follow-up phone conference with some 14 members of the workshop participants.

3. **Validation through 'deeper dives':** These emerging characterisations were subsequently tested in a series of

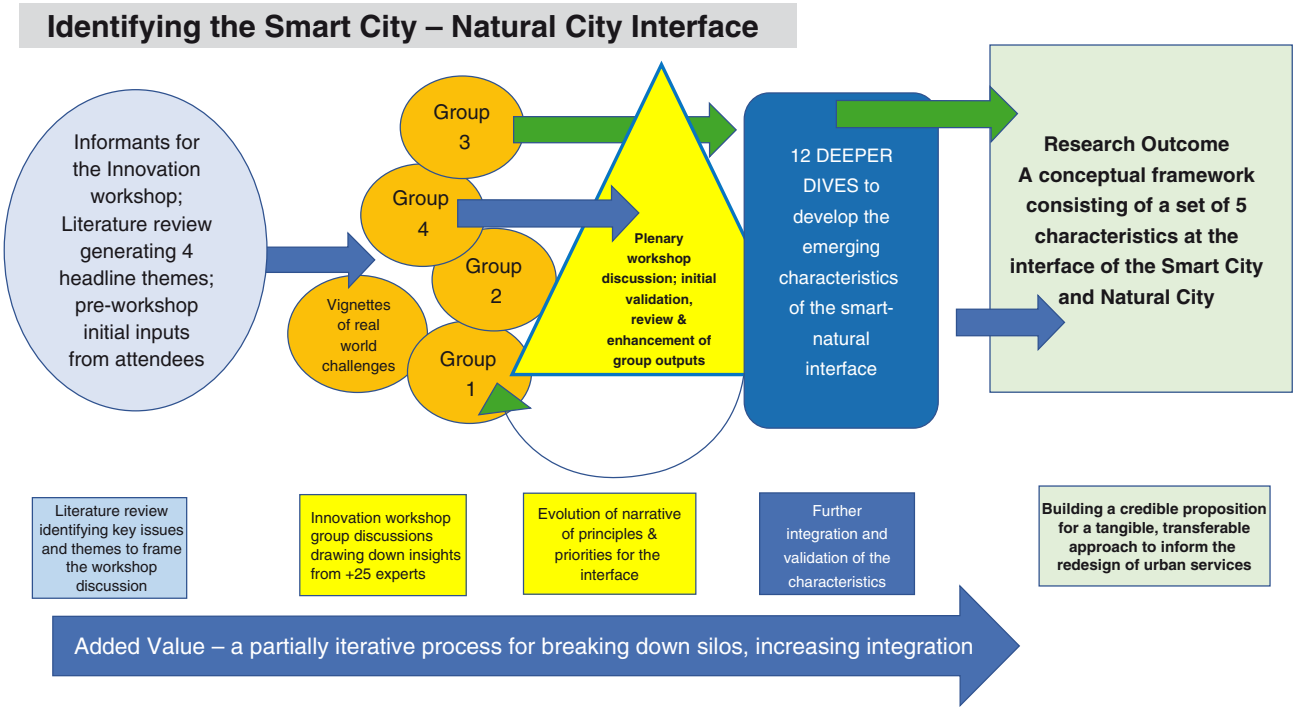

Figure 2. Process diagram for identifying the Smart City – Natural City Interface.

semi-structured interviews and discussions in some 12 follow-up 'deeper dives' involving workshop participants and a number of other appropriate audiences of academic and other experts. We asked our expert collaborators to address a relevant live example and a template was designed to secure consistent feedback from the 'deeper dive' participants (Table 2).

We used a variety of forms of engagement, involving presentations and semi-structured discussion, conference telephone calls, Skype calls and face to face meetings between September and November 2017 (Table 3).

Ethical Statement: The research described in this paper adhered to the UKRC-approved ethical framework for the Urban Living Birmingham Project and which was administered by the ULB Project's Consortium Management Committee. The CMC was chaired by the

Principal Investigator of the ULB Project who was delegated responsibility for ethical matters. Oversight was provided through bi-monthly meetings throughout the period of this research in 2017. All of the participants in the research engaged in the Innovation Workshop and subsequent interviews on a voluntary basis, consenting through email acceptances.

4. **Defining the Smart City – Natural City Interface:** the authors used the outcomes of the deeper dives to further construct the 5 characteristics that we suggest identify the opportunity and challenges in this new conceptual space. The set of 5 is described in the results and discussion sections below. A full summary of the key informant points arising from the process of engagement is provided in a meta-table in Appendix A (included as extended data (Grace *et al.*, 2019)).

The meta-table allows the reader to follow the threads from the literature review-driven inputs to the innovation workshop to the final 5 characterisations of the smart-natural interface. The 5 characteristics are described in column F. Columns A to E show the 4 thematic inputs and research challenges (column A) alongside the results of the workshop group discussions, narratives that emerged from individual groups and summary comments (columns B to D) with the collective summary of the 12 deeper dives (column E) that helped to validate that particular one of the set of [the 5] characteristics. It illustrates the association of the comments and the evolution of the characterisations.

We can note that some expert insights can be assigned to shaping more than one of the characterisations whilst a single theme from the review also inspired different expert advice. It is the richness in combination of the results from each stage of the research project that enabled the synthesis of the final descriptions of the 5 characterisations.

Results - Characterising and constructing the Smart – Natural Interface

The outputs from the research process generated 5 interconnected principles or characterisations at the interface between the Smart City and the Natural City. We have described these as conceptual 'spaces' and are captured in Figure 3 (see underlying data (Grace *et al.*, 2019)).

Table 2. Template used for Deeper Dive discussions.

Name:	**Current position and contact details:**
Question	**Description**
a) Choose and look at a particular challenge you are facing within the city and consider it through your usual (current) lens.	
b) Summarise the challenge in a sentence or two and make a short list of the outcomes or solutions you get from your current approach.	
READ THE DESCRIPTION OF THE 6 CHARACTERISATIONS	
c) Now using the same challenge, look at it through the combined lenses of the 6 Smart-Natural characterisations. What outcomes emerge?	
d) Does this create better outcomes? In what way?	
e) How would using this lens change the way you work? What would you need to change in your role to make it happen?	
f) Is there any other characterisation you have identified we should consider?	
g) Any other comments?	

Table 3. Methods used to facilitate 'deeper dives' into the definition of the Smart-Natural City Interface.

	Expert Contributors and selected topic	Date and form of discussion
1	Birmingham City University Computing, Engineering and Built Environment Faculty staff and post-graduate students [15 attendees]; HS2 and city centre redevelopment	Seminar on 4th October 2017
2	Innovation workshop attendee - Independent Consultant; future commercial viability of city parks and green spaces.	By teleconference on 17th October 2017
3	Innovation workshop attendee - Senior Officer local authority – Growth; High Speed 2 and associated regeneration	Meeting on 17th October 2017
4	Senior Officer local authority – Development; City centre development and associated regeneration	Meeting on 17th October 2017
5	Innovation workshop attendee - Director – Health & Well-being; Green spaces and opportunity for innovation in community health service delivery	By teleconference on 17th October 2017
6	Ten experts – 8 attendees of the Innovation Workshop plus 2 others representing Local Authority/ Digital-Smart City and the Business/Environment sector (who could not attend the workshop); several examples were raised, including linear transport infrastructure and new development	By teleconference on 13th October 2017
7	Innovation workshop attendee - Development company, Director; new settlement development	Meeting 25th October 2017
8	Innovation workshop attendee - Consultancy Smart Cities, Director; new urban development	By email during October 2017
9	Innovation workshop attendee - Academic; the challenge of air quality especially around schools,	By email during October 2017
10	Academic; Housing issues	By email 16th October 2017
11	Academic and Project Manager; new housing development	Meeting 20th October 2017
12	Academic and Project Manager; the operation (individually and collectively) of UK (and international) cities to enable best practice	By email 8th November 2017

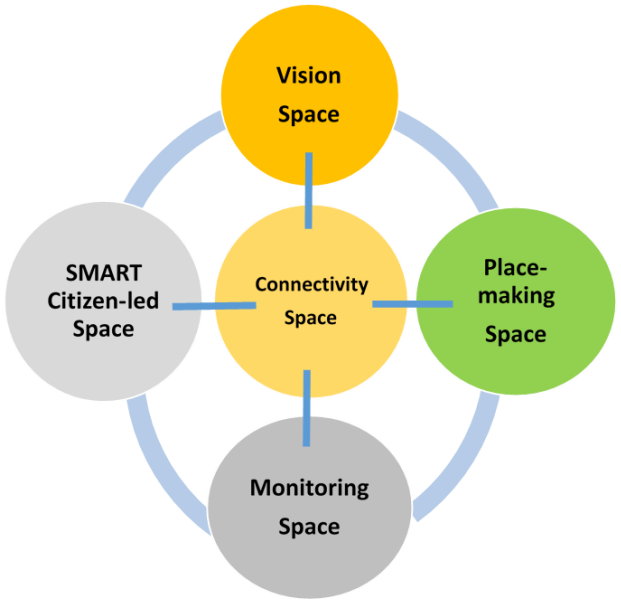

Figure 3. The characteristics of the Smart – Natural Interface: connectivity at the hub.

Drawing on the material from the innovation workshop and deeper dives, we can summarise each of the 5 characteristics of the Smart-Natural Interface within a hub and spoke framework as follows.

A connectivity space

This space forms the hub of the interface where people, digital technology, places and nature connect across each other to improve performance. In conceptual terms it is the space between smart urban strategies and social-ecological systems thinking for the 'whole-city'; where grey and green infra-structure metamorphose into 'silver green' through the com-bination of smart and natural (or biophilic) city solutions that generate multiple benefits.

To demonstrate the identification and evolution of the 5 char-acteristics, we have provided a detailed narrative of the way the Connectivity space was formulated in Box 1. For the other characteristics, as described below, Appendix A allows the reader to follow the threads from the literature review-driven inputs to the innovation workshop and 'deeper dive' conversations to the final 5 characterisations of the smart-natural interface (see extended data (Grace *et al.*, 2019)).

Box1. Example showing the formulation of the connectivity space from the meta data

Informed by the literature review, the innovation workshop sought to address multiple challenges for the whole city at the same time. This evolved through an exploration by the workshop participants of how social connectivity and cohesion could be supported as part of connecting people back with their city and using smart technology to move toward a more natural city.

The expert group discussion suggested that there should be deliberately designed attempts to join up agendas, informed by targeted data collection; this would (a) evidence metrics that connect the local to city to regional outcomes and (b) would give an open data source for green and blue infrastructure linked to community aspirations and delivery programmes.

In the deeper dive conversations, our experts from local authority and other agencies thought that they would as a result "*be driven to change points of contact with people, engaging a broader variety of people and groups in different (better) ways*" (Senior Regeneration Officer; Birmingham City Council).

In turn this would inform changes in behaviours across decision making that could be more confident in taking informed risks for more benefits. To reinforce this steer, the deeper dive conversations in particular suggested that the whole set of the characterisations would ask people to present information in more accessible ways and to connect citizen-led science with big data to inform decision making.

A second theme contributing to the Connectivity characterisation, concerned the challenges and opportunities of the city as a system from a 'people' perspective. Given the societal challenges of inequalities across Birmingham, the workshop discussions considered how the Smart-Natural interface can help break down barriers to change across the city. The expert group quickly identified the issue of language and how terminology can define silo thinking, encouraging us to think in terms of 'us', that is to share issues and co-produce solutions, and not 'them' as the deliverer of solutions. Our business sector representative noted a weakness in limited references to the business sector but identified an opportunity to develop a new *"business value model"* whereby the private sector could innovate new solutions to the delivery of nature and so, in turn, suggested that *"accountability for the delivery of benefits can be shared across collaborating organisations"* (Senior Executive; Business).

Looking across both of these themes, a senior local authority manager from the City Council suggested that the characteristics could help *"create an engagement framework"* with the interface as a means of changing the connection between city authorities and citizens; allowing for new innovative and connected ideas to come through and helping the city council behave differently, as an enabler rather than a provider of services.

The third theme contributing to the Connectivity characteristic suggested the importance of taking an infrastructure and systems perspective to integrate delivery. The importance of having a city systems approach which could combine digital technology and nature emerged as a key element of connected thinking; the common aim of *'silver green'* solutions for infrastructure was identified.

Our health and well-being experts suggested that, for the evolution of city systems, *"the opening up of data and information can enable people to understand risks and choices and to push for better facilities, greenspace, air quality etc."* Nature was quickly identified as a core concern that should be embedded in infrastructure from the outset and debate began about what digital technology applications could assist blue and green infrastructure. The deeper dive conversations explored how better information provides a sounder base for effective engagement and investment decisions. Indeed, our health experts endorsed systems changes which are *"more complex but much more powerful than reverting to individual and largely technical innovation which are much easier to measure"* (Director; Health & Well-Being Consultant).

A vision space

This space is where there is a clear and bold co-produced vision for the kind of liveable city we need. This reflects a move away from economic, social and environmental silos to re-imagining city spaces within more interdisciplinary and exciting co-produced visions. Using interactive technology is key here to engage and excite people and communities in to help shape making more informed choices and decisions for their city.

A place-making and place-keeping Space

This space reflects where living, learning, working and recreating functions collectively meet to form more integrated smarter natural solutions centred around creating new places and also improving existing places. It responds to political and environmental challenges by championing silver green infrastructure and driven by the increasing body of evidence that supports the value of natural capital for people, business and the economy of the city. Crucially it does not pit green and grey infrastructure against each other.

A SMART citizen-led space

This participatory-led space is where citizens are able to access and resource the necessary data to help them make better decisions about how they live their lives and where/how they can themselves influence change through using and interacting with data in real time. Thus this becomes a participatory social learning space where the flow of information is two-way; between people and city managers and planners. Communities will be empowered through new evidence about their place being made available in different, smarter and more accessible ways. Through a better understanding of technical processes citizens can directly engage with service providers and suggest innovations, helping to integrate policy and delivery and potentially leading to better service re-design.

A monitoring space

This space is where ICT and smart applications are used to measure, track and monitor progress of all the other spaces and associated characterisation metrics. There is a need to establish baselines and identify the indicators for the Smart-Natural interface e.g. the health and economic benefits that accrue from co-designed and community managed spaces. This is essential if the interface is to have traction and help identify accountabilities for the delivery of more integrated and better services and benefits for people and that, in turn, can help justify investment.

The drivers from the literature, the inputs from the expert group and the validation through the deeper dives have shaped the 5 characteristics collectively, through being informed by multiple strands of knowledge and advice, with overlapping interests. Indeed, we suggest, that the methodology has helped expose a web of connectivity underpinning the strength of this new conceptual thinking.

Discussion – realizing the value and opportunity of the Smart City – Natural City interface

Towards a hybrid governance model at the Smart - Natural interface

To date there has been only sporadic progress in the convergence of theory, policy and practice of Smart and Natural concepts in city planning and governance (UN Habitat, 2016). The literature does not yet address fully the urban ecology perspectives and potential of the smart city (Colding & Barthel, 2017) whilst Sagl *et al*. (2015) make the stark conclusion that it seems doubtful that any improvement in quality of life can be demonstrated to have resulted (to date) from most of the developments related to the establishment of smart cities. A comparison of the list of the world's top 20 smart cities with those within the Biophilic City network reveals only one common member, Singapore (Eden Institute, 2018). The research reported here makes a contribution to filling these conceptual, policy and delivery gaps.

Where convergence is evident, it is the sustainable cities paradigm and its' spawning multiple hybrids that dominate (Hassan & Lee, 2015). However, the often called for holistic approach is all too easily disintegrated into silos due to hard-nosed financial, economic and political barriers reinforced by current institutional myopia (FCC, 2016: Scott *et al*., 2004). For example, in the recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment it was recognised that nature as expressed through ecosystem services is in fundamental decline globally and where still economic growth is not decoupled from environmental degradation. Even in biophilic cities, approaches to biophilic solutions have often been found to be mostly random (el-Baghdadi & Desha, 2017).

Our conceptual framework offers a different pathway to move out of silos through navigating five spaces simultaneously to build sustainable and resilient cities city that are now desired (Ravetz, 2016; United Nations, 2015). Crucial to our conceptualisation is that the framework revolves around a connectivity space rather than a vision. In this way this helps ensure that visions are grounded across key participants, stakeholders and evidence thereby challenging current mainstream urban planning approaches and strategies (Scott *et al*., 2013). By addressing the dis- functionality between different urban futures discourses, the five principles and their associated characterisations can help bridge the often encountered policy and delivery gap (Matthews, 2010). This was most evident in the deep dives when narratives were framed by the participants across each space helping them reflect upon their own initiative. This in many ways reveals the power of the process itself (Glass *et al*., 2013) where re-thinking past/current or future activities in reflective mode can be helpful in getting people to connect outside their usual comfort zones. In such respects the co-production of the conceptual framework helps build bridges for multiple audiences to engage with a move away from elitist vocabularies, so supporting the contention of Scott *et al*. (2018). This becomes a starting point for more fertile conversations and shared dialogue about city systems and governance where social learning and knowledge exchange (see Scott *et al*., 2013) help to understand existing (mis-)connections and interdependencies (Lockwood, 2010). Moreover, there is potential to strengthen and form new alliances and partnerships for the benefit of nature and people through the connectivity space itself. Below we signpost some of the key outcomes that enable move from hypothetical benefits and use the Smart- Natural City interface to add value to existing urban planning and governance.

The ULB project found improved governance to be at the heart of addressing the challenges facing Birmingham (Leach *et al*., 2018).Success will depend on effective governance frameworks that have clear, accountable and transparent decision making processes, with effective monitoring of interventions and strong evidence-led leadership (Ahvenniemi *et al*. 2017: Lockwood, 2010; Scott *et al*., 2018). This suggests that we should view the city as an evolving ecosystem to start to close the current conceptual and policy gap between smart city and natural city frameworks. This would overcome some of the risks identified by Gulsrud *et al*. (2018) that the coupling of ecology and technology could heavily reduce human involvement in decision making.

By using the shared 'Visionary Space' we have available a crucial but currently neglected step in rethinking and reimagining the kind of natural and smart city "we" collectively need. That is, if 'SMART' can be more multifunctional, inclusive and participatory it can cater for social equity and environmental progress. Constructing a digital environment that systemically embeds the natural environment through a 'network of networks' that link, say, sensor networks co-designed by citizens with networks of other remote sensors at the local as well as the city scale will be one of the challenges in governing this evolving ecosystem. This will respond to the suggestion of Colding *et al.* (2019) that policy makers should make digital smart cities more humane and socially smarter and help deliver on the importance of the value of natural capital and subsequent ecosystem goods and services to citizens (see Connop *et al*., 2016; Forest Research, 2011; Newman, 2014; UK NEA, 2011 and UK NEA, 2014). It can also be a filter of data required to address specific natural environment challenges, such as the loss of biodiversity and trend toward a homogenization of terrestrial ecological assemblages associated with human land use identified by Newbold *et al*. (2018).

By their simultaneous use, the 5 characteristics of the Smart-Natural city interface have the potential to help start dialogues to resolve concerns (Arts *et al*., 2015; Roberts, 2017) over how these benefits are transferred to and received by urban populations and the circumstances under which this can happen most effectively. The use of this new approach can guard against widening the digital divide and amplifying poverty gaps as described by Hernandez & Roberts (2018), allows us to 'see the expertise of citizens' (Noveck, 2015b) and so address the disconnect challenge identified by Colding & Barthel (2017). This has the potential for high impact in cities such as Birmingham which exhibit this problem but has an age structure with relatively high proportions of young people (BCC, 2014b) who will be familiar with the technology.

The research outcomes identified within the Smart-Natural City interface two particularly strong opportunities.

Infrastructure and systems perspective: embracing a 'silver-green' model. The exploitation of the Smart-Nature Interface can fill the gap identified by Gaston *et al.* (2013) for the development of new kinds of ecosystem process models to help manage conflicts and inform city design and management. In particular the interface can be exploited to focus attention away from the polarisation of grey and green infrastructure towards an urban ecosystem that stresses and optimises the more positive 'silver-green' infrastructure; this necessarily combines smart and natural attributes as a default solution for infrastructure and can produce better outcomes for people and the environment. Critical here is the realisation that people are an integral part of natural systems. Here the development of improved design standards such as BREEAM and Building with Nature (Callway *et al.*, 2019; Jerome *et al.*, 2019)

This would be a key integrative tool, using smart, digital technology to allow connections to be made across silver, green and blue components. Through this integration, exploiting the interface can help the wider mainstreaming of nature in decision making, avoiding the binary positioning that sees green pitted against grey and help nature based solutions to be integrated within existing built infrastructure (Hansen & Pauliet, 2014).

Towards Smarter Green pathways using SMART citizens. Secondly, as well as integrating physical infrastructure, the rise of the Smart Citizen offers exciting new potential at the smart-natural interface. This sees the integration of enabling technology with people and environment in terms of their expectations of high quality living environments with accessible green infrastructure. This provides decision makers and communities a means of achieving co-creation pathways (Mahmoud & Morello, 2018) and the ability to exploit fully the opportunities being presented by urban computing and key dimensions on data (Arts *et al.*, 2015; Zheng *et al.*, 2014), both of which can have a substantial impact on ecology and nature conservation. In particular, the combination of multiple sources of data on people, on nature, communication and especially participatory sensing to inform governance models. It also endorses work such as that by Seresinhe *et al.* (2017) on 'scenicness' which combine public perceptions and ratings of landscape with new data handling capabilities. This would work for enhancing new developments and retrofitting the existing city spaces that link them, provided the data is generated from identified challenges and problems (Gaffney & Robertson, 2018). It would help address the gap identified by Capdevila & Zarlenga (2015) that the social/community/human aspect of the smart city has not been sufficiently integrated in the smart city policies. It does, however, require the application of more interactive better decision-support tools so that they can better visualise data.

Good Smart City governance recognises the importance of co-creation with citizens and digital inclusion (Eden Institute, 2018 p8). The use of the smart-natural hybrid space encourages us to create citizen-led dialogues that can connect with established techno-centric dialogues that currently dominate much city planning (Adams *et al.*, 2014). This intersection is related to the learning capacity of citizens, communities and institutions in dealing with common problems and so can enhance the performance of the smart and natural city. The interface can assist with identifying the appropriate ICT and environmental measurements as an important integrating and connectivity mechanism, such as that described by Zheng *et al.* (2014) and Carton & Ache (2017) for citizen-sensor-networks. Furthermore, the space explicitly allows for exploiting the value of social media and Big Data arising from our use of technology. Social mapping applications (such as 'schmapped'; IWUN, 2017; McEwan *et al.*, 2019) and social networks (such as Twitter; #greeninfrastructure and #naturebasedsolutions) for understanding the use of local green space (Roberts, 2017) can create a human powered participatory sensing network that can be combined with remote sensing into SMART city systems and applied in the context of optimising the multiple benefits from ecosystem services.

Conclusions and recommendations

This research has designed a transferable method from the Birmingham experience to other cities to start new dialogue that bring the hitherto separate SMART and natural and policy interventions together. Crucial to our progress in this transdisciplinary endeavour has been the innovation workshop and its management within a safe learning space. By identifying key players across the Smart-Natural City interface we have started new dialogues on common themes thereby securing significant additional value from the participant's insight and experience. The need to enable interdisciplinary and transdisciplinary thinking here becomes key as does the need for enablers and catalysts who can enable this to happen (Newcastle City Futures, 2017; Tewdwr-Jones *et al.*, 2015; Tress *et al.*, 2005).

Emerging urban socio-ecological-technological relationships have been noted by Gulsrud *et al.* (2018) and Colding & Barthel (2017). The combination of steps in our research methodology has allowed us to describe the identity of the Smart-Natural City interface in the form of its 5 characteristics and exposed two distinct opportunities; the development of silver-green infrastructure and working with citizens to create smarter green pathways that can connect people with their place and nature. In doing this it responds to and provides a platform for further work on the techniques for boosting citizen participation in smart cities identified by Mora & Deakin (2019).

These can prove to be a powerful means of addressing the dis-functionality that exists between several policy silos in a city (Scott *et al.*, 2013) where we champion the "power of the process" (Glass *et al.*, 2013). The subsequent design, testing and exploitation of this hybrid space between the two separate urban discourses allows city planners and citizens to get 'smarter with nature' so that it generates more benefits to people and the city and helps shape conversations that can lead to a re-design of public services.

We recognise that there is an undoubted tension between the practice-led predilection towards short-term, reactive and incremental changes as opposed to the need for wider cultural and behaviour change in city governance (Buck & While, 2017; Low, 2002; UN Habitat, 2014) and which is exemplified in our case study of Birmingham (Kerslake, 2014). This heralds important questions as to the ability of our more strategic framework to

provide the necessary tools and technology or outcomes (the key natural capital and services) that address specific and immediate practice problems.

A particular challenge will be the creation of a new business value model that can substitute for public funding of the nature that supplies ecosystem services to people. The use of the set of characterisations can provide improved urban diagnostics which engage with people, to better understand and 'read' (Leach *et al.*, 2018) city systems over the long term. This in turn helps to unlock the governance barriers for more joined up working across traditional silos.

This research has revealed the opportunities that can emerge at the boundary or interface between any two or more policy areas. The importance of considering connectivity in both policy and spatial terms has especially emerged; this may be unsurprising but our framework provides a starting point and a route map for ensuring that the challenge of exploiting digital technology for connected urban futures, futures which can benefit both people and nature. It is an approach which merits further testing across other cities that aspire to be biophilic and smart, as well as within Birmingham itself.

Data availability

Underlying data

Environmental Information Data Centre: Record of expert inputs shaping future city discourses for Urban Living Birmingham. https://doi.org/10.5285/474e090d-4502-432c-b8de-ce9f33571f8e (Grace *et al.*, 2019)

This project contains the following underlying data:

- ULB-GettingSmarter-datasetMatrixfeedbackfromExperts-Anonymised2A.rtf (Matrix of Feedback from Expert Collaborators)
- ULB-SmartNaturalCityWorkshop12thSept2017-writeup-ofnotescomments-Anonymised2A.rtf (Comments and key points captured on the day from the plenary and group discussions)
- ULB-Smart-Natureworkshop-Group1draftnarrative-Anonymised2A.rtf (Record of Group 1 outputs from the Innovation Workshop)
- ULB-Smart-Natureworkshop-Group2draftnarrativeAnonymised2A.rtf (Record of Group 2 outputs from the Innovation Workshop)
- ULB-Smart-Natureworkshop-Group3draftnarrative-Anonymised2A.rtf (Record of Group 3 outputs from the Innovation Workshop)
- ULB-Smart-Natureworkshop-Group4draftnarrative-Anonymised2A.rtf (Record of Group 4 outputs from the Innovation Workshop)

Extended data

Environmental Information Data Centre: Record of expert inputs shaping future city discourses for Urban Living Birmingham. https://doi.org/10.5285/474e090d-4502-432c-b8de-ce9f33571f8e (Grace *et al.*, 2019)

This project contains the following extended data:

- ULB-Smart-Nature-AppendixA-anonymised.rtf (Meta-table which organises and summarises all of the outputs from the Innovation Workshop held in Birmingham, UK on 12th September 2017 and subsequent group discussions and individual or collective 'deeper dive' conversations that were held between September 2017 and November 2017)
- ULB-Smart-Nature-InformativenoteforSC-NCworkshop-final-anonymised.rtf (Briefing Note provided for expert attendees ahead of the Innovation Workshop)
- ULB-GettingSmarterpaper-NERCDataRepository-SupportingInformation.rtf (copies of photographs of the collective 'stickies' contributions at the workshop)

Please note an account must be made to be able to access and download the data.

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Open Peer Review

Current Peer Review Status: ✔ ✔

Version 2

Reviewer Report 08 April 2021

https://doi.org/10.21956/emeraldopenres.15181.r27422

✔ **Manuel Pedro Rodríguez Bolívar**
Department of Accounting and Finance, University of Granada, Granada, Spain

In my opinion, the concerns I had with the first version of the paper have been answered accordingly. Therefore, thank you very much for your effort in improving the paper. I hope it will be interesting for the academia.

Therefore, I think that the paper should be accepted in its current form.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Smart cities. Smart Governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 22 March 2021

https://doi.org/10.21956/emeraldopenres.15181.r27421

✔ **David Ludlow**
Department of Architecture and the Built Environment, University of the West of England, Bristol, United Kingdom

On the basis of the recent revisions provided I can now approve this paper to passing peer review.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: urban planning and ICT enabled urban governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 17 August 2020

https://doi.org/10.21956/emeraldopenres.14295.r26981

?

David Ludlow
Department of Architecture and the Built Environment, University of the West of England, Bristol, United Kingdom

The paper and its underlying research activity are a most welcome contribution to the smart city debate with focus on urban planning and governance. Urban living labs indeed support “new dialogue” providing a critical enabler of both integrated and open governance, as required. However, as regards the conceptual frame for the research there are some questions that might be addressed. Critically this concerns the simple dialogue of “smart” with “nature” that places smart in a false relationship with the policy area. The smart city potentials supporting ICT enabled urban governance must respond to the user requirements (urban planner) that is critically defined in relation to the need for policy co-benefits solutions for a sustainable and carbon neutral city. Some review of the article to address these issues would be beneficial.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Is the argument information presented in such a way that it can be understood by a non-academic audience?
Yes

Does the piece present solutions to actual real world challenges?
Yes

Is real-world evidence provided to support any conclusions made?
Yes

Could any solutions being offered be effectively implemented in practice?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: urban planning and ICT enabled urban governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 28 Aug 2020

Michael Grace, Birmingham City University, Birmingham, United Kingdom

Our thanks to David Ludlow for his review and comments. The suggestion of adding and strengthening the reference to the user needs of urban planners for smart solutions is a good one and we will revise the paper accordingly.

Best wishes,

Mike

Mike Grace
BCU

Competing Interests: No competing interests were disclosed.

Author Response 26 Jan 2021

Michael Grace, Birmingham City University, Birmingham, United Kingdom

Thank you again for your comments. We have amended the paper in direct response to the issues you raised.

The paper has been amended to include additional commentary on the relevance of the research for urban governance and in particular from the perspective of urban planners engaged in policy making for green infrastructure. In particular we have added stronger points on the smart city sections; featuring Joss et al 2017 and drawing on work across smart cities role of governance and globalisation and, on integrating the smart and natural city, we have highlighted the role of governance using Ben Yahia et al 2019. The Malmo case was useful in homing into particular city's vision, Parks 2019.

Additional literature on urban greening has been referenced in the further commentary on governance implications. We have also filled the gaps noted by the reviewer with additional references to 3 systemic and recent reviews of smart city progress globally, including Mora & Deakin 2019. We have noted that these agree with the experience of Birmingham, that they provide endorsement of the purpose behind the research described in the paper and that our findings help to address some of the issues the literature identifies. This additional new material responds to and strengthens comments from both yourself and fellow reviewer Bolivar.

Some further changes to the paper have been made in response to reviewer Bolivar's commentary.

Competing Interests: No competing interests were disclosed.

Reviewer Report 03 August 2020

https://doi.org/10.21956/emeraldopenres.14295.r26940

?

Manuel Pedro Rodríguez Bolívar
Department of Accounting and Finance, University of Granada, Granada, Spain

- Is the work clearly and accurately presented and does it cite the current literature?

The work is clearly presented and cites current literature, although a deeper literature search is needed. Only as examples of literature related to the paper, but not cited int the text are:

Bibri, S. E. (2020). *Advances in the leading paradigms of urbanism and their amalgamation: compact cities, eco–cities, and data–driven smart cities*. Springer Nature[1].
Colding, J., Barthel, S., & Sörqvist, P. (2019). Wicked problems of smart cities. *Smart Cities*, *2*(4), 512-521[2].
Kumar, T. V. (2020). Smart environment for smart cities. In *Smart Environment for Smart Cities* (pp. 1-53). Springer, Singapore[3].
Li, X., Fong, P. S., Dai, S., & Li, Y. (2019). Towards sustainable smart cities: An empirical comparative assessment and development pattern optimization in China. *Journal of Cleaner Production*, *215*,

730-743[4].
Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., da Costa, E., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic review of the literature. *Sustainable cities and society*, *45*, 348-365[5].

Therefore, I would suggest authors to undertake a deep literature search and incorporate into the text some new literature. Indeed, some literature into the text is not current literature and should be replaced by more recent literature (for example, Tress et al., 2005).

- Is the study design appropriate and does the work have academic merit?

Yes, the study is well-designed and the work has academic merit.

- Are sufficient details of methods and analysis provided to allow replication by others?

No. The literature search should be better explained. For example, Which databases were used to perform the literature review? Which was the query used and the key terms of the study? Did authors use Web of Science, SCOPUS, EBSCO, DGRL, etc. or did they only use Google Scholar? How did authors select the 4 key propositions? Which was the method used for this selection?

On another hand, the deeper dives are performed using different methods (teleconference, face meetings, email, etc.). The question here is, was there a unified guide for the interviews? Is there a structured questionnaire followed through the different methods?. These questions are not answered into the text of the paper.

- If applicable, is the statistical analysis and its interpretation appropriate?

There is no evidence of the way that authors chose the 5 interconnected principles or characterisations of the interface between the Smart City and the Natural City. I would suggest authors to explain it in a greater detail.

- Are all the source data underlying the results available to ensure full reproducibility?

Yes. The data is provided by the authors.

- Are the conclusions drawn adequately supported by the results?

Yes, but conclusions should be improved with policy implications and future research directions.

References

1. Bibri SE: Advances in the Leading Paradigms of Urbanism and their Amalgamation. *Springer*. 2020. Reference Source
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5. Yigitcanlar T, Kamruzzaman M, Foth M, Sabatini-Marques J, et al.: Can cities become smart without being sustainable? A systematic review of the literature. *Sustainable Cities and Society*. 2019; **45**: 348-365 Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Is the argument information presented in such a way that it can be understood by a non-academic audience?
Partly

Does the piece present solutions to actual real world challenges?
Partly

Is real-world evidence provided to support any conclusions made?
Partly

Could any solutions being offered be effectively implemented in practice?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Smart cities. Smart Governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 28 Aug 2020

Michael Grace, Birmingham City University, Birmingham, United Kingdom

We would like to thank you for these review comments and the pointers to the other literatures sources. We will consider the literature and the implications for the paper; the very recent book 'Untangling Smart Cities' by Mora and Deakin (Elsevier, 2019) is also relevant and provides support for the findings of our work. . Also we will aim to clarify the issues noted around the literature search, interview structure and method for choosing the 5 characterisations.

Thank you again.

Mike

Mike Grace
BCU

Competing Interests: No competing interests were disclosed.

Author Response 26 Jan 2021

Michael Grace, Birmingham City University, Birmingham, United Kingdom

Thank you again for your comments. We have amended the paper in direct response to the concerns you raised.

Additional literature on urban greening has been referenced in the further commentary on governance implications. We have also filled the gaps noted by the reviewer with additional references to 3 systemic and recent reviews of smart city progress globally, including Mora & Deakin 2019. We have noted that these agree with the experience of Birmingham, that they provide endorsement of the purpose behind the research described in the paper and that our findings help to address some of the issues the literature identifies. This additional new material responds to and strengthens comments from both yourself and to fellow reviewer Ludlow.

We have clarified the description of the databases we used for the literature search and especially the use of BCU's 'Summon' search tool which accesses multiple databases.

The methodology section was restructured to improve clarity on transferability and replication.

The paper now includes additional tables and information on the selection of the 4 propositions and the semi-structured interview questions used for the deeper dives. A table 2 has been added that sets out the proforma used for the deep dives to demonstrate consistency.

The process e adopted to choosing the principles has been explained in the meta table (Annex A); We have amended the text to make this clearer and a link is provided to the meta table held on the agreed repository. We have used the example of the connectivity space (as in the original discussion) but previously it was not a separate box. It is now Box 1 and has a reference in the text. The text has been changed to better tie in with the meta data.

The underlying data sources are described in the text box and Annex A. This has now been better described in the text through to Box 1 from Appendix A and the supplementary data. We have asked the journal Editors to ensure that the links to the extended data and underlying data repository are operational, to ensure that readers can readily access the data.

Competing Interests: No competing interests were disclosed.