Do smart cities realise their potential for lower carbon dioxide emissions?

Cavada, Marianna; Hunt, Dexter, Rogers, Chris

Abstract

'Smart cities' embrace technologically based solutions as an enabler of efficient, affordable and more sustainable urban living in times of resource scarcity, persistent austerity and high-tech innovations. However, cities' evermore complex systems are, albeit unwittingly, causing mismanagement, future uncertainty and lack of transparency to exacerbate their challenges. Climate change is likely to be the greatest of the contextual challenge scale and in terms of scale and diversity of impacts. This paper explores the role of smartness indicators, in which 'green' undoubtedly is a large innovation engine, yet not the only one. Similarly, the beneficial impacts of 'green' technology solutions are yet to be fully understood or rigorously established. Cities that adopted smart roadmaps embedded lower carbon dioxide (CO2) emissions within the environmental sustainability agenda; however, the degree to which the two issues have been directly linked is unclear. Findings from this study suggest that lower carbon dioxide emission initiatives are embodied within the environmental sustainability initiatives agenda, yet are not clearly defined in the smart cities ideology. This paper proposes a balanced combination of human talent, 'green' innovation and technological innovation – the interdependent triptych philosophy for 'smart city' resilience that can be adapted and offer tailored solutions for cities, communities and individuals.

1. Introduction

Although 'smart cities' is a popular perception of contemporary cities, it is not yet a self-explanatory term (Caragliu et al., 2009). The phrase was first coined around the turn of the new millennium, a general interpretation of the meaning being the empowerment of urban centres to evolve expediently from what had gone before (Heap, 2012). In the current complex context this includes rapid urbanisation, constantly evolving and transformative technologies and a plethora of other related challenges. Therein 'smart cities' are hailed as a 'system of systems' approach fundamental to dealing with the unprecedented complexities of modern day urban living (Naphade et al., 2011), one of which is the growing influence of climate change.

It is suggested that cities lead the smart agenda by 'redefining what it means to be a smarter city' (IBM, 2012) where technology is used for systems optimisation and leadership to tackle climatic issues successfully (Hill et al., 2011). IBM supports the idea that this technology is the medium for enhancement of city operations and city life: in particular, efficient infrastructure (utility, sewerage, energy, security systems and health innovations) that will run operations more smoothly and improve sustainability. However, perhaps this understates what smartness is (or is not) because of the context and complexities of where 'smartness' is created, and where exactly it is constrained requires a little more investigation. For example, in the developed world many embrace 'smart' technological opportunities from within cities, and argue that they act as a connection platform between citizens, geographical context and 'things', allowing for people to be seamlessly 'connected' using data, information and technology in real time (Doherty, 2013). However, this inherent widening of the horizon of citizens' own options (intimately connected to those of other citizens) might then be the forbearer of a society in which innovative city interventions are developed and implemented (Harrison et al., 2010) without considering the consequences. In some respects perhaps the smart cities agenda inadvertently moves (or has moved) towards a simulated city context in which deployment of 'netizens' (or cybercitizens) exists, and according to Gabrys

(2014) could provide a fiscal process that is worth trillions of dollars. Moreover, might the action of merely concentrating on the technology alone ultimately prove harmful to the necessary ideology that a truly smart city requires (Murgante and Burroso, 2013)?

However, as sceptics suggest, misconceptions of 'technology' and 'controlled behaviours' should be the positive perspective of a smart city ideal, leading to an array of economic risks that would undermine the smart agenda (Greenfield, 2013). In general, it is assumed that advanced technology is the main driving commodity, the likely biggest facilitator in which engagement is required in the wider conceptual system of sustainable urbanities.

Undoubtedly, innovations within technology and efficiency sectors will implement city advancements, although these require careful consideration as what appears to be smart in one city may or may not be smart in another – 'smartness' is context dependent. This requires those involved in the smart agenda to work alongside all stakeholders (Lombardi et al., 2011a) to develop a city's smart vision, taking into consideration contextual and geographical differences – what is sustainable is determined locally: local conditions set local priorities (Lombardi et al., 2011b). The smart ideal, as an enabler towards sustainable city living, is a 'holistic frame' based on three principles: 'to reduce their ecological footprints and resource needs, to deepen connections to landscape and place and to enhance livability and quality of life while expanding economic opportunities' (Beatly and Newman, 2013). Complex city systems and human interventions are the ones risking climate change, whereas understanding issues connected with cities and complexities can help measure and decrease the impacts of carbon dioxide (CO2) emissions and climate change (NAS, 2010). In this respect, individual choices would either reflect a response to city challenges, such as carbon dioxide reduction, or be stringently set within the context of a lens that considers most deeply their views. Within an energetic economic context, this might provide a foundation for enjoyable, sustainable and optimal smart city living (Duckenfield, 2013) and as a primary solution to problems of rapid development seen ever more frequently within many cities (Nam and Pardo, 2011).

While it might be suggested that technology leads to optimisation in cities there may also be disbenefits, the long-term impact of which is yet unknown. In addition, the inextricable links between liveability and fiscal prospects, with innovation as the main urban element (e.g. 'eco-districts', 'local gardens' and technological projects such as the 'centre for neighbourhood technology district downtown' and others) cannot be ignored (Eugenios et al., 2014).

Therefore, evaluating the carbon dioxide significance of smartness is undoubtedly going to be problematic, not least when engineers have yet to evaluate fully the complexities of the smart agenda itself. In other words, what is the real meaning of the term 'smart city' when we take into consideration, as with sustainability, local priorities and local conditions (Cavada et al., 2014)? Without such a definition and associated indicators, there would undoubtedly be confusion and much difficulty when trying not only to quantify, but also to compare readily, what constitutes city smartness in different areas worldwide – carbon dioxide reduction being a small element within this overarching philosophy.

With this in mind one of the associated challenges appears to be a lack of official smartness indicators at international or national levels, and where they do exist 'low carbon dioxide' appears to be somewhat lost within the smart cities agenda. This may be because existing rankings that reveal the smartest cities (and highlight related initiatives) have been generated by single institutions and publications, meaning compatibility is subjective at the very least while it is also evident that a smart city is more than achieving carbon dioxide reduction alone. In addressing this problem more clearly

this paper identifies a range of sources that provide smart city rankings to elucidate where ‘smart’ fits in and how this relates to an agenda of ‘low carbon dioxide’.

2. Methodology

Through a stepwise methodology this research examines the initiatives related to the smart cities agenda. A database in Microsoft Access is created, to describe the complexity of smartness. It documents the individual cities that have been announced smart in addition to the initiatives that these cities adopted and awards they won. In the dataset, the relationship between ‘city and initiatives’ is explored to give information on the city with the most initiatives, number of smart cities awards and awards themes. Due to the plethora of initiatives, we are able to see the figures of initiatives per city, initiatives themes and initiatives categories. The authors then examine the ranking in initiatives categories and identify the role of the carbon dioxide emissions as part of the initiatives. To identify carbon dioxide emissions on individual smart cities, we test the smart initiatives as case studies and record how they differentiate. The following are the stepped objectives of this paper

■ Step 1: to create a smart city database that can be interrogated (Section 3.1)

■ Step 2a: to identify trends in published material on city rankings (Section 3.2)

■ Step 2b: to establish key themes used within city rankings (Section 3.3)

■ Step 2c: to identify leaders in city rankings (Section 3.4)

■ Step 3a: to establish smart categories, subcategories and initiatives (Section 3.5)

■ Step 3b: to investigate smart city status in two case studies (Section 3.6).

3. Results

3.1 Step 1: city ranking awards trend

The dataset is created from smart city publications, having the city as the focus of the dataset, which becomes the connection between the city information (scale, location and information source) and initiatives. This allowed for datasets to be interrogated according to areas within this research according to each key step and the initiatives that smart cities have taken to become smart to be determined. In addition, the awards that smart cities were awarded can indicate some of the steps that these cities took to become smart. Both initiatives and awards are supported by their sources, whereas the initiatives are categorised according to initiative themes (Figure 1).

3.2 Step 2a: smart city awards (and related ranking) publication trends

By looking at published materials on smart city awards (and related ranking) over the period 2004–2014 (Figure 2), it can be seen that there is growing interest for those reporting on and comparing the performance of cities in terms of smartness and related themes (see Section 3.3).

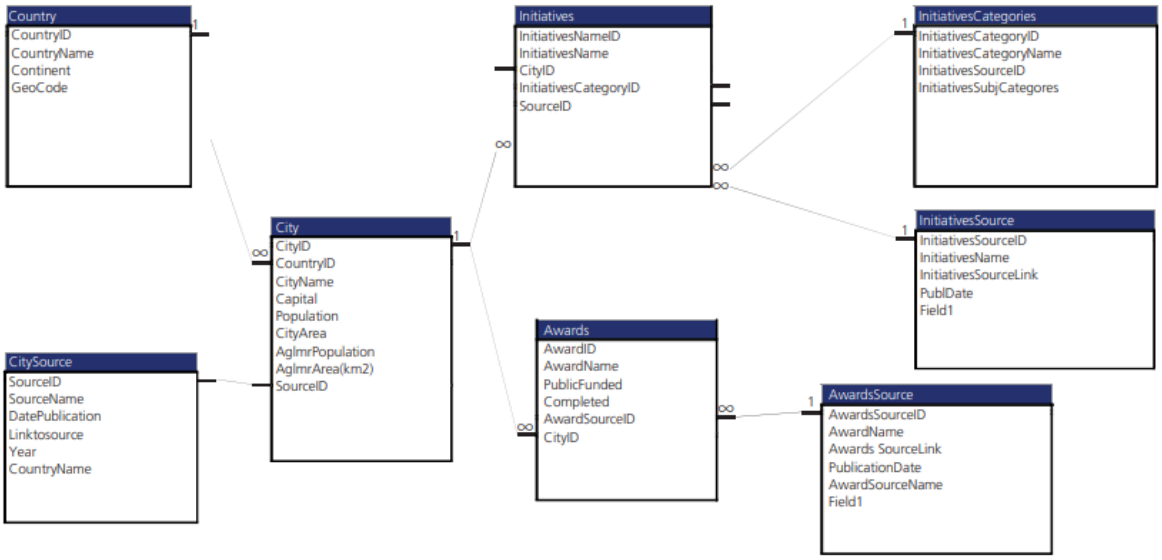

Figure 1: Interrogation of the dataset in Microsoft Access

City awards were the first to introduce awards for intelligence as a shift towards digitalisation, followed by the EU Civitas awards and Eurocities awards during the first decade of the new millennium. Soon after 2010 the awards for EU biodiversity capital and EU green capital were introduced, along with the first smart cities awards; however, probably for economic reasons, these stopped. It is evident that city awards started as intelligence awards; there was a shift early in the current decade towards climate response, green and Civitas awards (city, vitality, sustainability). However, the rapid growth of the awards from 2013 indicates a resurgence of international interest.

3.3 Step 2b: smart city ranking themes

When comparing these published materials on city rankings it is possible to characterise them according to five overarching themes, as shown in Table 1. Most of the sources belong to a smart theme, although these are complemented by other key city themes – sustainability and climate, innovation and liveability. Interestingly, when considering the themes being used to judge the awards to cities it can be seen that many focus on climatic responses, intelligent communities, design, mobility, technical innovation, public participation and smartness – see, for example, the Civitas Initiative (2004–2014) co-financed by the EU, Intelligent Community (ICF, 2002–2015), the EU Climate Leadership Awards (C40, 2013–2014), World Design Capital (ICSID, 2008–2014), green EU Capital of Biodiversity (Fundacion Biodiversidad, 2011) and Smart City Expo (2012), between 2002 and 2015. Therefore, the majority of the awards are given primarily on green (including climate change mitigation) and innovation criteria, whereas mobility, resilience and economy have less prominence (Figure 3).

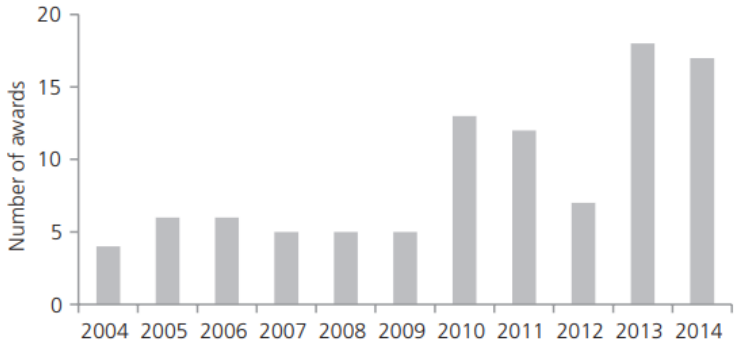

Figure 2. Number of awards on city rankings in period 2004 to 2014

Table 1: City ranking themes and sources

Theme	Named ranking	Sources
Smartness	Top 10 smart cities on the planet	Cohen, 2012
	10 most impressive smart cities on Earth	Delgado, 2012
	Top ten smart cities in the world	IME, 2014
	The 20 best cities on the planet	Willett, 2014
	Smart cities – technology	Wakefield, 2013
	Smart cities – infrastructure economics	Laneri, 2009
	Smart cities – market analysis	Alcatel-Lucent, 2012
	The New Economy's Smart Cities 2014	The New Economy, 2014
	Top 50 smartest cities	National Geographic, 2014
	Smart city	Smart City Expo, 2012–2014
	Scitech smart cities	IOL Scitech, 2014
Sustainability and climate	EU capital of biodiversity	Fundacion Biodiversidad, 2011
	City climate leadership awards	C40, 2013–2014
	EU green capital	EC, 2015a
	Sustainable cities	Arcadis, 2015
	North America sustainable cities	Corporate Knights, 2013
	EU Civitas	Civitas Initiative, 2004–2014
Innovation	Intelligent community	ICF, 2002–2015
	CNN most innovative cities	Eugenios *et al*., 2014
	Top global cities of today	Hales *et al*., 2014
	EU cities of the future	fDi Intelligence, 2014
	World design capitals	ICSID, 2008–2014
	Access city awards	EC, 2015b
	iCapital	EC, 2014
Liveability	Eurocities	Eurocities, 2015
	Mercer quality of life	Mercer, 2014
	Economist liveability ranking	The Economist, 2014

3.4 Step 2c: cities leading smart city rankings

When considering all of these key ranking systems, which in total consider 282 cities from 52 countries in five continents, it appears that the EU has the biggest concentration of so-called 'smart cities' (Figure 4(a)). The USA is considered the smartest country, followed by The Netherlands (Figure 4(b)), and New York is considered the smartest city, followed by Amsterdam (Figure 4(c)). Interestingly, Stockholm, Ghent and Nantes have at least three awards each for sustainability (Figure 5), but it is of interest to note that they do not feature in the smartest top 12 city leaders according to the authors' research of existing smart city rankings, although Toronto and Seoul do. Interestingly, cities internationally provide a wider smart roadmap, which includes technological innovations as well as smart interventions apart from just sustainable solutions.

3.5 Step 3a: categories, subcategories and initiatives

In order to describe, rank, then make an award for smart city performance accurately, the primary step has to be to identify the generic key criteria (or subcriteria) and initiatives (considered here to be an action taken to improve a city's smartness associated with an indicator that can be used to measure the efficacy of this action) that are being adopted. For example, in Scotland a smart initiative was considered to be the introduction of 'open data' (OpenDataScotland.org, 2013) to achieve smarter, more transparent and efficient data use. When considering all the smart city approaches in parallel, this research has identified that six broad categories exist, consisting of 798 initiatives (Table 2).

According to Table 2 it can be seen that environmental sustainability is the dominant category with a total of 179 indicators and actions in cities. Climate change is very much considered within this section, with 64 indicators and actions associated with it (Figure 6). What is surprising, and what is most striking from Table 2, is that 'smart city programme' features within the 'civic' sections, and therefore the link between carbon dioxide reduction and smartness is being lost even though the link is readily apparent. On the whole, cities are responding to the carbon dioxide reduction challenge (Figure 6), but it is not necessarily being driven by (or even linked sufficiently to) the smart cities agenda. The question is whether it could be or should be in order that opportunities are not lost.

The interesting point here is that systems not derived for measuring smartness per se have categories (akin to drivers of change) and indicators not dissimilar to smart city categories. For example a 'sustainability rankings' system from Corporate Knights (2013) uses a combination of three themes (ecology–economic–culture) that encompass 27 indicators and actions (focused on sustainability and material flow analysis) applied to 20 cities (within the USA and Canada). While this research presented some contextual differences in terms of economic, climatic and census data, it can be seen that five categories emerge, which in combination create a sustainability index providing a narrative of 'environmental quality, economic security, governance and empowerment, infrastructure and energy and social wellbeing'. This might be considered a complete view of the sustainable city (Corporate Knights, 2013), but is not derived exclusively to measure smartness.

On the other hand the 'smart cities wheel' (Cohen, 2012) ranking approach applied to 12 cities provides a simple methodology of 'actions and indicators' specific for smart cities and is equally divided into very similar (albeit broad) themes

- environment
- economy
- society (people and living)
- mobility
- government.

In this system a collection of 400 indicators are equally distributed between: smart environment, which contains urban planning; resource management; and smart buildings, which includes carbon footprinting and energy consumption indicators (Cohen, 2014). While there is no unique category for smart technology within this methodology, it does feature as an indicator in the government, mobility, society and economy dimensions. Smart living corresponds to the quality of life dimension and refers to culture and happiness, safety and wellbeing in terms of living conditions. In other words, it appears that existing sustainability indicator systems are being applied (or reinterpreted) according to a smart cities agenda. In a way this almost mirrors how environmental indicators were

reinterpreted in the late 1990s to fit the sustainability agenda. There is nothing wrong with this approach – it merely shows how robust some indicator sets are and how flexibly they can be applied.

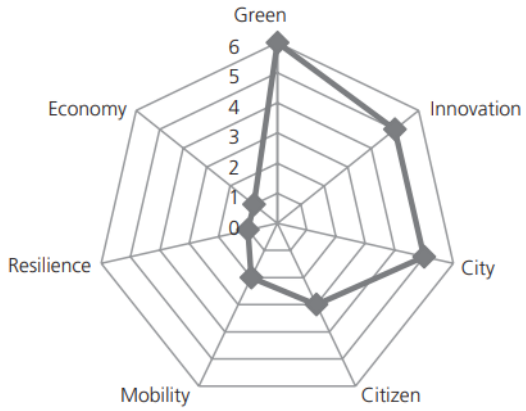

Figure 3. Smart city awards (2009–2014) showing number of awards per theme

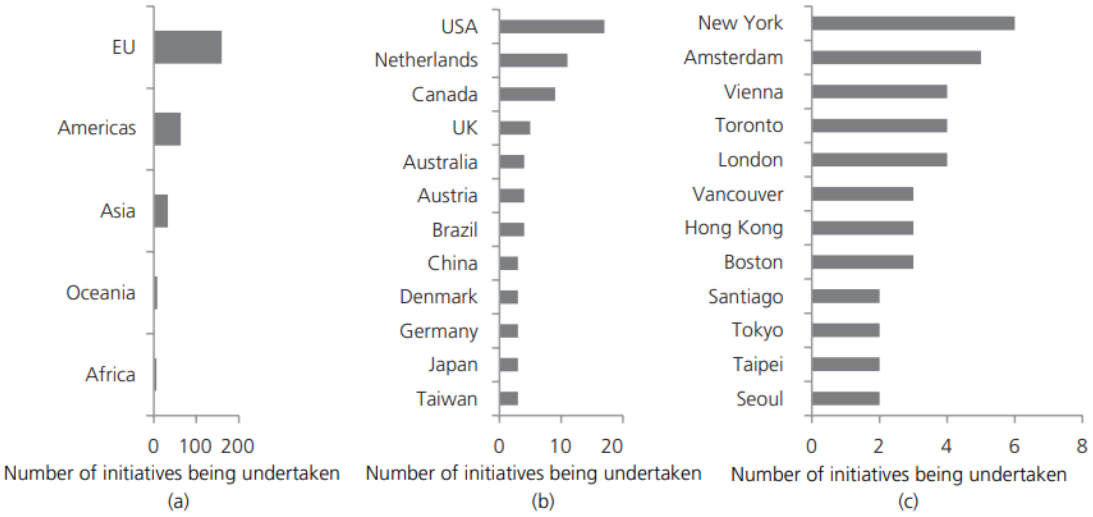

Figure 4. Smart city leaders in terms of initiatives being undertaken by: (a) continents; (b) country; (c) city

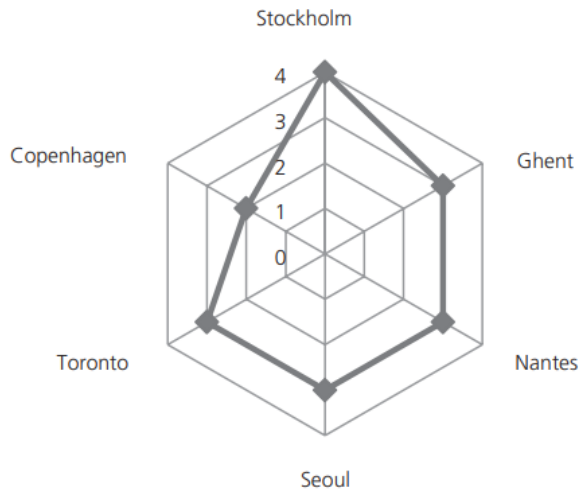

Figure 5: City awards (axis refer to number of awards)

3.6 Step 3b: applying smart categories to case studies:

Copenhagen versus Singapore In this step the criteria highlighted in step 3a are applied to two case studies: Copenhagen and Singapore. Both have been awarded exemplar status in terms of 'smartness', although by different institutions. Firstly, in 2014 Copenhagen became the first three-time winner of the most liveable city in the world award according to the 'Quality of Life Survey 2014' carried out by the international magazine Monocle (2014). This was based on considering the 'human dimension' in urban planning, taking into consideration liveability, which includes regional and cultural differences and integration across all five driving forces (i.e. social coherence, economic growth, environmental sustainability, infrastructure and energy, and good governance). While smart was not at the core of this 'liveability' award, its contribution to the smart agenda cannot be ignored. For example, in the same year Copenhagen was awarded the European Green Capital Award (EC, 2015a). 'Green initiatives' have proved to be a fiscal element of why Copenhagen has become a smart city – the creation of a green economy has not only added value to the development of companies themselves, but also added value in terms of lower carbon dioxide emission gains (Abild, 2011). In 2012 it was ranked as the number one smart city in Europe, once again due to a focus on its citizens and green initiatives, contributing towards a shared aim of becoming carbon dioxide neutral by 2025 (Cohen, 2012). Copenhagen is now considered a thriving city populated with cyclists and pedestrians who are proud of its inherent green qualities. As one of the 'most impressive smartest cities of the world', these qualities extend from its green corporations to everyday green living and the long-term planning processes, which for Copenhagen started back in 1925 during an initial 'urban planning commission' (Delgado, 2012). Even now this ethos remains and forms a cornerstone for why Copenhagen is so highly rated among its city peers. For example, the 2011 City Council plan outlined for 2025 shows the growth plans of the city and focuses on climatic challenges and low carbon dioxide emissions. The key to its success is within the citizen–business–governance collaboration (Mortensen, 2012). The main aim of the green vision embedded therein was carbon dioxide neutrality, although what is interesting is the fact that this has led to improvements in employment and development, and a shared vision that builds on existing knowledge, rather than reliance on new developments in 'smart' technology and research (Mortensen, 2012). Copenhagen's cleantech companies' community and fiscal development appears to be key to a system that values employment growth and overall desire to become smarter therein (Lubanski, 2012). The fact that Copenhagen has been named a smart city is due not only to the

clarity of its shared green vision, but to the way that the vision has worked as a catalyst for its city life, improved mobility, creation of a green economy and enhancement of research knowledge. In Figure 7(a), created according to the categories outlined previously in Table 2, it can be seen that the main focus that makes Copenhagen smart is its drive for sustainability (42%) followed by technology (31%) and mobility (19%). In comparison, Singapore (Figure 7b), which was named number one smart city by Forbes magazine (Laneri, 2009), the Institute of Mechanical Engineers (IME, 2014) and BBC news (Wakefield, 2013), has focused more on technological innovation (38%) and human talent (29%). This shows that, overall, a very different perspective was taken in each, contributing towards their smartness accreditation in very different ways. Most strikingly, technology is prominent, but is not the only contributor as some may imagine.

Table 2. Smart city categories, subcategories, and initiatives

Category	Subcategory	initiatives
Liveability	Health, resilience, quality of life	31
Commercial	Start-ups, public–private partnerships, small- and medium-sized enterprises, growth, industry, economy, business	85
Mobility	Cycling, infrastructure, urban, transportation	85
Digital technology	Open data, digital, network, innovation, technology	156
Civic	Global, leadership, culture, human talent, governance, knowledge institutions, smart city programme	171
Environmental sustainability	Climate change, energy, biodiversity, soil land, waste, air quality	179

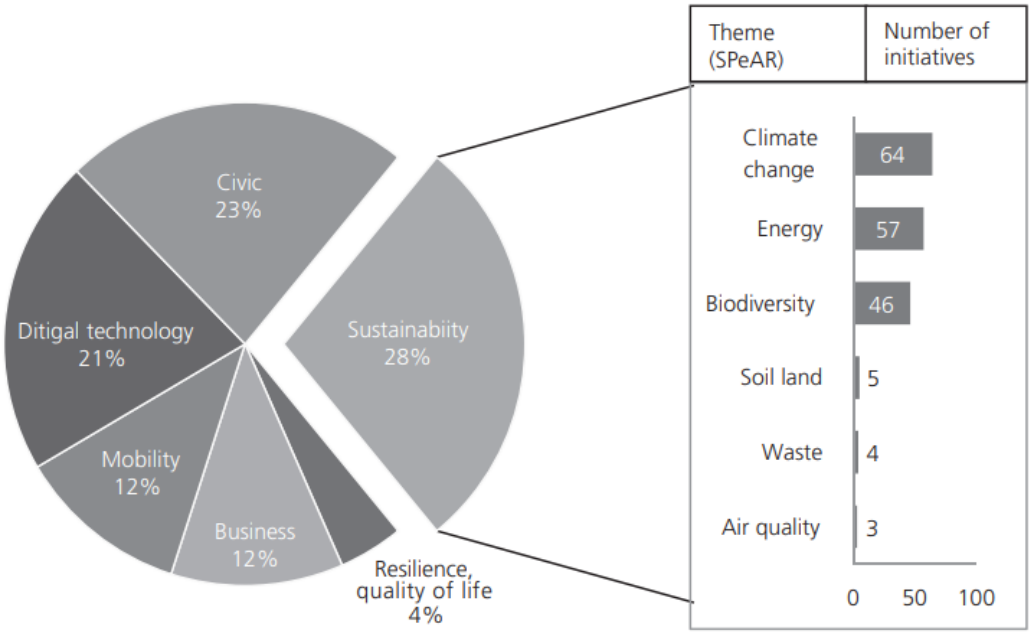

Figure 6. Smartness categories, showing initiatives for environmental sustainability, themes taken by Sustainable Project Appraisal Routine (SPeAR) (Arup, 2000)

If context is considered as smartness empowerment within cities, as suggested in the introduction, then most likely Singapore has succeeded as an international trade centre, and has enabled active business due to the short span of the nation's history and geographical location that suggested Singapore be a trading hub between other nations (Mahizhnan, 1999). Unlike other cities, Singapore

was more able to ‘exploit the differential in information between people and between places’, and after 150 years had the chance to become independent to upgrade its information technology services and telecommunications – not due to its gradual industrialisation, but by rapidly educating its citizens and getting the know-how of the new technologies. According to the national information technology plan in 1986, the focus of the city smartness therein was not on the economic paradigm, but more on the smartness of its people (Mahizhnan, 1999). Singapore’s vision now, as described in iN2015 (2006) is very much about finding ways to use technology information (‘infocomm’) to improve commercial sectors and citizen’s lives, and is much less associated with carbon dioxide. However, advancements therein (e.g. energy efficient appliances/vehicles, wireless communications, smart metering, longer battery life) are all part of the solution by doing more with less, thus allowing citizens to be connected while reducing the need to move or providing a means by which it can be done more efficiently and cleanly. The smart vision fundamentals are, however, much broader in Singapore; they empower innovation, integration and internationalisation by focusing on people, infrastructure and the global economy. Since this 10-year vision started, Singapore has advanced its digitalisation capabilities in governance, health, tourism and connectivity, and set itself up as not only a highly regarded international competitor (iN2015, 2006) but also a ‘smart’ city – yet in a very different guise to Copenhagen.

The examples of Copenhagen and Singapore are undoubtedly unique in their own right. Through ingenuity, knowledge of green technologies and a smart way of engaging people, companies and government, an international ‘unique’ smart city case has been created in Copenhagen. Similarly, Singapore’s smart development sprang from its own short legacy of strategic business into the world’s leader of information technology by structuring requirements around its users and by creating new skills and confidence. The ethos of translating ‘Copenhagenisation’ or ‘Singaporisation’ to other cities, while promoted by some and revered by others, simply cannot happen, because of the circumstantial complexity or context within each and every city. What pertains to smartness therein is unique to that place.

3. Conclusions

Smart cities’ popularity has grown exponentially in the last decade. In order to understand whether smart cities are maximising their potential to reduce carbon dioxide emissions, a plethora of smart initiatives, rankings and awards have been considered in order to reflect on the complexity of views into what smartness is or what it could or should be.

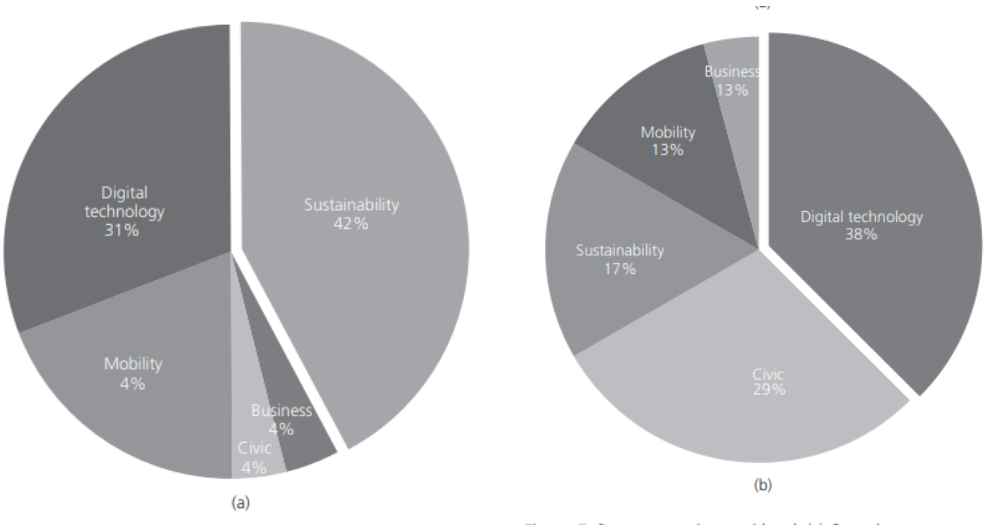

Figure 7. Smart categories considered: (a) Copenhagen, (b) Singapore

According to this research a 'smart city' appears to include a vision that considers five key categories, in which 72% of the initiatives occur in environment sustainability, digital technology and civic initiatives in the majority of cases. While there is less dominance of business, mobility, resilience, quality of life and liveability (28%), their integral contribution cannot be ignored. Environmental sustainability is currently the major influencing sector (28%) for smart city rankings, and the area of opportunity for where low carbon dioxide initiatives exist, yet they are not sufficiently exploited within the smart vision. Unfortunately, the smart agenda appears to be more widely apparent within the civic category. This shows that threads of smartness undoubtedly form threads within all categories, although these must be teased out so that opportunities are not lost with respect to carbon dioxide reduction.

Through smart city case studies of Copenhagen and Singapore, it can be concluded that a smart city vision reflects its own smart solutions according to contextual variables. Copenhagen has adopted a roadmap to become smart; however, the unclear philosophy of smart cities should not lead to the Copenhagenisation of cities. Therefore, to superimpose a smart city vision or practice onto another context is not simply smart, as the system that has been developed due to that particular urbanity worked in accordance with its own specific context. However, we can learn from these global examples and understand how they became smart, and importantly realise the complexity of the vision that reflects the existing complexity of the place. The variables that each city adopts could belong to a proposed 'environmental sustainability–digital technology–civic– mobility–business–resilience' combination; or to put it more simply a hypothesis of the triptych 'talent–green–technology'. Smartness is a complex concept and should be ever changing in order to reflect current and future conditions, and therefore we need to be sure that smart low carbon dioxide initiatives being proposed now are resilient and enhance liveability both now and in the future. This research further proposes that the understanding of city data could enhance the methodology used herein in order to give a more rigorous description of a city's smart complexity.

Acknowledgements

This study was funded by the Engineering and Physical Sciences Research Council under the current Liveable Cities programme (grant EP/J017698 – Transforming the Engineering of Cities to Deliver Societal and Planetary Wellbeing).

REFERENCES

Abild L (2011) Minister for Climate and Energy has a groundbreaking day. Copenhagen Cleantech Cluster Journal 1: 4–6. Alcatel-Lucent (2012) Getting Smart about Smart Cities. Market Analysis. Situation the Smart Opportunity, page 1. See http:// www2.alcatel-lucent.com/knowledge-center/admin/mci-files 1a2c3f/ma/Smart_Cities_Market_opportunity_MarketAnalysis. pdf (accessed 08/03/2015).

Arcadis (2015) Sustainable Cities Index. See https://s3. amazonaws.com/arcadis-whitepaper/arcadis-sustainable-cities index-report.pdf (accessed 09/03/2015). Arup (2000) SPeAR® (Sustainable Project Appraisal Routine). See http://www.arup.com/Projects/SPeAR.aspx (accessed 04/02/2015).

Beatley T and Newman P (2013) Biophilic cities are sustainable, resilient cities. Sustainability 5: 3328–3345. Burton VSP and Robinson R (2013) People for Smarter Cities. See http://www.ibm.com/smarterplanet/global/files/ uk__none__smarter_cities__ibm_uk_paper_people_for_ smarter_cities.pdf (accessed 22/12/2014).

C40 (2013–2014) City Climate Leadership Awards, London C40 Cities Climate Leadership Group. See http://www.c40.org/ awards (accessed 02/03/2015).

Caragliu A, Del Bo C and Nijkamp P (2009) Smart cities in Europe. 3rd Central European Conference in Regional Science, Košice, Slovak Republic.

Cavada M, Rogers C and Hunt D (2014) Smart cities: contradicting definitions and unclear measures. In Proceedings of the 4th World Sustainability Forum, 1–30 November 2014. Sciforum Electronic Conference Series, vol. 4, f004. Civitas Initiative (2004–2014) Cities in Motion Towards a New Role for Cities in European Transport Policy. See http://www. civitas.eu/content/cities-motion-towards-new-role-cities european-transport-policy (accessed 13/02/2015). Civitas Initiative (2013) http://www.civitas.eu/ (accessed 16/09/2014).

Chourabi H, Nam T, Walker S et al. (2012) Understanding smart cities: an integrative framework. 45th Hawaii International Conference on System Sciences, HI, USA, pp. 2289–2297.

Cohen B (2014) The 10 Smartest Cities in Europe. Fast Company Co.Exist. See http://www.fastcoexist.com/3024721/the-10- smartest-cities-in-europe (accessed 16/09/2014). Corporate Knights (2013) 2013 Sustainable Cities results. Corporate Knights: the Magazine of Clean Capitalism. 5 June 2013. See http://www.corporateknights.com/reports/ sustainable-cities/2013-sustainable-cities-results-13704731/ (accessed 12/02/2015).

Delgado R (2012) 10 Most Impressive Smart Cities On Earth. Freshome. See http://freshome.com/2013/02/07/ 10-most-impressive-smart-cities-on-earth/ (accessed 23/10/2014).

Doherty P (2013) The Digit Group Inc., Smart Cities: How to Build Sustainable and Resilient Environments in an Increasingly Urbanized World. McGraw Hill Financial Global Institute, London, UK, pp. 2–17.

Duckenfield T (2013) Smart Cities – the Who's, What's, Where's? Smarter Moving Cities Survey: Technical Details. Steer Davies Gleave, London, UK. EC (European Commission) (2012) Communication from the Commission Smart Cities and Communities. European Innovation Partnership. European Commission, Brussels, Belgium, pp. 2–15. EC (2014) The European Capital of Innovation 'iCapital' Award. See http://ec.europa.eu/research/innovation-union/index_en. cfm?section=icapital (accessed 05/02/2015). EC (2015a) European Green Capital Award (2015). See

http://ec. europa.eu/environment/europeangreencapital/winning-cities/ 2014-copenhagen/index.html (accessed 14/03/2015). EC (2015b) Access City Award. Employment, Social Affairs & Inclusion. See http://ec.europa.eu/social/main.jsp? catId=1141&langId=en (accessed 22/02/2015).

Eugenios J, Hargreaves S and Rawlins A (2014) Most Innovative Cities Methodology. Money CNN Cable News Network. See http://money.cnn.com/technology/most-innovative-cities/ methodology/ (accessed 14/03/2015). Eurocities (2015) Eurocities Awards. See http://www.eurocities.eu/ eurocities/eurocities-awards (accessed 17/03/2015).

fDi Intelligence (2014) The fDi Report 2014. See http://ftbsites.ft. com/forms/fDi/report2014/files/The_fDi_Report_2014.pdf (accessed 03/02/2015). Fundacion Biodiversidad (2011) Capitals of Biodiversity. European Municipalities Lead the Way in Local biodiversity protection. European Capitals of Biodiversity. See http://ec. europa.eu/environment/life/project/Projects/index.cfm? fuseaction=home.showFile&rep=file&fil=COB_European_ ENG.pdf (accessed 05/02/2015).

Gabrys J (2014) Programming environments: environmentality and citizen sensing in the smart city. Environment and Planning D: Society and Space 32(1): 30–48. Greenfield A (2013) Against the Smart City. Do Projects, New York, USA.

Hales M, Peterson ER, Pena AM and Gott J (2014) Global Cities Index and Emerging Cities Outlook: Global Cities, Present and Future. A.T. Kearney. See http://www.atkearney.com/ documents/10192/4461492/Global+Cities+Present+and +Future-GCI+2014.pdf/3628fd7d-70be-41bf-99d6- 4c8eaf984cd5 (accessed 03/02/2015).

Harrison C, Eckman B, Hamilton R et al. (2010) Foundations for smarter cities. IBM Journal of Research and Development 54(4): 350–365. Heap R (2012) How to Become a Smart City: A Beginner's Guide. UBM future cities, London, UK. See http://downloads.deusm. com/ubmfuturecities/How_to_Make_Your_City_Smarter.pdf? p_redirone=yes&piddl_promo (accessed 10/02/2015).

Hill D, Doody L, Watts M and Buscher V (2011) Arup UrbanLife: The Smart Solution for Cities. Arup, London, UK, pp. 7–11. IBM (2012) Smarter, More Competitive Cities: Forward-Thinking Cities are Investing in Insight Today. IBM Corporation, New York, USA. ICF (Intelligent Community Forum) (2002–2015) Intelligent Community of the Year. See https://www.intelligentcommunity. org/index.php?src=gendocs&ref=Top7_by_Year&category= Events&link=Top7 (accessed 03/02/2015).

ICSID (International Council of Societies of Industrial Design) (2008–2014) World Design Capital. See http://www. worlddesigncapital.com/ (accessed 03/02/2015). IME (Institute of Mechanical Engineers) (2014) Top Ten Smart Cities in the World: Beyond the Hype, Where is the Cleverest City? See http://www.imeche.org/news/blog/top-ten-smart cities-in-the-world (accessed 12/02/2015).

iN2015 (Intelligent Nation 2015) (2006) Imagine your World. Innovation. Integration. Internationalisation. Report by the iN2015 Steering Committee Authority. IDA Infocomm Development Authority, Singapore.

IOL Scitech (2014) Race is on to Develop Smart Cities. See http:// www.iol.co.za/scitech/technology/news/race-is-on-to-develop smart-cities-1.1791592 (accessed 09/03/2015). Laneri R (2009) In pictures: the world's smartest cities. Forbes Magazine, 12 March

2009. See http://www.forbes.com/ 2009/12/03/infrastructure-economy-urban-opinions-columnists smart-cities-09-joel-kotkin_slide.html (accessed 28/08/15).

Lombardi DR, Caserio M, Donovan R et al. (2011a) Elucidating sustainability sequencing, tensions and tradeoffs in development decision-making. Environment and Planning B, Planning and Design 38(6): 1105–1121.

Lombardi DR, Porter EJ, Barber ARG and Rogers CDF (2011b) Conceptualising sustainability in UK urban regeneration: a discursive formation. Urban Studies 48(2): 273–296. Mahizhnan A (1999) Smart cities: the Singapore case. Cities 16(1): 13–18.

Mercer (2014) 2014 Quality of Living Worldwide City Rankings – Mercer Survey. See http://www.mercer.com/content/mercer/ global/all/en/newsroom/2014-quality-of-living-survey.html (accessed 28/08/2014). Monocle (2014) Quality of Life Survey 2014. See http://monocle. com/affairs/quality-of-life-survey-2014/ (accessed 05/11/2015).

Mortensen J, Rohde FJ, Kristiansen KR, Clausen MK and Lubanski M (2012) Danish Smart Cities: Sustainable Living in an Urban World. Copenhagen Cleantech Cluster, Copenhagen Capacity, Copenhagen, Denmark.

Murgante B and Burroso G (2013) Cities and smartness: a critical analysis of opportunities and risks. Computational Science and Its Applications: ICCSA 2013 Lecture Notes in Computer Science 7973: 630–642. .

Nam T and Pardo T (2011) Smart City as Urban Innovation: Focusing on Management, Policy, and Context. 5th International Conference on Theory and Practice of Electronic Governance (ICEGOV2011), New York, NY, USA.

Naphade M, Banavar G, Harrison C, Paraszczak J and Morris R (2011) Smarter cities and their innovation challenges. Computer 44(6): 32–39. NAS (National Academy of Sciences) (2010) Advancing the Science of Climate Change. Expert Consensus Report. Board on Atmospheric Sciences and Climate, The National Academies, Washington, DC, USA. National Geographic (2014) The 2014 Traveler 50: World's Smartest Cities. See http://travel.nationalgeographic.com/ travel/special-features/traveler-50/ (accessed 14/03/2015). OpenDataScotland.org (2013) http://www.opendatascotland.org/ (accessed 17/08/2015). Smart City Expo (2012) Smart City Awards. See http://www. smartcityexpo.com/en/premios-2012 (accessed 09/03/2015).

The Economist (2014) A Summary of the Liveability Ranking and Overview. Intelligence Unit. See http://pages.eiu.com/rs/eiu2/ images/Liveability_rankings_2014.pdf (accessed 09/03/2015). The New Economy (2014) The Rise of the Smart City. Technology. See http://www.theneweconomy.com/technology/ the-rise-of-the-smart-city (accessed 08/03/2015).

Wakefield J (2013) Tomorrow's Cities: Do you Want to Live in a Smart City? BBC News. See http://www.bbc.co.uk/news/ technology-22538561 (accessed 14/03/2015). Willett M (2014) The 20 Best Cities On The Planet. Business Insider. See http://www.businessinsider.com/iese-smartest cities-in-motion-index-2014-5?IR=T (accessed 14/03/2015)