

# **Construction 4.0 and Built Assets in-Use: Creating an E-topia or Dystopia?**

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## **Abstract**

Construction 4.0 makes many promises. Not only will the use of technologies improve productivity in the construction of our future Built Environments, but also enhance their operation and maintenance as they become Smart Cities. These latter stages in the built asset project life cycle are impacted by Construction 4.0 technologies able to both automate and optimise their operations, thus bringing benefits for facilities management, whilst also linking the built environment fabric to wider societal and governmental systems. However there is growing concern that Construction 4.0 is directing our industry towards a 'smart dystopia', a situation with as much vulnerability as resilience, without due consideration or challenge. For example, the automation of operational processes arguably increases vulnerabilities to cyber-attacks, corruptions in data or energy loss, whilst the constant collection of worker and citizen data by smart building and infrastructure raises concerns around surveillance and privacy, as well as issues of exclusion. Although Construction 4.0 has the potential to enable our industry to support the delivery, operation and maintenance of an E-topia, these ethical and social challenges should perhaps be considered before we unquestioningly embed its technologies within our built assets for use throughout the duration of their life cycles.

**Keywords:** E-topia, Smart Cities, Sustainability

## **Introduction**

The Fourth Industrial Revolution (4IR) is transforming our world at a rapid pace, and the development and use of technologies within industrial activities is bringing about significant change. The construction industry, experiencing its own 'Construction 4.0' revolution (FIEC 2017), is seeing such change at all stages of the built asset lifecycle, as well as within the inherent characteristics and capabilities of the assets themselves. For example, the use of Building Information Modelling (BIM) in the design phase is growing; BIM not only supporting enhanced collaborative design (Champ 2018) but also now used to inform the later stages of a project through the growing use of 4D (planning) and 5D (cost) BIM (FIEC 2017) as the functionality and capability of the technology grows. Autonomous GPS and Artificial Intelligence (AI) controlled plant (Construction Manager 2018) and drones (Gammon 2017) are appearing on our construction sites alongside the human workforce, with robots suggested to be not all that far behind (Sherratt et al 2019). The operational phase is mobilising more advanced Building Management Systems (BMS) that draw on Digital Twins and the Internet of Things (IoT) as well as AI and Machine Learning (ML) functionalities. The data collected by such technologies and its subsequent manipulation and application enables asset optimisation in-use, and is also used to support maintenance teams in enhancing the effectiveness of ongoing facilities management operations (e.g. Hodson 2014).

Construction 4.0 has been welcomed by the industry and its clients (Sherratt et al 2019) not least because of the promises it makes for improved productivity and efficiencies (Dalenogare et al 2018), coupled with the long-standing desire to revolutionise and modernise our industry for the better (e.g. see Farmer 2016 for a UK perspective). However, despite the potential benefits Construction 4.0 technologies can bring to every stage of the construction life-cycle, there are also potential concerns.

Here we focus on the ethical and social challenges that result from the adoption and inclusion of Construction 4.0 as it affects the end product, the smart built asset itself, and how technological enhancements associated with the operation and maintenance life cycle stages of our industry may have wider influence. We first talk to the collective form of such assets as found in the 'Smart City', and draw on research of this specific phenomena to step back and explore how our industry is contributing to its creation, before questioning our role therein. We use this opportunity to consider whether we, as built environment professionals, are happy to be part of this change as we influence

the adoption of Construction 4.0 from 'Strategic Definition' to 'Use' (RIBA 2020). We query whether we are heading towards an e-topia or a 'smart dystopia', a situation with as much vulnerability as resilience, and with a direction of travel predetermined by technocratic optimism with little contemplation or challenge. We hope this paper is able to provide an alternative perspective of Construction 4.0, focused on the far end of the built asset life cycle, with the goal of stimulating discussion and the generation of a more considered, balanced and holistic Construction 4.0 narrative going forwards.

## **Construction 4.0 and the Smart City**

### **What is the Smart City?**

While there are numerous definitions and interpretations of Smart Cities, most of these can be encapsulated in the definition of Townsend (2013:15): 'Smart Cities are places where information technology is combined with infrastructure, architecture, everyday objects, and even our bodies to address social, economic and environmental problems.' This definition goes beyond describing what smart cities are, but also what their purpose should be – addressing real-world problems and not just enabling unbridled hedonistic consumerism or the creation of a 'computer for living in' (Ratti and Claudei 2016). As Mitchell (2000:147) suggested, 'traditional urban patterns cannot coexist with cyberspace. But long live the new, network-mediated metropolis of the digital electronic era' termed an 'e-topia', where 'lean, green cities...work smarter, not harder'.

Söderström et al (2014) suggest that there are actually two Smart City narratives. The first is rooted in the agendas of the technology owners themselves, such as IBM, Cisco and others who direct the narrative of efficient and sustainable cities through the use of ICT as a strategy to grow their own dominance in that market. Smart Cities essentially become a market formation strategy, which also buys into the needs of cities to be seen as globally competitive. However, this rather blunt commercial approach has been tempered by incorporating additional individual and societal aspects, promoting characteristics such as Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment and Smart Living (Batty et al 2012) which humanize the discourse and bridge the agendas of market economics, smart cities, smart growth and sustainability. The alternative narrative presents an urban vision that focuses on the human first and foremost, '... in which technology is used to empower community networks, to monitor equal access to urban infrastructures or scale up new forms of sustainable living' (Söderström et al 2014:318).

Whatever the agenda ultimately, as Townsend (2013) points out, Smart Cities are the result of integrating information technologies with infrastructure, architecture and everyday objects, making them a product of Construction 4.0 operation and maintenance technologies. ICT systems can be seen as providing digital urban nervous systems that obtains data from many different sources, including the built environment, to 'sense and act' (Neirotti et al 2014), thus optimizing service delivery and resource use; and as facilitators of bottom-up self-organization and democratic participation through digital communication platforms (Söderström et al 2014).

### **How are We Constructing the Smart City IRL?**

Our industry is already rising to the challenge of the construction of Smart Cities. We have developed building components, materials and management systems able to draw on the New Wave of Computing as termed by Bibri and Krogstie (2017), which includes Ubiquitous Computing, Ambient Intelligence, IoT and Sentient Computing (AL and ML). These technologies make use of hardware such as tablets, smartphones, sensors, wireless communication networks, the Internet and telecommunication systems, and cloud computing, as well as software that enables big data analytics, modelling and simulations, data visualization and data integration methods. Together they form a constant pervasive technological backdrop which allows Smart Cities to respond to their users, to optimize flows (e.g. transport, energy, waste, information), to enable objects to interact

with each other and their users, and create urban systems and services to provide real-time information to users and operational managers.

This can even be done without the need for human interaction at all, as the technology itself is able to observe, manage and change our built environments to any parameters set by its users (Neirotti et al 2014), or even those it subsequently deems optimal itself. Smart grids and the IoT can monitor energy use within single and multiple buildings, and systems controlled by AI make appropriate changes to heating, ventilation and air conditioning to optimise energy consumption, run system diagnostics and send maintenance requirements to service providers without the need for any human intervention.

The inclusion of user data through active smartphone monitoring further enhances such systems, enabling buildings to open and close doors as users move through them, switch on the coffee maker and even order the office supplies. Technologies embedded in our infrastructure remove the need for human monitoring as they are able to actively manage public transport systems depending on passenger loads, whilst traffic management through traffic lights or Smart Motorway lane controls can optimise capacity depending on volume and flow. On smaller scales we, as users, can now control our homes and their contents through a variety of Apps built into their very fabric, Apps help us find the best parking space in the city before we even arrive (Prevelianaki et al 2019), or tell us when the next bus will come, or which cafes nearby serve the best coffee, should we need to wait a few minutes.

### **The E-topian Smart City**

The contribution of our industry to the Smart City is clear; it is through Construction 4.0 technologies specifically developed for the operation and maintenance life cycle stages of built environment assets that Smart City ambitions can be realised. Our industry can significantly contribute to the 'smartness' of a city through technologies embedded in the very fabric of their infrastructure and architecture, and these technologies can in turn offer many benefits.

For example, by integrating and holistically co-ordinating the many information flows presented by sensor networks, satellite and other camera surveillance, telecommunications traffic and data harvested from social media, a feat only achievable by Sentient Computing, cities can improve the efficiency of their resource use, better plan infrastructure development, manage traffic and transport systems, provide safer environments and improve service delivery. They are also able to better manage disasters, establish early warning systems of system failure and thus support resilience within the built environment as a whole. As Ratti and Claudei (2016:28) put it: 'Today's smart city is an engineer's or computer scientist's dream come true. Every piece of information is instantly revealed, and the urban machine can be controlled and optimized.'

However control, efficiency and system optimization are not the only advantages of Smart Cities. Batty, et al (2012) argue that smart cities are also inherently equitable cities, in which digital platforms enable citizen science and encourage community engagement in urban decision-making. Ratti and Claudei (2016) also discuss how Smart City platforms can encourage bottom-up self-organization which supports initiatives such as ride-sharing, community clean-ups and alerting local authorities of areas requiring maintenance. Smart city technologies can empower an engaged citizenry by providing them with opportunities to directly engage, to provide input on planning decisions or to alert the City to service delivery issues, thus leading to more democratic decision-making. Using social media platforms, citizens can also self-organize to take ownership of their city, help each other, establish resource sharing and other exchanges, and build community.

That Smart Cities are considered to fundamentally be a good thing is clearly demonstrated by the way in which cities around the world now compete to be included in the list of the 'Smartest Cities in the World'. There are a plethora of indices used in a variety of rankings, each with their own definitions and criteria. For example, the IESE Cities in Motion Index includes indicators such as

number of mobile phones, Wi-Fi hotspots, percentage of households with access to the internet, and peculiarly, how many Apple Stores there are, to determine a city's Smartness (Beronne and Ricart 2018). In contrast, the IMD Smart City Index (2019) argues that such indices are too technology-centric, and instead base their ranking on how citizens perceive the priorities and effectiveness of smart city initiatives, drawing on a relatively small sample survey of citizens.

But no matter the ranking, or indicators used in their measurement, Construction 4.0 has enabled our industry to become fully engaged with, and rapidly become committed to, the design, construction, operation and maintenance of Smart Cities. Across the world, our industry and its supply chains have sought to develop products and processes able to mobilise these technologies to not only improve productivity in the construction of our future built environments, but also maximise the 'smartness' of their operations, maintenance and use on completion and occupation. Although as described above the Smart City is arguably much more than its physical built spaces and places, and so Construction 4.0 is also inevitably making a significant contribution to the realisation of this positive and benevolent vision of the future. However we should perhaps also proceed with caution. Although the fabric of Smart Cities has the possibility to be used for good, there is also the potential for it to become more malevolent, and contribute to ethical and societal challenges that have not been equivalently highlighted, and which should arguably not go entirely unacknowledged.

### **Ethical and Social Challenges of Built Assets In-Use**

The concept of the Smart City has now become ubiquitous, with discussions ongoing as to precise definitions, their modelling and indices, and, perhaps inevitably, how best to create them (Allwinkle and Cruickshank 2011) through the applications in part of Construction 4.0 technologies. However, technology itself is not neutral, it can be used for good or bad. Furthermore, and arguably critical in considerations at this stage of Construction 4.0 and global Smart City developments, it is also awarded an autonomy (Ellul 1954) that enables it to dictate human action. As Mander (1996:344) noted, 'society accepts the onrush of... technologies with alarming passivity, and without any systematic consideration of the social and political changes they bring.' Indeed, rather than meeting the needs of society, technology instead *compels* society to perpetually adapt (whether it wants to or not) in order to meet the dictates that the associated technological process of technique (see Ellul 1954 for a detailed explanation of this process) imposes upon it. Fundamentally, just because we can, does not always mean we should (see Sherratt 2019 for a consideration of this with specific regard to Construction 4.0 within the design and construction phases of the life cycle).

We only need look to the first industrial revolution for the negative social and ethical consequences of what we now consider normal with regards to industry, production and automation. This period of history saw considerable '... social and human costs resulting from the systematic application of science and technology to the production of life's necessities and wants. Populations were dislocated, communities and neighbourhoods destroyed, local cultures undermined in order to prepare conditions congenial to modern industry.' (Wolin 2004 [2016]:400). This same process of people adapting (willingly or not) to the dictates of technique is also evident in much more recent developments in digital and social technologies: 'Individual web pages as they first appeared in the early 1990s had the flavour of personhood. MySpace preserved some of that flavour, though a process of regularized formatting had begun. Facebook went further, organizing people into multiple-choice identities [this 'standardisation' of format greatly facilitating their ability to generate profits by selling the data gathered in this way.]... If a church or government were doing these things, it would feel authoritarian, but when technologists are the culprits, [they] seem hip' (Lanier 2011:48).

It is the inability to challenge or even question that is important here. Today, arguments against Construction 4.0 or Smart Cities cannot be framed without those asking them being seen as 'Luddites', creating an echo from the early nineteenth century that for many of us, now living in the world created by the focus of the Luddite antagonism, actually seems both sane and sensible.

However, as our future Smart Cities are comprised of rational and efficient (and autonomous) technological processes able to resolve two of our planet's most pressing evils of society, climate change and exclusion, why would any challenge even be necessary?

Yet there is growing concern that this reliance on information technology and the data collected through a range of digital platforms is creating a smart dystopia. Smart Cities also have the potential for social polarization, educational and financial demands made on citizens in order to participate in urban life, technocratic and autocratic governance, and excessive surveillance. An engineering approach focused on quantitative data analysis in pursuit of system optimization has been suggested (Söderström et al 2014), but this voice is far quieter than that currently championing both Construction 4.0 (Sherratt 2019) and the Smart City itself. Here, we now focus on three aspects the Smart City promises to enhance: urban resilience, sustainability and inclusion. Constraints of space dictate this scope, however these are also areas of contemporary interest for our industry as a whole, reflecting as they do relevant Sustainable Development Goals (United Nations 2020) and thus aligning to ambitions for the future of our built environment. Here, we aim to explore some of the ethical and social challenges therein, with the intention of adding balance and indeed some measure of volume to the questions that perhaps should be asked of our adoption of Construction 4.0 and the resultant Smart Cities of the future.

### **Vulnerability Masquerading as Resilience**

The ability for Smart Cities to react in real-time to critical events, such as extreme weather events or terrorism, to mitigate their impact and quickly re-optimize operations of the City systems to enhance their resilience, is often presented as a key strength but also creates an inherent vulnerability. Concerns have been raised since the advent of Building Information Modelling (BIM), one of the very first steps in the Construction 4.0 revolution, about the security threats this could bring to the built environment (Gunshon and Sherratt 2014). The potential weaknesses in the creation of Digital Twins of all buildings and infrastructure, containing all access, maintenance and product data, was further enhanced by the development of internet-linked Building Management Systems (BMS). The risks of operating such interconnected systems was clearly exposed in 2014 by hackers who stole the credit and debit card data of 40-million US Target customers by accessing the system through the internet-connected heating, ventilation and air conditioning (HVAC) system used for maintenance purposes, but from which the hackers were easily able to jump into Target's payment systems (Vijayan 2014).

When such vulnerabilities are scaled up, through the Internet of Things, to the level of the Smart City, the consequences become far more significant. Cerrudo (2015) provides a detailed account of the many ways software vulnerabilities threatens the security and resilience of a City, and in a follow-up (Cerrudo, 2018) gives examples of incidents including ransom attacks on the City of Atlanta's Municipal Systems, the San Diego Public transportation system, the University of Calgary, as well as a 2015 attack on Ukraine's power grid which left 230 000 people without electricity. Such cyber-attacks are not necessarily terror related or carried out for commercial gain. The temptation for bored teenagers in the USA to lock all the doors and activate the sprinkler system in a large shopping centre in the UK is considerable, given the kudos they can then secure online when they post about their activities, making such mischievous activities not entirely unimaginable (Gunshon and Sherratt 2014).

Such considerations also exclude the much more mundane risks of systems simply 'going down', leaving users bereft, unable to pay for things, enter or leave buildings, or move about their Cities, and it should perhaps be better acknowledged that the technological resilience of Smart Cities is also their inherent vulnerability.

## **Keeping the Lights On: Energy, Sustainability and Climate Change**

As the United Nations (2019a) states: 'Climate Change is the defining issue of our time and we are at a defining moment. From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly.'

One of the key arguments for the use of Construction 4.0 technologies in the operation and maintenance of assets has been the consequential increased efficiencies and therefore overall reductions in energy use. Construction 4.0 Building Management Systems (BMS), able to mobilise AI and ML to better manage the IoT, are thus able to make a positive contribution to the sustainability agenda, reduce urban energy and thus the carbon footprint of Smart built assets overall. Notwithstanding the fact that this may render the roles of the professional facilities manager and their teams obsolete, as their work is transferred to the technology, the fundamental fact remains that Smart uses energy too. In fact, without energy, specifically electricity, Smart simply cannot function.

All Smart City technologies use energy to power devices, crunch and share data. As of 2015, the world's data centres were responsible for 2% of global carbon emissions (Avgerinou et al 2017), almost equivalent to the aviation industry, yet attracting far less negative publicity about their unsustainable operations. Projections suggest that the energy needed to run the digital infrastructure needed to support a connected and smart world has already increased from over '...7% of global electricity demand in 2012 and continue(s) to grow at least 7% annually through 2030, double the average rate of electricity growth globally' (Cook et al 2017:15). Indeed, Cisco (2018) has predicted that the Internet of Things will soon generate more than 500 zettabytes per year in data (one zettabyte = one trillion gigabytes) while global cloud IP traffic will reach 19.5 ZB (1.6 ZB per month) by the end of 2021, and these numbers are expected to grow exponentially year-on-year, not linearly.

The energy use and subsequent carbon footprint of Smart Cities, in both their immediate use and the requirements of the data centres required for their operation, is therefore of significant concern. Although separating Smart City energy use from that of its residents as they, for example, use social media or stream data to their personal devices is problematic, it has been stated that the '...explosive growth in our digital consumption is driving massive new investments in digital infrastructure, particularly power hungry data centres...with the larger cloud computing and colocation facilities capable of consuming as much power as a medium size city' (Cook et al 2017:17). So perhaps concern should be raised that when that medium size city itself also starts consuming more data than its non-Smart benchmark, the demand for power and consequential impacts on climate change will only increase further. As Harris (2018) wryly notes: 'about a decade ago, we were being told to fight climate change by switching off our TVs and stereos. If the battle is now even more urgent, how does it fit with a world in which router lights constantly flicker, and all the devices we own will be in constant, energy-intensive communication with distant mega-computers' and indeed the very fabric of the built environment that surrounds them. There is considerable irony in the potential for Smart Cities, through exponentially increasing energy use, to significantly contribute to the climate change crisis, despite Smart promises to support '... new forms of sustainable living' (Söderström et al 2014:318) in its Cities.

A further and rather more fundamental concern is raised by Townsend (2013), who points out that in most developed cities, the power grid is old and already failing, and increasing the burdens on it is therefore a considerable risk. Should the grid fail the consequences can be considerable, as the UK found in 2019 when over a million people were affected by a major power failure that left homes and infrastructure without power (BBC 2019). For a Smart City to fail in this way would be even more catastrophic.

## **Inclusion, Exclusion and Exploitation**

The notion that Smart Cities are also inherently equitable, enabling all citizens to engage in their planning, management and operations from a bottom up perspective (Batty, et al 2012; Ratti and Claudei 2016) is fundamental to the social and humanistic arguments for the Smart City, however Smart City technologies also present a number of ethical and social justice issues. Technologies which engage directly with users inevitably assume that such users have access to interface devices (such as smart phones) and data. For example, in Sweden bus tickets, parking and even public toilets are now paid using smartphone payment systems (Savage 2019). This means that those who cannot afford the technology or the data are excluded from participating in the day-to-day activities of the city, as well as any participation in citizen engagement platforms.

Globally 57% of the population are internet users, with a quarter of a billion new users coming online in 2019 (Statista 2019) with the fastest growth rates seen in Sub-Saharan Africa (GSM Association 2019), however a significant digital divide (Epstein et al 2011) remains. The affordability of devices and data determines how much Smart is feasible; in South Africa data packages as small as 50Mb are available, enough for WhatsApp with no images but not a YouTube video, reflecting a market only able to afford such amounts. For those unable to afford a device or the data required to access email or Apps, or even the skills to navigate a digital world they may never have seen before, the Smartness of the City may prove totally irrelevant.

Moving to digital transactions and a cashless society further undermines the informal economy (Kearney and Schneider 2018) which props up an increasingly marginalized sector of society faced with growing systemic inequality and social exclusion, and often relies on cash handouts to simply survive. Although technology providers frequently draw on arguments that the shift to Smart helps to hinder black markets and money laundering, this does not seem to be a considerable barrier to those bent on such activities as the growing use of cryptocurrencies and activity on the dark web shows. Indeed, Bell (2018) notes that 'Some of the internet's biggest marketplaces are now being exploited by money launderers thanks to their online payment systems, ease of use and huge global adoption (which allows criminals to hide in plain sight among thousands of other users)'.

Further exclusion is possible due to the fact that Smart Cities are inevitably linked to the City's management in the form of councils, governments or other enforcement agencies. The same technologies that assist law enforcement can be used by governments to shut down civic protests or other unwelcomed social activities, even excluding specific citizens, identifiable through their user data, and preventing them from participating in the City at all. The constant collection of worker and citizen data raises significant concerns around surveillance and privacy. When Smart City governance can demand access to your social media accounts, harvest data from your every online interaction and transaction, and follow you through their city step by step, there remains no safe space for criticism of that governance. Indeed, Japanese company Vaak (2019) has developed software that can predict criminal behaviour before it happens, and citizens can be accused of a crime before it has even been committed, based on Smart computer algorithms. When sedition is a crime, this creates significant risks of exclusion and exploitation of the Smart City by those with power.

An issue that is barely raised when the concept of the Smart City is considered, is the domestic abuse facilitated by Smart technologies and its ability to be used in 'gaslighting'. During the recent #metoo movement a number of women reported how their partners used smart technologies to harass and control them (Bowles 2018), using security surveillance to spy on them in their homes, changing Wi-Fi passwords, monitoring calls and internet activity, and using phone apps to remotely reset temperatures, switch on and off lights and even lock women in their homes. That Smart can and does enable such abuse is a factor that should be far more prominent in measured considerations of the use of technology in our Smart Cities and Homes.



There remains at present a lack of mechanisms to protect citizens from the misuse of Smart Construction 4.0 technologies and perhaps more importantly the generated data. This returns to the narratives put forward by Söderström et al (2014), contrasting the value of Smart Cities to the technology owners, and to the markets for the data they can generate, with any value to the residents of those Cities themselves. Indeed, the data can be collected by governments, but also the individual Smart technologies by their owners and operators, as well as those managing the built assets and estates. All of which raises concerns around invasions of privacy and the social consequences that could follow, as this data can be readily monetised through for example, targeted advertising, feeding the filter bubbles created by Google and Facebook algorithms (Pariser 2011).

The Smart City could, in effect, create a space of total social control, with which the citizens and users of the city, or more specifically those who are financially able, are more than happy to voluntarily engage, unbothered by those capitalising on their willingness to share their lives digitally. Yet as Naomi Klein (2020) recently reminded us, when considering how technology companies are now exploiting the opportunity the Covid19 pandemic has provided to collect yet more of our personal data, concerns about '...Smart Cities filled with sensors supplanting local government' had already been raised, despite their being '...sold to us in the name of friction-free convenience and personalisation'. The ability for Construction 4.0 technologies to also facilitate and support things such as 'location tracking and cash-free commerce, obliterating our privacy and entrenching racial and gender discrimination' (*ibid*) should also be a major concern. We ought to be more mindful when we are constructing spaces able to monitor and capture data from everyone who walks through them that technology is not neutral, and data is not just a marketable commodity, but can also be a tool for ethical and social injustice. As Ratti and Claudei (2016:31) ask: 'How smart must your bed be before you are afraid to go to sleep at night?'

### **We Need Smart, But Different**

But this is not to dismiss the potential of Smart and Smart technologies to bring any benefit at all. However, what benefit and to whom is perhaps a much more relevant question and we, as built environment professionals, need to be content to be compliant with the answer. Indeed, many of the problems above fall into categories many citizens of the world would be more than happy to have. Smart City visions frequently contain luxurious glass skyscrapers, festooned with the greenery of living walls and surrounded by beautifully landscaped public spaces, with a few autonomous vehicles in the streets and drones flying in the clean air. Yet these are arguably the dreams of engineers and academics in wealthy countries, billionaires with large egos, and the rapacious elites of failing states who seek luxury havens in the squalor that surrounds them.

When the realities of our global cities are considered, and the realities of the people who live in them recognised, this traditional Smart City vision does not find an easy fit, and this is something we need to more explicitly acknowledge in our professional ambitions. The United Nations (2019b) foresees that by 2050 the global urban population will have almost doubled, with most growth in India, China and Nigeria. A study by Hoornweg and Pope (2014) predicts that by that 2050 the largest cities in the world will be Mumbai, Delhi, Dhaka and Kinshasa, with Lagos at number 6 and Cairo at 11; by 2075 Kinshasa will top the list; and by 2100 the top three cities will be African, namely Lagos (at 88 million people), Kinshasa, and Dar es Salaam (73.6 million people). At present, these cities are suffering issues of significant social inequality, severe overcrowding, problematic political leadership, overburdened infrastructure, dangerously high levels of air pollution and significant vulnerability to climate change.

These will be the Cities of the future, and they all want to be Smart, or at least are planning Smart Cities on their peripheries as enclaves for tech-savvy elites. The existing cities themselves remain self-organising chaos, constantly hovering on the brink of collapse, yet surprising resilient. Smart Construction 4.0 technologies could do much to improve circumstances and the lives of the citizens of these cities, yet the vision of African and Asian Smart Cities is all too often to abandon the existing

city (and its current citizens) in favour of shiny and unaffordable, but Smart, new settlements which become enclaves for the upper classes (see Michaelson 2018 for the case of Cairo). This is in essence aspirational speculative property development which is doomed to fail, as evidenced by the hundreds of 'ghost cities' scattered across Asia (Sorace and Hurst 2016). And whilst these vanity cities were being constructed, resources and efforts could have been used to improve living conditions in the existing cities they hoped to leave behind. We should reflect and consider if we are happy to support a 'Construction 4.0 Revolution' that results in such consequences.

We need Smart Cities, but different. The Smart City should return to its initial promise of an e-topia for all. We are currently suffering from the trifecta of climate change, a level of ecosystem loss scientists have labelled the sixth great extinction event, and the pervasive pollution legacy of the industrial revolutions that have gone before. The consequences of this are already being realised: in 2017, 227.6 million people were displaced worldwide as a result of natural disasters and extreme weather events that occurred between 2008 and 2016 (Internal Displacement Monitoring Centre 2017). This is creating an unfamiliar and unknowable world in which our Future Cities will have to function. Construction 4.0 should look to how best to build Cities able to adapt, transform and respond to this changing world, rather than focus on glass towers in the deserts and islands of obscene comfort in a sea of misery.

## **Conclusions**

We study history so we do not repeat the mistakes of the past. Whilst Construction 4.0 and Smart Cities have much to offer, we should perhaps look to the lessons of previous industrial revolutions and climate change science and consider very carefully what dreams we chase, who we trust and how, and where we invest our time and resources.

There are undoubtedly many benefits to the incorporation of Construction 4.0 within our built environments. It enables the operation of such spaces to draw on a wide range of data and analyse it to respond effectively to external influences and user needs, whilst also drawing on digital communication platforms to enable bottom-up self-organization and an empowered and engaged citizenry. However, we should also consider the unintended consequences that it brings. The reliance on energy-hungry Smart technologies can actually reduce a city's resilience, increase its contribution to climate change, make its systems more vulnerable to cyber-terrorism, and expose its citizens to data theft. Shifting to digital transactions and citizen engagement grows the digital divide and increase the vulnerability of the most exposed members of society by shutting them out of social and economic systems. There is the potential for Construction 4.0 technologies to be used to facilitate oppression, whether by a dysfunctional state, or as accessory to domestic abuse, and concerns about what constant surveillance will do to important rights such as freedom of expression and association, and the right to privacy. We must, as built environment professionals, at the very least acknowledge these issues when we look to support Smart through the application of Construction 4.0 technologies within our built environment, architecture and engineering projects. We should ensure that the ethical and social challenges that surround the use of Construction 4.0 in the operation and maintenance of assets are raised, and mitigated where possible through our practice.

Even more shamefully, we should be far more cognisant of the fact that these are actually problems for only part of the planet. Although these ethical and social challenges are significant for some, for others Smart Cities have become an albatross around their country's neck, offering nothing to their future but ghost towns and debt. And this talks to something more fundamental and core to the role of the built environment professional. For example, the ICE's own 'Shaping the World' initiative, which itself draws on the UN Sustainable Development Goals, explicitly acknowledges the global challenges facing the world and how engineers can look to provide solutions. We should perhaps therefore be questioning whether we are happy for Construction 4.0 to contribute to exploitation

and increasing inequalities, and instead perhaps direct our efforts to more worthy activities and causes able to reduce them in reality.

The realities of our planet and its global citizenry should arguably be at the forefront of the Construction 4.0 and Smart City agenda. In the face of coming global changes, a truly Smart city would create community and foster relationships outside of cyberspace. It would nurture whatever nature is left, and create spaces for new communities of life to emerge. Judicious use of technology has the potential to bring global equality into reality, could help us change and adapt, to connect that which we have forced apart, marrying human ingenuity to the wisdom of Mother Nature so we can regenerate the planet and our societies, and create a radically different future which all of humanity can thrive and not just survive. Now that would be Smart.

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