Smart Cities & Urban Communities Most Vulnerable to Climate Change

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Introduction

According to many climate change experts, national politicians and city leaders, smart cities lead the way in combating climate change issues (White, 2016) (Luque-Ayala and Marvin, 2015) (Moreno Pires et al., 2017) (van der Most et al., 2018) (Calthorpe, 2011) (Appleby, 2020). Calthorpe argues that smart cities have yet to meet their full potential and that "urbanism is the foundation for a low-carbon future, and the most cost-effective solution to climate change, even more so than renewable energy” (Calthorpe, 2011p.8-10). A plausible assessment considering most cities are primary nodes supporting business, education, research, labour, and economic networks. In other words, these cities are connected to an international network of cities, they are urban environments which have direct access to high-status decision-makers, sophisticated research and development institutions, high-tech fabrication facilities, data management and distribution organisations, financial experts, and the socioeconomic influences. Wich are ideal resources from with which to build a contemporary and connected response to the world’s climate change challenges.

However, it is rarely acknowledged that most major cities are also built on coastlines, dry riverbeds or near river systems. A paradoxical condition where many of these globally connected smart cities appear locally vulnerable to hazardous conditions created primarily by climate change. Which creates an increase in sea levels, large storm surges and unpredictable weather patterns frequently result in a higher risk of flooding and drought. A risk exacerbated by rapid population growth, urban sprawl, social inequalities, land-use and struggling neighbourhood waste and water systems (Rosenzweig et al., 2010 p.909). Resulting in floods and drought that strain city infrastructure and undoubtedly threaten the lives, livelihoods and property of the city’s more vulnerable citizens.

Whilst smart cities have captured the imagination of policymakers, big business and government in a universal sense, this review explores more modestly, the nature of a smart city approach to localised climate change risk and resilience. Asking, whether smart city methods support urban communities which are most vulnerable to the risk of flooding, and what the advantages and disadvantages might be in adapting and using data-based technology familiar to smart city designer, within these communities?

This literature review, will initially present a brief outline of the climate change challenge before exploring various definitions of a ‘smart city’ and how they relate to the context of mitigating climate change risk. The review will introduce scholarly insights regarding the use of data and technology in cities, whilst exploring whether a smart city approach to climate change has policy potential. This paper will also highlight examples of 'smart city' techniques used to improve flood-related, risk, resilience, mitigation, and monitoring through the application of contemporary technology and data systems. The paper goes on to examine whether smart city methods of flood resilience are designed to benefit and include vulnerable[1] communities[2]. And lastly, the paper will offer examples of case studies examining how vulnerable groups have been involved in smart city planning and whether the partnership has benefited from the use of data-based technologies and closer collaboration with government and other stakeholders.

Hence, this review aims to contribute to a greater understanding of smart city approaches to climate change and the resulting floods. Exploring the effects of flooding in vulnerable urban communities and how the use of data-based technology can benefit those involved.

[1] There are different conceptualizations and terminologies of vulnerability which has become particularly problematic in research on global climate change (Fussel, 2005). This paper acknowledges vulnerability to natural and human-induced hazards concerning climate change (IPCC 2001), in the context of environmental hazards (United Nations International Strategy for Disaster Reduction 2004) and concerning floods (Connor & Hiroki 2005; Van der Veen & Logtmeijer 2005).

[2] There are different conceptualizations and terminologies of committee (Marilyn Hamilton 2009) (perk,1993). In the context of this research, community refers to a group of people with a common identity based on factors such as geography, culture, kinship, political affiliation, business, professional and/or personal interests (Adenrele Awotona 2012)

Methodology

Several measures were followed to ensure a high-quality review of the literature. Initially a comprehensive search of peer-reviewed journals based on a wide range of key terms including, climate change, urban vulnerability and risk, smart city approaches to climate change, smart cities and vulnerable communities, smart city approaches to flood risk, community involvement in smart city resilience and local adaptation to floods in smart cities. The relevant databases were also searched, these included Google Scholar, Web of Science, Scopus, ScienceDirect, Wiley Online Library and scholar portal journals. The reference section for each paper found was explored to locate additional articles. Furthermore, key internationally recognised educational and technology journals from around the world were explored independently, Whilst newspaper articles, governmental reports and corporate literature was sourced and examined to give further detail and insight. The search revealed more than 40 peer-review articles published from 2006 to 2020, News articles, government reports and corporate literature from which to ask, How are smart city approaches tackling issues around risk and resilience, particularly concerning climate change? how do the Smart Cities approach support urban communities most vulnerable to climate change risk? And are there advantages and disadvantages in an increased use of data and technology within these vulnerable communities?

Keywords: Smart Cities; Climate change; Smart cities and climate change; Vulnerable communities; Flood risk; Flood resilience.

Context

Climate change is one of the defining issues of our time. According to Barack Obama, "There's one issue that will define the contours of this century more dramatically than any other, and that is the urgent threat of a changing climate"("Remarks by the President at U.N. Climate Change Summit," 2014). The catastrophic effects of climate change are being suffered globally, and it is predicted that the effects of climate change will only increase in the years to come. The upheaval created in the climate system, mainly by increasing emissions of greenhouse gases giving rise to extreme weather events, will have severe socio-political and economic implications. These extreme weather conditions increase the risk of dangerous events such as drought and flooding which affect untold numbers of people, taxing economies, disrupting food production, creating unrest and prompting migrations which lead to infrastructural strain and ultimately the loss of life in rural and urban conditions.

According to a network of the world's megacities assembled to address climate change, "[i]n terms of size, cities occupy only two percent of the world's landmass. But in terms of climate impact, they leave an enormous footprint. Cities consume over two-thirds of the world's energy and account for more than 70% of global CO_2 emissions" (Why Cities?, 2020) Therefore, cities and their inhabitants require detailed consideration when developing modern mitigation and adaptation strategies to combat climate change impact.

The current mainstream approach to address the risk of climate change impact is to develop cities with capacity for high tech initiatives based on data collection and monitoring systems. To build a vast network of sustainable and low-carbon urban initiatives. A technocratic response to climate change reflecting a smart city concept defined as, "a city that uses information and communications technology (ICT) to enhance its liveability, workability and sustainability" (Smart Cities Council 2014) or, as the US Office for Technical and Scientific Information suggests, " a city that monitors and integrates all of its critical infrastructures – including roads, bridges, tunnels, rail, subways, airports, seaports, communications, water, power, even major buildings - can better optimise its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens" (Hall et al., 2000).

In other words, a contemporary top-down approach aiming to meet the challenges of climate change in the confidence that smart city technology will improve urban resilience by, addressing the efficiency of service systems, ensuring a more sustainable use of resources, facilitating better water management and increase the resilience of its communities through initiatives supported by intelligent communication applications, monitoring and data systems.

However, "in the last fifty years, our view of cities has been turned on its head" (Batty, 2017, p.2). Cities are no longer a relatively straightforward technocratic configuration of order and controlled from the top down. The traditional hierarchical systems of dealing with climate change issues such as flood risk management are struggling (Papadopoulou and Giaoutzi, 2017). For scholars like Batty and Hollands, cities are becoming more like organisms with patterns that evolve from the bottom-up, creating, "the patterns that we see emerge as the product and outcomes of millions of individually motivated decisions and in so far as there is any top-down planning, this is usually short-lived, nonetheless designed to solve urban problems at different scales but rarely having lasting continuity" (Batty, 2017,p.5).

According to Lierop this transition of urban systems informed by the local rather than the state is an attempt to address the idea that, “[t]he city as we know it is ill-equipped to cope with changing demographics and rapid population growth. Nor is it prepared to protect residents from extreme heat, rising seas and erratic weather” (Lierop, 2019). Thus, giving rise to an age where smart city approaches require reconfiguration (Pelton and Singh, 2019) (Batty, 2017).

The Smart City

There are many descriptions of what ‘smart cities’ are. For example, Hollands feels they represent a problematic “Urban Labelling phenomenon”(Hollands, 2008, p.1), whereas March considers them an "important urban strategy" against the backdrop of climate change (March, 2018). When asking, “what are Smart Cities”, you will find the answer ambiguous and descriptions contested within various sectors of academia, industry or government. However, there seems to be some common denomination between most interpretations. Angelidou, (Angelidou, 2015 p.95) suggests there are two main criteria in explaining a smart city: the technology-oriented approach and the people-oriented approach. Extensive literature appears to recognise the first approach, based primarily on Information, mass data collection and Communication Technology (ICT), the emergence of the internet of things (IoT) (Eremia et al., 2016 p.14; (Jucevičius et al., 2014); (Batty, 2012) and (Mehmood et al., 2017), or as the World Bank suggests, "a technological-intensive city", an urban context imbued with sensors and interconnected devices gathering real-time data to improve public service efficiency and environmental impact (Muente-Kunigami and Mulas, 2015; “Smart Cities,” 2015). A city using new and innovative methods of managing or administrating the complexities of urban life such as traffic, overpopulation, energy consumption, resource management and environmental protection etc. (Eremia et al., 2016 p.13). recognising that smart cities are associated with the use of digital devices linked to an ordinal infrastructure that produces massive amounts of data. Smart cities are reported to have invited tech and data-based companies such as IBM, Cisco and Siemens to invest heavily in urban systems that advance the knowledge of how cities function (Batty, 2012).

These smart city proponents, promote the use of innovations like decision support systems (DSS)[3](van der Most et al., 2018), IoT and big data analytics (Mehmood et al., 2017). In other words, the connection of digital services equipped with sensing, actuation and computing capabilities with the internet and ICT (Jucevicˇius et al. 2014) services. Connections that aim to transform the urban context locally, whilst informing and linking it to a global network of urban futures.

[3] For further information on DSSs like ‘Planning Kit Room for the River’, a helpful instrument in the development of alternative strategies for flood management along the river Rhine and its distributaries please ref to (International Symposium on Flood Defence et al., 2006, p.763-769)

However, Greenfield takes a position arguing that from a technological perspective, the current model of smart city doesn't go far enough and that current thinking is "maximalist, dinosaurian, intellectually lazy" (Greenfield, 2017). Greenfield feels that networked technological approaches to urban design would be better applied to citizen-led initiatives rather than, "data collection programmes dictated by a narrow elite" (Greenfield, 2017p.18). He advocates the use of 'lean development' in Minimal Viable Products' (MVPs) as an alternative to the current mindset which is driven by the perceptions and capabilities of large multinational IT firms instead of taking direction from the actual expressed needs of a city's population. Instead of a "placeless, one-size-fits-all template", Greenfield suggests the potential in MVPs and the 'lean design' theory behind them. Amazon, Airbnb and Uber are all examples of MVP development that began by offering a version of a product with just enough features to satisfy early customers and provide feedback for future product development, a "the place to gain and share knowledge, empowering people to learn from others and better understand the world"(Quora, 2018). Greenfield suggests that the potential in a 'lean development' approach to urban innovation offers an alternative to the way data and data-driven tech might occupy the urban context. An approach that should be informed by, "four sources: people making data, people making things, people making places, and people making networks"(Greenfield, 2017).

Greenfield appears to straddle the technology-oriented approach and the people-oriented approach. The people-oriented approach appears to focus more on the role of human capital, involving the needs of people and communities (Albino et al. 2015, p.3-21). Hollands (Hollands, 2008a, 2015), Eremia et al (Eremia et al., 2016) and Greenfield (Greenfield, 2017) argue that smart cities use a participatory governance approach[4] and invest in human and social capital as well as transport and ICT infrastructure. An investment that achieves economic growth, a high quality of life and responsible management of natural resources. Hollands explores the perception of the 'smart city' label, underlying assumptions hidden within the process of defining a city as smart, and how its "pro-business and neo-liberal bias" might alienate or exclude many of the city's inhabitants (Hollands, 2015, 2008). His critique wrestles with the word 'smart' and how on one hand, it has been used to imply the synergy between urban conditions and technological innovation. On the other hand, it has also

[4]. Approaches which are based on the premise that citizens have both the right and the responsibility to participate in the processes of public decision-making. ... Participatory governance approaches emphasize the importance of 'evidence-based' interactions between citizens and the state(Coghlan and Brydon-Miller, 2014).

become synonymous with, “e-governance, communities and social learning and addressing issues of urban growth, social and environmental sustainability” (Hollands, 2008, p.304). Hollands posits that ‘Smart urban labelling’ distracts attention from some of the negative effects the development of new high-tech and networked data-structures are having on cities. He explains that, “In essence, the disjuncture between image and reality here may be the real difference between a city actually being intelligent, and it simply lauding a smart label” (Hollands, 2008, p.305).

However, the definition of smart cities proposed by Giffinger et al. (2007 p.10-12) appears to unify the technology-oriented approach and the people-oriented approach. In this definition, a smart city is viewed as one that is effective and efficient in the following six domains: smart economy, smart people, smart governance, smart mobility, smart environment and smart living. Rather than simply being characterized by new technological developments, Giffinger et all view a ‘‘true’’ smart city as a modern urban condition that will also consider the importance of education, culture, governance and quality of life. (Giffinger et al., 2008)

How are smart city approaches tackling issues around risk and resilience concerning climate change?

It is fair to assume that a smart city primarily tackles risk and resilience using systems based on big data analysis, cutting-edge ICTs and virtual systems to digitally connect its citizen to urban infrastructures and city services (Batty, 2013). A smart city appears to be developing an approach to climate resilience and risk through entrepreneurial interventions that promote technology-led urban improvements based on large amounts of data analysis.

According to organisations such as C40 Cities, CDP, AECOM and Bloomberg Philanthropies in a report published in 2014, a smart city approach was "reducing the climate risks faced by citizens and businesses"(CPD, 2014, p.3). And by offering cities the capacity to model and deliver flood management plans, test emergency response systems, as well as the means to focus on projects that protect the most vulnerable (CPD, 2014,), smart cities are leading the way on climate change risk mitigation and resilience. This approach was supported by governmental consultancy firms such as Mckinsey & Company, which suggest that "Smarter cities are resilient cities" (Jaana Remes and Woetzel, 2020), and therefore, city authorities should continue procuring technology to solve the challenges posed by climate change. The type of technological products, that offer urban and local agencies the means to facilitate preventative measures and respond effectively to emergencies whilst planning for long-term sustainability and growth. Or as Mischke and Woetzel put it, the means to '*future-proof'* the city (Mischke and Woetzel, 2018).To these authors, a city's infrastructure is a critical aspect to a city's resilience, stating that cities should place, "a high priority on making infrastructure systems as resilient as possible to emerging trends, disruptions, and risks" (Mischke and Woetzel, 2018,p.2).

Resilience in this sense means developing an approach to enhance city infrastructure and responding to its precarious nature when under strain from climate change. An approach designed in reaction to post-disaster analysis indicating that urban infrastructure is vulnerable to natural disasters such as hurricane, flood, earthquake etc. (Wilbanks and Fernandez, 2014). Therefore, fundamental to a smart city approach is the integral use of smart technology, big data and IoT to help predict and prevent equipment failure, weakness in flood-water drainage systems, traffic congestion, blackouts etc. In other words, a data-based approach to resilience and risk in the shape of wide-beam monitoring[5], and the advantages of connecting and evaluating information from each facet of a city's infrastructure (Kitchin, 2014). This will essentially provide real-time information for the planning of exit systems, water system management, and alleviating the potential strain on emergency systems.

Hill and Martinez-Diaz concur and although avoiding the term 'smart city' in their recent book focused on building resilience and preparing for climate disruption (Hill and Martinez-Diaz, 2020), They acknowledge a familiar approach to resilience where connected cities play a primary role in the future. Hill and Martinez-Diaz argue that in this 'Anthropocene era', an approach to resilience is urgently required to empower communities as they manage 'climate impact'[6] now and in the future.

Therefore, a set of resilient measures that will save lives and protect the vulnerable in society are required. Hill and Martinez-Daz offer lessons for building resilience and state that in their view the term resilience refers to the capacity of a community to mitigate, absorb, adapt and recover from the influences of climate change (Hill and Martinez-Diaz, 2020a; Kramer, 2016). A capacity that involves a range of initiatives from small scale, short term, low impact actions referred to as **'***no regret'* measures to the large scale, high impact, long term measures understood as *'transformational'*. Hill and Martinez offer examples of 'no regret' measures such as "the deployment of early warning systems for natural disasters and disease or climate change education for engineers, lawyers, and healthcare professionals" and transformational measures that include, "changing the shape of cities by making different land-use choices, significantly altering crop composition and agricultural practices for millions of people, and relocating entire communities" (Hill and Martinez-Diaz, 2020, p.4). Measures that appear to be top-down in tone and underpinned by Big Data, ICT, IoT, sensors and modelling tools familiar to a Smart City approach. Hill and Martinez argue that data collection devices are significant analytical tools to be used by an array of applications to support climate resilience and that critically, suggesting that it's the adaptation of attitude, ability and availability of data management in vulnerable communities today that is the way to build a resilient tomorrow (Hill, 2020, p. 98-115).

Confident that smart city, technological tools hold the only viable option in becoming resilient to future climate change upheaval, many scholars like (Hill and Martinez-Diaz,

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[5] The term, wide-beam monitoring refers to the growing scope of technology and its depth of linked analysis
[6] Climate impacts are the expected and realised consequences of climate change on natural and human systems.

2020b) (De Lange and De Waal, 2013; Miller, 2020) (Granier and Kudo, 2016), argue that building a resilient tomorrow requires the development of initiatives such as ‘Smart Water Technology’ (SMT), in other words, a means to collect share and analyse data from local, national and international equipment and water networks. SMT’s that can detect faults in the water management systems and services infrastructure, forecast equipment flaws, energy inefficacy and ensure regulations are met. However, according to Zion Market research, these technologies are “expected to generate revenue of around USD 31.6 billion by the end of 2024”, offering an indication of the sheer scale of investment needed. (ZEON, 2018).

There is a vast array of tech-tools used by Smart Cities authorities in an approach to resilience and risk management (Konecny et al., 2020) (Guo et al., 2020). National, regional and city decision-makers require an inordinate amount of information to make considered decisions based on data fed forecasting, modelling, and real-time analyses of urban conditions. Since the 1960's government-owned satellites, scientists and the media have collected weather and climate data and scientific institutions like the UK Met Office’s HadCRUT, NASA’s GISTEMP, NOAA’s MLOST and the Japanese Meteorological Agency. These agencies collected and processed the information, developing datasets and offering climate predictions to governments, and prominent businesses organizations

Today, there are many other more affordable, accurate and versatile data capture tools available (yeo, 2015). Smart Cities are accessing sophisticated and relatively affordable technology such as *CubeSats, Earth-observing (EO) satellites* (Jackson and Simpson, 2020), and *drones* (Khan et al., 2018) providing useful data for “city information modelling (CIM), 3D mapping, satellite and aerial imagery, remote sensing and data analytics at scales from street corners to megalopolises” (Jackson and Simpson, 2020, p.530). Space, air, ground and sea-based sensors produce such massive amounts of data that “[t]he US National Oceanic and Atmospheric Administration (NOAA) alone, collects 20 terabytes of environmental data from satellites and other sources every day”(Hill 2020, p.98). Sensors are developing mass data everywhere, from company-owned mini-satellites to smartphones that can turn any citizen into an environmental data-collection agent.

Mobile phones have evolved to the point where they can offer a direct method from which individuals can participate in helping cities address climate change risk. Thousands of volunteers can collect information about the impacts of extreme weather events and share them over social media platforms. In crisis conditions, mobile apps like 'MyMapVolunteers', a location-based service that can collect the location data of 'disaster volunteers' and present the data in the form of digital maps (Indriasari et al., 2017). (Frigerio et al., 2018) explores the use of these mobile systems of data collection by testing MappERS (Mobile Applications for Emergency Response and Support), a smartphone app designed to access geospatial data collected by citizens. In their research, Frigerio et al found that the app, "enhanced the active participation and response of the population in territorial and flood-risk mitigation in Frederikssund, Denmark", who are more often or not the first actors in surveillance strategies. The app appeared to be useful during a flood crisis, providing a communication link between city residents and civil-protection agents as well as an "effective tool to support the decision-making process during a crisis and to improve the awareness of the community and their disaster resilience" (Frigerio et al., 2018, p.1).

There are a growing amount of interactive mobile technology applications such as *Disaster Droid*, which maps a route that helps volunteers to reach the maximum number of incidents in one disaster site within the best timeframe; *First Aid*, a navigational system which plots the easiest way to receive medical aid; and *Help Me*, a smart rescue application. Dujardin et al, argue that the potential opportunities for mobile phone data concerning urban climate change adaptation to risk have yet to be realised. That mobile phone data can provide, "spatially-explicit assessments of urban vulnerability, and shows the ways these can help developing more dynamic strategies and tools for urban planning and disaster risk management" (Dujardin et al., 2020, p.98). Mobile phone devices are interesting in that they occupy all stops on the 'data road map' in other words these compact facets of technology occupy each stage of the data life cycle (DLC) participating in data creation, analysis, storage and processing. A fractal or downscaling of a smart city's **'**Fog-to- Cloud'[7] data management construct that individualizes data management(Sinaeepourfard et al., 2018).

Central to a smart cities approach to the issues around climate change risk and resilience are the methods of managing formats of structured, semi-structured unstructured data (big data) (Sinaeepourfard et al., 2018). Huge amounts of historical, last-recent and real-time data require data agencies to clean, store, process and package the information before it becomes

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[7] Fog-2-Cloud (F2C) the term for a hierarchical data management system used in the context of smart cities (Sinaeepourfard et al., 2017). The F2C system combines the advantages of both the centralised cloud and localised distributed data management / application in a city.

useful to decision-makers. For city authorities[8], data processing seems just as important as data collection. Therefore, they require sophisticated technology to process mass data looking for patterns and algorithmic support to improve infrastructure, water management and emergency responses on one hand whilst using processed data to develop powerful models that forecast the potential climate change disaster and response on the other. Data based catastrophe models are used to prepare and tests scenarios. They calculate the likelihood, location, loss and legacy of a disaster whilst running response and preventative measures (Hill and Martinez-Diaz, 2020b; Jackson and Simpson, 2020). The knowledge learnt through emergency scenario modelling, help improve and prepare three main types of city system: Operations Systems, City User Systems and City Infrastructure Systems[9] (Jucevičius et al., 2014).

Smart city authorities and tech-commerce, have recognised that largescale (ie global, regional, and national in scale) climate impact modelling must be scalable to make detailed resilience decisions at an urban scale. This has led to downscaled, super localized or 'highly granular modelling[10]' technology that tailors information to focus on specific issues. Hill and Martinez-Diaz introduce a collective of experts called *One Concern*[11], which use scaled-down modelling to "measure resilience and predict the impact of disasters to business and communities combining natural sciences with advanced AI/ ML capabilities" (Hill and Martinez-Diaz, 2020b; Wani et al., 2020). Whereas, *Coastal Risk*[12], is an organisation that also used micro-modelling to "provide[s] homeowners, businesses and governments with a state-of-the-art comprehensive assessment of current and future flood risk". Over the last ten years, there has been an increase in organisations offering schemes using big data, high tech, and granular modelling to augment the smart city approach to resilience and risk with regards to climate change. The United States have capitalised on the launch of these initiatives and

[8] In the context of the smart city and urban projects, decisions are made on three main levels: strategic, tactical and operational by city municipalities (Giang et al., 2017) in the understanding that the Smart City Ecosystem consists of Municipalities, National Government, Citizens and/or the public, Technology Developers, knowledge institutions and knowledge creators (Heezen, 2018).

[9] The terms, 'Operations Systems' relates to the city processes and governance, 'City User Systems' relates to the system used by businesses and citizens, and 'City Infrastructure Systems' relate to the energy, water, communications, and transport systems (Willis and Aurigi, 2018)

[10] Granular modelling is geared toward representing and processing aggregated chunks of information - information granules. These granules are collections of information that are familiar. The modelling divides the problem into a more manageable scale to provide a better insight into its nature.(Gacek, 2013)

[11] For further information please refer to the company website: https://www.oneconcern.com/

[12] For further information please refer to the company website: https://floodscores.com/

provide a *Climate Services for Resilient Development* (CSRD)[13] and the '*Climate Resilience Toolkit'*[14] used to guide climate-smart decision, policy and planning. Moreover, The World Resource Institute has developed an open-source online modelling tool, *Aqueduct floods*, which is a modelling tool that measures water-related flood risks around the world (Kuzma, 2020).

[13] CSRD explains that, "at the core of the group's commitment is delivering climate services—including the production, translation, transfer, and use of climate information—purposefully designed to enable policymakers and decision-makers to address significant problems and create solutions"(CSRD, 2020)

[14] The Climate Resilience Toolkit is a comprehensive platform from which to address resilience in the face of climate change upheaval. For further information please refer to https://toolkit.climate.gov/.

How can an increased use of data and technology foster citizen's ownership and empowerment in the context of climate change-related issues?

> *"Citizens and urban communities need to play a larger role in defining the end to which those technologies will be put. However, city governments, smart city developers, and urban residents don't always know how to have these conversations or how to encourage people to define how and under what conditions technologies and data will be employed"(Halegoua, 2020, p.xvi)*

Despite the growing interest in granular modelling and the fact that we live in unprecedented times of climate and weather data collection, analysis and modelling capacities, most vulnerable communities appear to lack the resources necessary to help plan and drive urban resilience. Salami et al (2017) claim that cities are a long way from achieving a situation where communities understand participatory flood risk management and have a robust awareness of flood hazards, vulnerability, and risk. They state that cities with advanced technological capabilities still lack the frameworks to address the "identification and assessment of the flood risks; exposure, susceptibility and adaptive coping capacity in the context of households' or communities' social, economic, cultural, institutional and physical vulnerabilities" (Salami et al., 2017, p.2). De Lange and DeWaal (2013) argue that critics often describe smart city projects as usually consisting of a *'triple helix'* configuration of government, knowledge production (academia) and industry (De Lange and De Waal, 2013,p.3), implying that citizens are often overlooked in policymaking. Thus positioning citizens as unequal agents in the co-production of a smart city approach to resilience and risk management. Often creating a process where citizens are expected to adopt a customer or end-user role and are used for feedback during the design process. This offers community members very little opportunity to contribute to the process of addressing the problems of climate change. However, De Lang and De Waal advocate a different more optimistic interpretation, one where a smart city approach to resilience and risk management offers an opportunity for citizen 'ownership' of the problem. Providing an alternative lens from which to view the role of smart city technology. De Lange and de Waal explore methods of ownership[15] that engage and empower citizens to act on complex collective urban problems.

[15] De Lange and de Waal apply the term 'ownership' in reference to, the degree to which citizens feel a sense of responsibility for shared issues such as flood and are taking action on the matter.

To appreciate the idea of citizen ownership within a community, it is important to acknowledge that scholars such as (Shin and Shin, 2012)and (De Lange and De Waal, 2013) posit an interesting perspective on the idea of community, feeling that it is “morally charged and problematic”, a term that in their view is parochial and “too reminiscent of small–scale and local ways of life instead of contemporary urban life”(De Lange and De Waal, 2013,p.6). These scholars prefer the term ‘network publics’ (Varnelis, 2012) in other words a collective of people connected by a shared ‘matter of concern’ rather than identified through location, class, heritage, cultural identity etc. A contemporary view which makes a lot of sense when you consider that climate change challenges exceed the local context. Issues such as resilience and risk involve a variety of stakeholders witch include, “[the] citizens themselves, but also authorities and policymakers on multiple levels, housing corporations, a wide array of social organizations and knowledge institutes involved in urban affairs, as well as local and global businesses” (De Lange and De Waal, 2013, p.6).

Therefore, citizen ownership is achieved through ‘*network publics’* and their response to a common issue. According to De Lange and de Waal, smart city technology facilitates a well-informed collective action. They cite examples of collaborative action against, airport noise pollution, social ills, and traffic congestion by using portable sensors, cameras, and mobile networks to model the problem and lobby for co-collaborative action. Furthermore, they highlight MIT’s Sensible City Lab[16] and MediaLab Prado[17] as tools that use the data developed by collectives to promote environmental issues of waste and air pollution as successful interventions using smart city technology. Thus, de Lange and de Waal argue that smart city technology and data-based approach is fundamental to a citizens relationship to resilience and risk, stating that, “urban technologies engage and empower people to become active in shaping their urban environment, to forge relationships with their city and other people, and to collaboratively address shared urban issues”(De Lange and De Waal, 2013, p.3)

[16] Trash Track follows the route of discarded objects: http://senseable.mit.edu/trashtrack/
[17] In the Air measures and displays air pollution http://www.intheair.es/

Examples of smart city approach that benefiting vulnerable communities.

Sponge City Program Guangzhou, China

Focusing in the Chinese city of Guangzhou, researchers (Meng et al., 2018) explore a program to improve the city's resilience to pluvial flooding in a context of rapid urbanization and climate change. Using a 'Sponge City' metaphor, the program**,** which uses a smart city philosophy, combines Guangzhou's ambitions to improve its resilience to flood risk, with a pursuit of a more sustainable way to build an attractive and liveable urban environment. Guangzhou identifies as a smart city, it uses sophisticated technology to improve weather forecasts, traffic congestion, healthcare services, and resilience to environmental issues. The city collects real-time information on traffic flows and visualizes it, allowing officials to use graphic analysis to manage traffic supported by the Tianhe-2 Supercomputer, also known as "the 'Milky Way 2', one of the world's fastest supercomputers". A computer system which has massive processing capabilities that powers citizen services (Chia, 2018). And yet the city is also an example of how urban expansion exacerbates vulnerability to flooding in the context of the changing climate.

Similar to the Low Impact Developments (LIDs) in the United States or Sustainable Urban Drainage Systems (SuDs) and the Blue-Green Cities (BGCs) approaches in the United Kingdom, the Sponge City program has been developed to adapt its technology to help address the city's vulnerability to flooding. The program encourages horizontal cooperation between spatial planning and other professions, traces and models innovation in the local spatial planning system and promotes common 'sponge' practices such as "bio-swales, rain gardens, pervious pavements, artificial ponds and green roofs" to reduce the peak discharges and to absorb urban stormwater through "soil infiltration, stormwater retention, storage, purification, recharge groundwater and improving the water quality of the runoff"(Chan, 2018) (Mesut et al., 2018). Chan explains that this idea of a sponge infrastructure delivers "multiple benefits to the general public by creating more recreational space improving the amenity value and the living well-being of a district" (Chan, 2018). "Designers will concede to the wisdom of nature to ensure water is absorbed when there's an excess: instead of water-resistant concrete, permeable materials and green spaces will be used to soak up rainfall, and rivers and streams will be interconnected so that water can flow away from flooded areas"(Leach, 2016). The program acknowledges that flooding causes more economic, social, and humanitarian damage than any other natural disaster (Global Resilient Partnership) and the Chinese government aims to develop the sponge city concept nationally.

Smart Communities in Japan

(Granier and Kudo, 2016) explore the idea of "Smart Communities" in Japan as a response to the reported lack of research into the practices of citizens in smart cities. Smart communities were explored to "enabled the Japanese to extensively integrate new, innovative technologies into their daily lives" (Beltran, 2017). Experts from Japan's influential Ministry of Economy, Trade and Industry (METI) has defined a smart community as being "a community of a certain scale in which various consumers participate and which has created a new social system" (METI, 2014). This social system is based on the networks created through the fusion of energy and digital technology, designed to reduce consumption and secure energy supply in a country vulnerable to the threat of natural disasters (METI, 2014).

Smart communities, according to Granier and Kudo, highlight the importance of ICT as a powerful aspect of public involvement in smart city projects of resilience (Gil-Garcia et al., 2016; Granier and Kudo, 2016; Marres, 2015). An intuitive that amplifies the importance of community and citizens participation and takes a more positive position with regards the, "seemingly crucial and relentlessly claimed citizens' "engagement" or "participation" in smart cities and the relative weakness of both actual practices" (Granier and Kudo, 2016, p.68). Smart communities have developed with an objective, "not to involve citizens in city governance, but rather to make them participate in the co-production of public services" (Granier and Kudo, 2016, p.61), allowing ICTs used by municipalities and electric utilities to steer project participants and to change behaviour. In other words, making not only the city's infrastructure"smart", but also its industry, commerce, business, and householders too (Granier and Kudo, 2016).

Granier and Kudo maintain that many smart city authorities struggle with public participation, with their input subject of various criticisms about its relevance and its efficacy. They explain that "[t]he lack of willingness and competence of ordinary citizens to contribute to policymaking is often highlighted, especially when it comes to technical issues"(Granier and Kudo, 2016, p.65), they go on to suggest that participatory mechanisms often aim at suppressing dissent and are tools of manipulation. In this respect, participation is considered as a 'policy instrument' aimed at ensuring the acceptance of a measure or a project, without any ambition to consider citizens input. As Chourabi et al. surmise, "addressing the topic of people and communities as part of smart cities is critical, and traditionally has been neglected" (Chourabi et al., 2012,p.2287-89).

However, the concept of a smart community in Japan acknowledges the community and the city as a whole, setting up a system of cooperation between the industry, government and residents (Gao et al., 2016) an alternative 'triple helix' to that of De Lange and DeWaal explained earlier in the paper. Forbes agrees and explains that "[i]n some countries, a smart city is all about improving industry or transportation, In Japan, it's about how to solve specific social issues and improve quality of life for the citizens" (Forbes, 2019).

The Chesterfield Heights Project, Norfolk, USA

The city of Norfolk is increasingly subject to the impact of high sea levels and regular flooding that occurs after heavy rains, particularly between September and December. Areas in the city suffer from inadequate water drainage systems, outdated, and poorly situated the century-old stormwater outlets to the sea are submerged even at low tides (Kramer, 2016). A Norfolk resident explains that:

"You have a thunderstorm and suddenly everybody in Norfolk is modifying how they get from point A to point B because they know certain streets, they won't be able to drive on," (Ann Phillips) (Kramer, 2016, p.22)

The Chesterfield Heights Project[18] was developed by a team of academics from architecture and engineer departments at Old Dominion University (ODU) and Hampton University in collaboration with NGO, local and government agencies. The multifaceted project focused on a rundown neighbourhood of 500 homes called Chesterfield Heights and developed its resilience to flooding by using smart city technology such as 'StormSense' (an IoT-enabled inundation forecasting research initiative), a network of ultrasonic and radar remote water level sensors to help establish the "regional resilience monitoring network"(Loftis et al., 2018, p.56). The project team ultimately proposed a unique network of cisterns built underneath the roads and house basements, the sealed cisterns with one-way check valves

[18] For further information please refer to : http://wetlandswatch.org/chesterfield-heights

would collect the flood water and would allow it slowly to seep back into the soil. The project later received $115 million from the Department of Housing and Urban Development's National Disaster Resilience to implement the plan that will be completed in 2023(Andrews, 2020).

Rio de Janeiro, Brazil

Sennett argues that smart city technologies have helped cities like Rio de Janeiro in their quest to become more climate change resilient. The city has had a torrid history of devastating flash floods, which has resulted in the exacerbation of social ills such as widespread poverty and violent crime (Sennett, 2012). In their attempts to combat the social problems and the challenges related to climate change, such as flooding, the citizens have adopted technology that large corporations like IBM and Cisco offer cities to mitigating risk and improving resilience. Sennett cites Rio de Janeiro case as a positive example of co-collaboration, highlighting the city's use of data-based applications for, 'forecasting' natural disasters scenarios, coordinating responses to infrastructure crises, and organising police responses on crime. He uses Rio as a contrast to a smart city's civil shortfalls as the report the troubles related to smart cities like Masdar in Abu Dhabi and Songdo in South Korea. Thus, promoting an important lesson that offers an alternative approach to addressing risk and resilience from a smart city viewpoint, one which is co-ordination rather than top-down orientated which is apparent in Masdar and Songdo. (Sennett, 2012)

How have smart cities approached the support of urban communities most vulnerable to climate change risk?

Rio de Janeiro offers an insight into the use of smart city applications and an approach that seems to help the city to potentially become more resilient. However, Vanolo suggests caution in assuming that technology is the only answer, and that in general "the idea that 'technologies will save us, guards technological-related activities against criticism; - most of the visual representations of a smart city (easy to find on the web) present stereotypical images of cities with plenty of hi-tech symbols, but without any visible human presence" (Vanolo, 2014, p.893). Online Smart city imagery and promotional material in particular appears to support Vanolo's reflections on duplicitous messaging. On one hand, editorials herald community and citizen engagement and yet seem to relegate social importance (Cardullo and Kitchin, 2019; Halegoua, 2020), and on the other, there seems to be a mismatch between, the marketing of multinational ICT industries or managerial elites that look to serve ordinary citizens (Halegoua, 2020,p.125) and the 'top-down' business-like realities of delivering modernisation and governance at the expense of local needs, activities and culture. (Batty, 2017; Greenfield, 2013; Hollands, 2008b; Kitchin, 2014a). Part of the issue seems to be that large organisations and major consultancies appear to be at a loss and are often frustrated with community engagement. Halegous states that, "[w]hen people are included in smart city plans, they are imagined as individual data generators, urban lifestyle and technology consumers, or the cause of urban problems" they "move and consume inefficiently, get lost, lose track of their children and belongings, cause crime and public safety hazards". (Halegoua, 2020, p129). According to Halegoua's research, the frustrations felt by organisations are strengthened by the lack of local community attendance at smart city meetings[19], or that citizens often display a general dissatisfaction, at times lack of enthusiasm and trust for smart city initiatives. In some cases, business leaders have taken the position that "many citizens aren't at the same level of readiness as their cities are" and therefore lacking the capacity to engage on a meaningful level (Halegoua, 2020,p129).

[19] Smart city summits often charge registration fees of more than £1000 in registration fees. For example, Bayfield training symposium, London, 31st July 2020 and called 'Understanding Cities', cost £1,161.54 for general admission and the registration fee for Smart Cities Connect Conference & Expo called 'Real Community. Real Solutions' in 2020 will cost $1495

There appears to be an unsettled feeling towards citizens as potential problems rather than problem solvers. For many decision-makers, they have become an irritation due to their "dynamic informality and messiness of their interactions and desires" (Halegoua, 2020, p.130). Wich has resulted in a disconcerting stance taken by city developers, government officials and owners of tech industries, the very fabric from which a smart city managerial pattern is cut. Hence, it is relatively easy to understand those that question smart city management patterns as being the foundation of networks overly technocratic and top-down in orientation. Networks which mainly serves top-down interests rather than those of the city's citizens (Greenfield, 2013; Hollands, 2015; Kitchin, 2014b). A bias that has raised concerns over how smart cities are orientated in their approach in tackling challenges related to emergency, risk, and resilience, especially from a so-called bottom-up perspective.

As a response to smart city biases or neoliberal orientations, there has been a concerted effort to develop inclusive *networks of trust* (Hollands, 2008b), to *empower local communities* (Cardullo et al., 2019; Cardullo and Kitchin, 2019; Poole, 2014) and cultivate *smart citizens* (Bull and Azennoud, 2016) by using smart city technology and data to help connect residents, local government and tech businesses to accomplish shared goals (Nhede, 2020). Creating approaches to risk and resilience through a range of methods that adopt technology as a way to help locals become more 'smart' savvy, whilst acknowledging culture, stewardship, social-cohesion, and grassroots-collaboration which are central to a city's civil composition and it's citizen based ownership of risk and resilience (Halegoua, 2020, p.152). These initiatives are inspiring a growing number of potential platforms, from which to explore an authentic approach to supporting urban communities most vulnerable to emergencies brought about by climate change. Acknowledging, that for vulnerable communities to be more resilient to climate change risk, smart city authorities have to invite citizens to play a more prominent role (Frigerio et al., 2018). Bull and Azennoud suggest that the idea of tech-literate members of public or 'smart citizens' should be cultivated (Bull and Azennoud, 2016), a suggestion that positions "smart citizens at the foundations for smart cities, recogniz[ing] citizen agency in addressing issues that governments and their tech partners attempt to ameliorate" (Bull and Azennoud, 2016, p.151). In other words, urban dweling people have to be willing to adapt to, in order to live in, smart cities. Although, the idea of a smart citizen, seems sensible and an interesting way to bridge the perceived knowledge gap between vulnerable communities, local authorise and the data-based technologies available. A situation where, two or three smart citizens located within vulnerable communities could become a conduit of knowledge and smart practice inside and shared between different neighbourhoods. However, the notion of developing smart citizens appears to imply a moral obligation to behave in a certain way and adhere to the collective project of building resilient smart cities which could exclude the most vulnerable of neighbourhood inhabitants. It could also construct another layer in the hierarchy of intellectual power between the informed and those that are technologically inexperienced or marginalised from the smart city ethos (Cardullo and Kitchin, 2019).

For many advocates of a smart city ethos, supporting urban communities most vulnerable to climate change risk means providing the resources to help citizen embrace technology and recognise a smart city's capacity for effective change. By taking ownership of the technologies available, citizens would feel 'empowered'. Therefore, more likely to be resilient and able to adapt to risk more efficiently (D. Lytras, and Visvizi, 2020). According to Martin, "technology can be used to empower people and strengthen communities"(Marin, 2017). And yet, the term 'empowering citizens' seems to be relatively ambiguous. It appears that once a citizen receives information about their environment, activities, or risk of flooding, whether, through apps, data systems, dashboards or digitised information and services, then it is assumed that this is providing civic or individual empowerment. An idea of empowerment via technology which that has been expressed in research grants, funding proposals, smart city project proposal literature, INGO Climate Change initiatives and corporate partners. However despite the growing interest around the various paths to citizen engagement (Cardullo et al., 2019; Cardullo and Kitchin, 2019; Poole, 2014), Halegoua maintains that from a smart city top-down perspective, "citizen engagement is generally envisioned in terms of customer service, crowdsourced conversations or access to big data sets" (Halegoua, 2020,p.141).

Nonetheless, there are studies of vulnerable communities becoming more empowered and using technology and big data whilst collaborating with government and business to develop a more resilient approach to climate change risk. For instance, with the support of top-down actors such as the UK Department for International Development, City Council, World Bank, Red Cross and the Open Geospatial Consortium. A poverty-stricken community highly vulnerable to flooding in the Tandale area of Dar es Salaam in Tanzania, started the Ramani Huria (Swahili for "Open Mapping") project, an open data sourced approach to community-based mapping (Minghini et al., 2018). With the help of drones made from modern material and local versions made from bamboo (Ackerman and Birnhack, 2019), university students and local community members mapped the urban areas most likely to be subjected to flooding. This enabled the local authorities to develop plans to protect and support suburbs at risk of flooding and to take real-time actions (Makoye, 2017). The project began by plotting roads, streams, and flood plains and has evolved throughout different districts to build flood resilience in communities across the city. It continues to evolve and has attracted international academic and corporate partnership. The project continues to develop and offers government and citizens a sophisticated co-created service.

Over the last decade, there have been similar projects to Ramani Huria. The 'Sensors in a Shoebox' project is a good example where teenagers from vulnerable communities in the united states are trained by university researchers to use micro senor kits and design surveys to track air urban environmental patterns (Crawford, 2017). With the increased access to personal technology and open data sources, there has been a marked increase of citizen engagement that promotes ownership of their urban context. A change in approach primarily by reporting their environmental concerns to local authorities via smartphone apps like, Fixmystreet[20], SeeClickFix[21], BOS:311[22], Commonwealth Connect[23] or accessing citizen science and crowdsourcing[24] platforms. See (See, 2019) suggests that citizens and communities through crowdsourcing have the potential to co-create tools such as flood early warning systems (EWS), and can also provide data for validating flood forecasting models. Therefore developing shared digital platforms that citizens can document and record the occurrence of flooding in real-time, thus helping authorities improve the "spatial and temporal availability of information for disaster response and management"(See, 2019,p.2). It appears that crowdsourcing platforms do offer a form of citizen engagement. Everyblock[25] was an early attempt by CityLab to create a 'hyperlocal' engagement through a news and discussion site in the United States, which was initially developed to provide a place to talk and share knowledge (Miller and Stone, 2009).

[20] https://www.fixmystreet.com/
[21] https://seeclickfix.com/
[22] https://www.boston.gov/departments/bos311
[23] http://commonwealthconnect.io/
[24] The term crowdsourcing refers to the outsourcing of tasks to a crowd that would otherwise be too large to accomplish by a single organization (Howe, 2006). The practice of utilizing the wisdom of a group for a common goal.
[25] https://us.nextdoor.com/everyblock

More platforms have followed the Everyblock ethos. Social platforms like Nextdoor and Neighbourland, are civic engagement platforms developed for (and funded) by “government agencies, developers, and civic organizations to collaborate with their fellow stakeholders in an accessible, participatory, and equitable way” (Westrope, 2020). Using the Neighborland platform, citizens of San Francisco were encouraged to share data and support a network of trust by helping to develop a *living document,* by giving feedback on the city’s ‘Resilient San Francisco Strategy 2018’, and by learning how they and their neighbours can be better prepared for the shocks and stresses which the city will face through climate change. (Lee, 2018).

These platforms are designed to encourage a civic trust in big-data based technologies and the smart city methods of gathering, storing and sharing information. Offering operational transparency in how the data is used and for what ends. Seemingly echoing Williams sentiments that “[b]ig data will not change the world unless it is collected and synthesized into tools that have a public benefit” (Singleton et al., 2017).

However, developed trust in the data generated will not necessarily mean an increase in public benefits. Hill makes an interesting observation using a quote from Nobel Prize-winning psychologist Daniel Kaneman stating that, “[n]o one ever made a decision because of a number (Hill and Martinez-Diaz, 2020A, p.9). The challenge in engaging communities vulnerable to climate change may not be overcome by building trust in data figures, the emphasis has to be about the translation or narration of data, so that it speaks to decision-makers and communities. Hill asks, “What good are the best models powered by the best data if the users fail to draw actionable insights from them”(Hill and Martinez-Diaz, 2020b, p105). Platforms of trust, require a reciprocal translation of climate change information, a combined narrative of community and expert perspectives, tailored to clearly instruct governments about local ‘needs’. Hence, Creating a sense of dual *stewardship* and citizen collaboration in promoting community-designed and owned projects that foster awareness and reliance to climate change risk. An approach that facilitates ab augmented digital inclusion and grassroots initiatives supported by a reliable communication infrastructure which ensures a sense of connectivity whilst addressing localised urban problems of flood.

Conclusion

This literature review on how smart cities approach urban challenges which are exacerbated by climate change, has explored the potential of data and technology used in the urban communities most vulnerable to flood. It has strengthened the argument that there is a need for “better methods for engaging in democratic collaborations around the future of our cities” (Halegoua, 2020 p.184) and highlighted the necessity to develop a more united approach to mitigating climate change-related risk in vulnerable communities.

Smart city approaches can provide resilience as a plausible strategy to confront climate change challenges and offer a multi-faceted approach, integrating policy, communities and technologies, based on information and communication (Chourabi et.al., 2012; Mustapha, McHeick & Melouli, 2016). However, this review also airs on the side of caution and recognises the danger of solely relying on data-sharing and high-tech as the fundamental part of the solution without the full involvement and participation of all relevant stakeholders and decision-makers. This full involvement could be achieved, this would contribute to the negotiated co-production of strategical solutions whilst exploring the interaction between these socio-cultural, economic, political, institutional and technological factors and the scope for addressing these could offer important insights for similarly challenging scenarios not only in Mexico but elsewhere in Latin America and the Global South.

Considering the social, economic and political aspects of affected communities, as well as understanding the physical origin of disasters, will contribute to developing resilience and prevent the consequences of exposure to hazards. This research approach considers both the macro-scale and the local scale, understanding that change can emerge in collaboration with communities, which know their territory and can engage in mapping potential hazards, monitoring key challenges, and developing co-produced strategies.

Ref:

Ackerman, E., Birnhack, M., 2019. Tanzania Builds a Drone Industry From Local Know-How and Bamboo - IEEE Spectrum [WWW Document]. URL https://spectrum.ieee.org/robotics/drones/tanzanias-homegrown-drone-industry-takes-off-on-bamboo-wings (accessed 5.21.20).

Albino, V., Berardi, U., Dangelico, R.M., 2015. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. Journal of Urban Technology 22, 3–21. https://doi.org/10.1080/10630732.2014.942092

Andrews, K., 2020. $112M flood resilience project breaks ground in Norfolk. Virginia Business.

Angelidou, M., 2015. Smart cities: A conjuncture of four forces. Cities 47, 95–106. https://doi.org/10.1016/j.cities.2015.05.004

Appleby, K., 2020. The smartest cities on climate: What can we learn? [WWW Document]. Smart Cities World. URL https://www.smartcitiesworld.net/opinions/opinions/the-smartest-cities-on-climate-what-can-we-learn (accessed 4.23.20).

Batty, M., 2017. The Age of the Smart City. https://doi.org/10.13140/RG.2.2.34783.87204

Batty, M., 2012. Smart Cities, Big Data. Environ Plann B Plann Des 39, 191–193. https://doi.org/10.1068/b3902ed

Beltran, 2017. Japan: The Vibrant Development of Smart Communities [WWW Document]. Planète Énergies. URL https://www.planete-energies.com/en/medias/close/japan-vibrant-development-smart-communities (accessed 5.8.20).

Bull, R., Azennoud, M., 2016. Smart citizens for smart cities: participating in the future. Proceedings of the Institution of Civil Engineers - Energy 169, 93–101. https://doi.org/10.1680/jener.15.00030

Calthorpe, P., 2011. Urbanism in the age of climate change. Island Press, Washington, DC.

Cardullo, P., Di Feliciantonio, C., Kitchin, R., 2019. The Right to the Smart City.

Cardullo, P., Kitchin, R., 2019. Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland. GeoJournal 84, 1–13. https://doi.org/10.1007/s10708-018-9845-8

Chan, F., 2018. The opportunities and challenges of the sponge city project in Chinese cities – the solution of urban flood and drought issues? Asia Dialogue. URL https://theasiadialogue.com/2018/06/01/the-opportunities-and-challenges-of-the-sponge-city-project-in-chinese-cities-the-solution-of-urban-flood-and-drought-issues/ (accessed 5.8.20).

Chia, J.L., 2018. How Guangzhou is powering its high-tech ambitions. GovInsider. URL https://govinsider.asia/digital-gov/guangzhou-smart-city-supercomputers-ai-digital-services/ (accessed 5.8.20).

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J.R., Mellouli, S., Nahon, K., Pardo, T.A., Scholl, H.J., 2012. Understanding Smart Cities: An Integrative Framework, in: 2012 45th Hawaii International Conference on System Sciences. Presented at the 2012 45th Hawaii International Conference on System Sciences (HICSS), IEEE, Maui, HI, USA, pp. 2289–2297. https://doi.org/10.1109/HICSS.2012.615

Coghlan, D., Brydon-Miller, M., 2014. The SAGE Encyclopedia of Action Research. SAGE.

CPD, 2014. Protecting Our Capital (How climate adaptation in cities creates a resilient place for business).

CSRD, 2020. Climate Services for Resilient Development [WWW Document]. URL http://www.cs4rd.org/ (accessed 5.7.20).

D. Lytras, M., Visvizi, A., 2020. SUSTAINABLE SMART CITIES AND SMART VILLAGES RESEARCH: rethinking security, safety, well ...-being and happiness. MDPI AG, Place of publication not identified.

De Lange, M., De Waal, M., 2013. Owning the city: New media and citizen engagement in urban design. FM 18. https://doi.org/10.5210/fm.v18i11.4954

Dujardin, S., Jacques, D., Steele, J., Linard, C., 2020. Mobile Phone Data for Urban Climate Change Adaptation: Reviewing Applications, Opportunities and Key Challenges. Sustainability 12, 1501. https://doi.org/10.3390/su12041501

Eremia, M., Toma, L., Sanduleac, M., 2016. The Smart City Concept in the 21st Century | Elsevier Enhanced Reader [WWW Document]. https://doi.org/10.1016/j.proeng.2017.02.357
Forbes, 2019. Japan BrandVoice: Japan Sparks New Life In Local Communities With Human-Centric Smart Cities [WWW Document]. Forbes. URL https://www.forbes.com/sites/japan/2019/12/23/japan-sparks-new-life-in-local-communities-with-human-centric-smart-cities/ (accessed 5.8.20).
Frigerio, S., Schenato, L., Bossi, G., Mantovani, M., Marcato, G., Pasuto, A., 2018. Hands-On Experience of Crowdsourcing for Flood Risks. An Android Mobile Application Tested in Frederikssund, Denmark. IJERPH 15, 1926. https://doi.org/10.3390/ijerph15091926
Fussel, H., 2005. Vulnerability in Climate Change Research: A Comprehensive Conceptual Framework.
Gacek, A., 2013. Granular modelling of signals: A framework of Granular Computing. Information Sciences 221, 1–11. https://doi.org/10.1016/j.ins.2012.08.028
Gao, W., Fan, L., Ushifusa, Y., Gu, Q., Ren, J., 2016. Possibility and Challenge of Smart Community in Japan. Procedia - Social and Behavioral Sciences 216, 109–118. https://doi.org/10.1016/j.sbspro.2015.12.015
Get the Data and Make Them Usable, 2020. , in: Building a Resilient Tomorrow. Oxford University Press, pp. 98–115. https://doi.org/10.1093/oso/9780190909345.003.0006
Giang, T.T.H., Camargo, M., Dupont, L., Mayer, F., 2017. A review of methods for modelling shared decision-making process in a smart city living lab, in: 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC). Presented at the 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC), IEEE, Funchal, pp. 189–194. https://doi.org/10.1109/ICE.2017.8279888
Giffinger, R., Kramar, H., Haindl, G., 2008. The role of rankings in growing city competition 14.
Gil-Garcia, J.R., Pardo, T.A., Nam, T., 2016. Smarter as the New Urban Agenda: a Comprehensive View of the 21st Century City.
Granier, B., Kudo, H., 2016. How are citizens involved in smart cities? Analysing citizen participation in Japanese ``Smart Communities''. IP 21, 61–76. https://doi.org/10.3233/IP-150367
Greenfield, A., 2017. Practices of the Minimum Viable Utopia. Architectural Design 87, 16–25. https://doi.org/10.1002/ad.2127
Greenfield, A., 2013. Against the Smart City [WWW Document]. Urban Omnibus. URL https://urbanomnibus.net/2013/10/against-the-smart-city/ (accessed 5.12.20).
Guo, H., Goodchild, M.F., Annoni, A. (Eds.), 2020. Manual of Digital Earth. Springer Singapore, Singapore. https://doi.org/10.1007/978-981-32-9915-3
Halegoua, G.R., 2020. Smart cities, MIT Press essential knowledge series. MIT Press, Cambridge, MA.
Hall, R.E., Bowerman, B., Braverman, J., Taylor, J., Todosow, H., Von Wimmersperg, U., 2000. The vision of a smart city [WWW Document]. 2nd International Life Extension Technology Workshop, Paris (FR), 09/28/2000--09/28/2000. URL https://digital.library.unt.edu/ark:/67531/metadc717101/ (accessed 4.17.20).
Hatuka, T., Rosen-Zvi, I., Birnhack, M., Toch, E., Zur, H., 2018. The Political Premises of Contemporary Urban Concepts: The Global City, the Sustainable City, the Resilient City, the Creative City, and the Smart City. Planning Theory & Practice 19, 160–179. https://doi.org/10.1080/14649357.2018.1455216
Heezen, M., 2018. Decision-Making in Ecosystems for Responsible and Inclusive Smart Cities.
Hill, A.C., Martinez-Diaz, L., 2020a. Building a resilient tomorrow: how to prepare for the coming climate disruption. Oxford University Press, New York, NY, United States of America.
Hill, A.C., Martinez-Diaz, L., 2020b. Building a Resilient Tomorrow: How to Prepare for the Coming Climate Disruption, 1st ed. Oxford University Press. https://doi.org/10.1093/oso/9780190909345.001.0001
Hollands, R.G., 2015. Critical interventions into the corporate smart city. CAMRES 8, 61–77. https://doi.org/10.1093/cjres/rsu011
Hollands, R.G., 2008a. Will the real smart city please stand up?: Intelligent, progressive or entrepreneurial? City 12, 303–320. https://doi.org/10.1080/13604810802479126

Hollands, R.G., 2008b. Will the real smart city please stand up?: Intelligent, progressive or entrepreneurial? City 12, 303–320. https://doi.org/10.1080/13604810802479126
Howe, 2006. The Rise of Crowdsourcing | WIRED [WWW Document]. URL https://www.wired.com/2006/06/crowds/ (accessed 5.21.20).
Indriasari, T.D., Anindito, K., Julianto, E., Pangaribuan, B.L.P., 2017. A Mobile and Web Application for Mapping Disaster Volunteers' Position in Indonesia. Int. J. Interact. Mob. Technol. 11, 98. https://doi.org/10.3991/ijim.v11i3.6477
International Symposium on Flood Defence, Alphen, J. van, Beek, E. van, Taal, M., 2006. Floods, from defence to management symposium proceedings: proceedings of the 3rd International Symposium on Flood Defence, Nijmegen, the Netherlands, 25-27 May, 2005. CRC Press, Boca Raton.
Jaana Remes, Woetzel, J., 2020. Resilience planning for smart cities | McKinsey [WWW Document]. URL https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/smarter-cities-are-resilient-cities (accessed 4.24.20).
Jackson, D., Simpson, R., 2020. Digital City: An Urban Perspective on Digital Earth, in: Guo, H., Goodchild, M.F., Annoni, A. (Eds.), Manual of Digital Earth. Springer Singapore, Singapore, pp. 527–563. https://doi.org/10.1007/978-981-32-9915-3_16
Jucevičius, R., Patašienė, I., Patašius, M., 2014. Digital Dimension of Smart City: Critical Analysis. Procedia - Social and Behavioral Sciences 156, 146–150. https://doi.org/10.1016/j.sbspro.2014.11.137
Khan, M., Alvi, B., Safi, E., Khan, I., 2018. Drones for Good in Smart Cities:A Review.
Kitchin, R., 2014a. The real-time city? Big data and smart urbanism. GeoJournal 79, 1–14. https://doi.org/10.1007/s10708-013-9516-8
Kitchin, R., 2014b. The real-time city? Big data and smart urbanism. GeoJournal 79, 1–14. https://doi.org/10.1007/s10708-013-9516-8
Konecny, M., Bandrova, T., Kubicek, P., Marinova, S., Stampach, R., Stachon, Z., Reznik, T., 2020. Digital Earth for Disaster Mitigation, in: Guo, H., Goodchild, M.F., Annoni, A. (Eds.), Manual of Digital Earth. Springer Singapore, Singapore, pp. 495–526. https://doi.org/10.1007/978-981-32-9915-3_15
Kramer, D., 2016. Norfolk: A case study in sea-level rise. Physics Today 69, 22–25. https://doi.org/10.1063/PT.3.3163
Kuzma, 2020. Aqueduct Floods Hazard Maps [WWW Document]. World Resources Institute. URL https://www.wri.org/resources/data-sets/aqueduct-floods-hazard-maps (accessed 5.1.20).
Leach, A., 2016. Soak it up: China's ambitious plan to solve urban flooding with 'sponge cities.' The Guardian.
Lee, E.M., 2018. San Francisco [WWW Document]. 100 Resilient Cities. URL http://100resilientcities.org/strategies/san-francisco/ (accessed 5.21.20).
Loftis, J.D., Forrest, D., Katragadda, S., Spencer, K., Organski, T., Nguyen, C., Rhee, S., 2018. StormSense: A New Integrated Network of IoT Water Level Sensors in the Smart Cities of Hampton Roads, VA. mar technol soc j 52, 56–67. https://doi.org/10.4031/MTSJ.52.2.7
Luque-Ayala, A., Marvin, S., 2015. Developing a critical understanding of smart urbanism? Urban Studies 52, 2105–2116. https://doi.org/10.1177/0042098015577319
Makoye, K., 2017. Drones help Tanzania slum residents map flood risk [WWW Document]. news.trust.org. URL https://news.trust.org/item/20170104070454-rd34w/ (accessed 5.12.20).
March, H., 2018. The Smart City and other ICT-led techno-imaginaries: Any room for dialogue with Degrowth? Journal of Cleaner Production 197, 1694–1703. https://doi.org/10.1016/j.jclepro.2016.09.154
Marin, F., 2017. From "smart cities" to "smart citizens": when technology meets activism [WWW Document]. URL https://www.ouishare.net/article/from-smart-cities-to-smart-citizens-when-technology-meets-activism (accessed 5.21.20).
Marres, N., 2015. Material participation. Palgrave Macmillan, Basingstoke.
Mehmood, Y., Ahmad, F., Yaqoob, I., Adnane, A., Imran, M., Guizani, S., 2017. Internet-of-Things-Based Smart Cities: Recent Advances and Challenges. IEEE Commun. Mag. 55, 16–24. https://doi.org/10.1109/MCOM.2017.1600514

Menoni, S., 2018. Integrated Knowledge in Climate Change Adaptation and Risk Mitigation to Support Planning for Reconstruction, in: Smart, Resilient and Transition Cities. Elsevier, pp. 227–235. https://doi.org/10.1016/B978-0-12-811477-3.00029-8
Mesut, U., van der Lans, M., Fong, C., 2018. SPONGE CITY: ErQi sponge city final report. TU DELFT.
METI, 2014. Smart Community / METI Ministry of Economy, Trade and Industry [WWW Document]. URL https://www.meti.go.jp/english/policy/energy_environment/smart_community/index.html (accessed 5.8.20).
Miller, C.C., Stone, B., 2009. 'Hyperlocal' Web Sites Deliver News Without Newspapers. The New York Times.
Miller, J., 2020. How Smart Water Makes Cities More Transparent [WWW Document]. Technology Solutions That Drive Government. URL https://statetechmagazine.com/article/2020/02/how-smart-water-makes-cities-more-transparent-perfcon (accessed 4.30.20).
Minghini, M., Brovelli, M.A., Frassinelli, F., 2018. AN OPEN SOURCE APPROACH FOR THE INTRINSIC ASSESSMENT OF THE TEMPORAL ACCURACY, UP-TO-DATENESS AND LINEAGE OF OPENSTREETMAP. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. XLII-4/W8, 147–154. https://doi.org/10.5194/isprs-archives-XLII-4-W8-147-2018
Mischke, J., Woetzel, J., 2018. Future-proofing infrastructure in a fast-changing world 54.
Moreno Pires, S., Magee, L., Holden, M., 2017. Learning from community indicators movements: Towards a citizen-powered urban data revolution. Environment and Planning C: Politics and Space 35, 1304–1323. https://doi.org/10.1177/2399654417691512
Muente-Kunigami, A., Mulas, V., 2015. Building smarter cities [WWW Document]. URL https://blogs.worldbank.org/digital-development/building-smarter-cities (accessed 4.23.20).
Nhede, N., 2020. Smart city, hyperconnectivity: environmental and financial benefits. Smart Energy International. URL https://www.smart-energy.com/industry-sectors/smart-cities/smart-city-hyperconnected-environmental-and-financial-benefits/ (accessed 5.21.20).
Pelling, M., 2011. Adaptation to climate change: from resilience to transformation. Routledge, London ; New York.
Pelton, J.N., Singh, I.B., 2019. The Coming Age of the Smart City, in: Smart Cities of Today and Tomorrow. Springer International Publishing, Cham, pp. 1–27. https://doi.org/10.1007/978-3-319-95822-4_1
Poole, S., 2014. The truth about smart cities: 'In the end, they will destroy democracy''' [WWW Document]. the Guardian. URL http://www.theguardian.com/cities/2014/dec/17/truth-smart-city-destroy-democracy-urban-thinkers-buzzphrase (accessed 5.13.20).
Quora, 2018. What Is A Minimum Viable Product, And Why Do Companies Need Them? [WWW Document]. Forbes. URL https://www.forbes.com/sites/quora/2018/02/27/what-is-a-minimum-viable-product-and-why-do-companies-need-them/ (accessed 4.16.20).
Remarks by the President at U.N. Climate Change Summit [WWW Document], 2014. . whitehouse.gov. URL https://obamawhitehouse.archives.gov/the-press-office/2014/09/23/remarks-president-un-climate-change-summit (accessed 4.17.20).
Rosenzweig, C., Solecki, W., Hammer, S.A., Mehrotra, S., 2010. Cities lead the way in climate–change action. Nature 467, 909–911. https://doi.org/10.1038/467909a
Salami, R.O., Von Meding, J.K., Giggins, H., 2017. Urban settlements' vulnerability to flood risks in African cities: A conceptual framework. Jàmbá 9. https://doi.org/10.4102/jamba.v9i1.370
See, L., 2019. A Review of Citizen Science and Crowdsourcing in Applications of Pluvial Flooding. Front. Earth Sci. 7. https://doi.org/10.3389/feart.2019.00044
Sennett, R., 2012. No one likes a city that's too smart | Richard Sennett. The Guardian.
Shin, Y., Shin, D.-H., 2012. Community Informatics and the New Urbanism: Incorporating Information and Communication Technologies into Planning Integrated Urban Communities. Journal of Urban Technology 19, 23–42. https://doi.org/10.1080/10630732.2012.626698
Sinaeepourfard, A., Garcia, J., Masip-Bruin, X., Marin-Tordera, E., 2017. Fog-to-Cloud (F2C) Data Management for Smart Cities 11.
Sinaeepourfard, A., Krogstie, J., Petersen, S.A., 2018. A Big Data Management Architecture for Smart Cities based on Fog-to-Cloud Data Management Architecture 14.

Singleton, A.D., Spielman, S., Folch, D., 2017. Urban analytics.
Smart Cities [WWW Document], 2015. . World Bank. URL https://www.worldbank.org/en/topic/digitaldevelopment/brief/smart-cities (accessed 4.14.20).
van der Most, H., Asselman, N., Slager, K., 2018. Experiences in developing and applying decision support systems for strategic flood risk management. International Journal of River Basin Management 16, 371–378. https://doi.org/10.1080/15715124.2017.1411925
Vanolo, A., 2014. Smartmentality: The Smart City as Disciplinary Strategy. Urban Studies 51, 883–898. https://doi.org/10.1177/0042098013494427
Varnelis, K., 2012. Networked publics. MIT Press, Cambridge, Mass.; London.
Wani, A., Nicole Hu, Frank, T., 2020. One Concern [WWW Document]. URL https://oneconcern.com (accessed 5.1.20).
Westrope, A., 2020. Nextdoor Acquires Citizen Engagement Platform Neighborland [WWW Document]. URL https://www.govtech.com/biz/Nextdoor-Acquires-Citizen-Engagement-Platform-Neighborland.html (accessed 5.21.20).
White, J.M., 2016. Anticipatory logics of the smart city's global imaginary. Urban Geography 37, 572–589. https://doi.org/10.1080/02723638.2016.1139879
Why Cities? [WWW Document], 2020. . C40 CITIES. URL https://www.c40.org/why_cities (accessed 4.2.20).
Wilbanks, T.J., Fernandez, S. (Eds.), 2014. Climate Change and Infrastructure, Urban Systems, and Vulnerabilities. Island Press/Center for Resource Economics, Washington, DC. https://doi.org/10.5822/978-1-61091-556-4
Willis, K.S., Aurigi, A., 2018. Digital and smart cities.
yeo, sophie, 2015. From buckets to beehives: how scientists collect climate data [WWW Document]. Climate Home News. URL https://www.climatechangenews.com/2015/01/16/from-buckets-to-beehives-how-scientists-collect-climate-data/ (accessed 4.30.20).
ZEON, 2018. Global Smart Water Management System Market Worth USD 31.6 Billion By 2024 [WWW Document]. URL https://www.zionmarketresearch.com/news/smart-water-management-system-market (accessed 4.30.20).