CIB World Building Congress 2019
Hong Kong SAR, China
17 – 21 June 2019

GOVERNANCE FOR RESILIENT SMART CITIES

Darren Nel
Hong Kong Polytechnic University, Hong Kong
Email: darren.nel@connect.polyu.hk
Verna Nel
University of the Free State, South Africa
Nelvj@ufs.ac,za

Abstract

Cities are becoming more complex as their population, size and diversity increases, as well as incorporating a growing range of networks that permeate them. Many such systems are emergent phenomena, arising from the interactions between people and place, while others have been deliberately created (e.g. power grids and transport networks) to manage the city. Furthermore, the governance of urban centres and regions amid the challenges of climate change, environmental impacts, economic crises, increasing inequality and social unrest demands an appreciation of the complexity of the city and its challenges. It also requires building resilience on many scales to deal with current and future challenges.

In this paper we focus on fostering urban resilience within a smart city and propose various principles to link these two concepts. The proposed principles draw on the characteristics of complex systems which facilitates our understanding of modern multifaceted urban environments. Furthermore, we discuss the ways in which multiple urban systems operate and interact at different spatial-temporal scales, which is essential to understand, as the nature of change varies, depending on the area's context. Through examples from the global South, we also point out the vulnerabilities of urban systems which smart city planning could have helped address.

From this foundation we proceed to develop principles for the governance of smart and resilient cities that extend beyond disaster risk management, to build general resilience through sound planning and governance.

Keywords: Resilience, smart cities, complexity, governance

1. Introduction

Cities are complex socio-ecological systems comprising multiple interacting systems. These include social (people, governance and political), economic, infrastructure (transport, information and communication technology (ICT), water, electricity, sanitation etc) and environmental systems. The entire socio-ecological system (SES) contains networks of energy and material flows linking people, processes and infrastructure. All complex systems are non-linear and dynamic. The numerous interactions and feedback connections allow information to move through the SES enabling both change and stability. SES operate at multiple spatial and temporal scales, with smaller systems moving more quickly within smaller areas in relation to larger systems. Complex systems are built from the bottom upwards, enabling them to respond to their environments, to adapt and self-organise, a process dubbed emergence. Unlike complicated systems (such as a computer), SES are not easy to control and if control is exerted, it tends to stifle the adaptability of the system (Cilliers, 2002; Gunderson and Holling, 2002; Holland, 1998).

Although complex systems can adapt, such adaption may not always be to a desired state if the resources to the system are eroded. ‘Slow burn’ or stress events may tip a system into an impoverished state from which it difficult to recover (Coaffee & Lee, 2016). Urban SES are under immense pressure at present and facing various social, economic and environmental challenges. Rapid urbanisation has exacerbated environmental problems of pollution, land degradation, social inequality and deprivation and stressed infrastructure (Bibri & Krogstie, 2017). Smart cities are both a response to these challenges and a means to manage the complexity.

There are many definitions of smart cities, each with a different focus, but generally they fall into two broad groups, one with a technological perspective and the other placing more emphasis on people (Albino, Berardi, & Dangelico, 2015; Kummitha & Crutzen, 2017; Mora, Bolici, & Deakin, 2017). The former views a smart city as “one that can be monitored, managed and regulated in real-time using ICT infrastructure and ubiquitous computing” (Kitchin, 2015:131). They use “smart urban technology solutions to improve liveability of communities and sustainability of cities—these technologies also include infrastructural ICTs that serve as the backbone such as internet and world wide web” (Yigitcanlar and Kamruzzaman, 2018: 50).

While technology, particularly ICT is central to a smart city, other authors place more emphasis on the human dimension. For Kummitha and Crutzen (2017), well educated citizens (smart people) are essential. Smart governance has a strong technological foundation which supports participatory governance and improves the quality of life and liveability of the city (Baron, 2012). A holistic concept of smart cities that includes ICT and related technologies but also a “balanced combination of human, social, cultural, environmental, economic, and technological aspects” (Mora et al., 2017:20). Social inclusion and equity form part of a smart and sustainable city. Sustainability is considered a key element and goal for smart cities by (Ahvenniemi et al., 2017; Bibri and Krogstie, 2017; Mora et al., 2017; Yigitcanlar and Kamruzzaman, 2018).

Smart cities thus seek to be equitable and socially just, environmentally sustainable economically prosperous, innovative and safe, and are supported by ICT and related technology. However, they also need to deal with the challenges of the modern city. A city must be able to survive crises and endure disruptions, yet still continue serving their citizens and remain competitive. Smart cities must be resilient!

Currently there is limited literature on the resilience of smart cities. In this paper we begin to explore this gap by applying the concepts of resilience to smart cities. This is the subject of the next section where we discuss the concept of resilience in more detail and examine how social and ecological capital and technology can contribute to resilience or reduced vulnerability, Thereafter, we suggest some principles for the governance of smart and resilient cities that extend beyond disaster risk management followed by a some concluding remarks.

2. Unpacking resilience

The concept of resilience, like those of sustainable development and smart cities has many definitions. Early and more basic definitions of resilience, often called engineering resilience, saw resilience as the ability of a system to withstand a disturbance. The speed of the recovery back to the systems equilibrium was the measure of the systems resilience (Holling, 1986). The engineering resilience perspective was later replaced by the ecological resilience approach. The ecological resilience defined resilience as the amount of disturbance that a system could absorbed before collapsing or moving into a different or stability domain (Folke, 2006).

The more recent and most widely endorsed evolutionary resilience perspective (sometimes called social-ecological resilience), views the resilience of a system as the ability to recover, adapt in the face of stresses and disturbances and maintain their function. Meerow et al (2016:45) sum up urban resilience as "the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity".

According to Carpenter et al. (2001), the evolutionary resilience perspective emphasises several important elements. First, that a system must be able to absorb a disturbance. Second that a resilient system is able to self-organise (as opposed to organisation forced upon by external factors, or complete lack of any organisation), adapt to change and if needed and to transform in the face of a disturbance. Third, evolutionary resilience emphasises that resilient SES are able to learn from the past and plan for the future (Coaffee & Lee, 2016; Walker & Salt, 2012). This confirms that resilience has become more than just planning for and minimising risk and potential disasters; resilience is also about seeing opportunities in crises, while actively seeking to improve the system (Peres, 2016). Finally, evolutionary resilience acknowledges that all complex systems consist of sub-systems which interact with each other across different spatial-temporal scales. Because of the non-linear interactions within these systems, small changes can have large, and unexpected effects across all scales (Gunderson & Holling, 2001).

With the increasing popularity of resilience in recent years (Zhang & Li, 2018) some scholars are concerned that resilience will be used interchangeably with sustainability (see Lu and Stead 2013). However, it should be noted that resilience and sustainability are not the same thing. Unlike suitability, resilience is a value neutral concept, meaning that resilience can imply both 'good' and 'bad' system states (Barnes & Nel, 2017). For example, an authoritarian regime which maintains power through fear and power could be regarded as being just as resilient, even more so, when compared to a liberal society which embraces democracy and freedom of speech (Elmqvist, Barnett, & Wilkinson, 2014). Thus, when resilience is seen as a non-normative concept, it can be better understood as an emergent characteristic of a complex system which reinforces and maintains some behaviours, whether good or bad. Therefore, to fully leverage the potential that resilience thinking offers cities, resilience must be framed within a normative position such as sustainable development (Peres, Landman, & Du Plessis, 2016). If framed within sustainable development, then resilience offers a theoretical framework to identify those aspects of the city- system whose resilience needs to be eroded while at the same time aiding in identifying the characteristics and behaviours which should be reinforced to further enhance the sustainable, resilient, development of a city (ibid).

Assuming that resilience is approached within the normative position of sustainability, how is a resilient city created and what is the role of smart city planning in creating smart resilient cities? Cities, like all complex systems, exhibit a set of common characteristics. When seen through a resilience perspective, these system characteristics become a means to assess and facilitate the formation of resilience.

Described here are some of the system characteristics which are regarded as having the greatest potential to build the resilience of cities.

1. Diversity

Diversity is critical in resilient systems as it creates complexity while providing the system with a multitude of options (S Salat, 2011). Diversity is normally studied as variation between types (e.g. land uses), within types (as different form of residential use) or in the arrangement of types. (Ferreira, 2016) distinguishes between functional and response diversity. Functional diversity, also known as structural diversity, pertains to the variation of functions that different elements of a system perform (e.g. shelter, commerce, transport). Response diversity is the variation within each function and can be considered as the scope of reactions to change within a system (Page, 2010). Spatial diversity considers the size and spatial distribution of functions and corresponding response (Salat & Bourdic, 2012). More diverse systems have more ways to deal with stresses, for example a more diverse economy will fare better than one with a narrow economic base. If there are acceptable public transport options, people will be more willing to use them instead of private cars. This can also relate to energy (e.g. solar, wind, gas or electricity).

2. Redundancy

Redundancy is the extent to which different systems elements can perform the same or similar functions either through exact duplication/ backups or through degeneracy (structurally different elements performing the same function) (Page, 2010; United Nations and Asian Development Bank, 2012). Redundancy is routinely built into ICT systems to ensure that the system can continue to function even if one part fails. Diversity, specifically response diversity, can also lead to redundancy (Cumming, Wilson, Walker, & Ostrom, 2008). When a system component is able to duplicate a function, it enhances its responsive capacity. Diversity further supports redundancy, such as in places with a range of alternative transport systems and routes, or sources of water, can cope under stress, whereas dependence on a single option makes a place vulnerable. Redundancy includes stores and capitals, including social and human capital. Simone (2004, 2010) writes of the informal relationships – social capital – that enables poor urban people to survive in the city. A smart city will ensure that there is redundancy in its critical urban services such as water, electricity and increasingly, ICT. As we write this paper, South Africa has been experiencing regular blackouts due to the national electricity supplier's inability to generate enough electricity to meet the country's needs arising from a lack of capacity in the system (Eskom, n.d.). Clearly the electricity generation system has neither redundancy nor resilience.

3. Modularity

Modularity forms when a system has sub-units that are weakly connected externally but contain strong internal connection, which enable the sub-units to function independently. This means, for example, that if part of a power grid is knocked out by lightning or a storm-surge, other parts of the system can continue to provide power. Furthermore, because the systems are still connected, it would still be possible to reroute power to affected areas, provided there was spare capacity Together with redundancy, modularity provide the means to mitigate and respond to disasters. However, both redundancy and modularity reduce efficiency. Thus, there is a need for balance between safeguards and efficiency.

4. Connectivity

Cities are often regarded as complex networks which facilitate the flow of goods and interaction between people (Batty, 2013). Through the strength and structure of the network, new locations are able to emerge (Salat, 2017). A lack of connectivity is often credited as a cause of failure after a shock (Ahern, 2011), such as Haiti after the 2010 earthquake when the harbour, airport and other transport infrastructure was damaged. High degrees of connectivity allow the system to quickly access, reorganise and redistribute resources and information should there be a failure. While good connectivity is paramount, the structures of the connections are also important. Networks whose structures are 'tree like' tend to be very efficient, however they are also very vulnerable should their capacity be exceeded or there is a failure on one of the main connections. In contrast networks whose structures are more 'leaf like' tend to have a multitude of connections, providing a greater degree of network redundancy. Networks which have a balance in their connectivity are both efficient and resilient (Salat & Bourdic, 2012). Connectivity, in the form of social media has been critical in helping people in disasters (Gao, Barbier, Goolsby, & Zeng, 2011)

5. Foresight & learning

Evolutionary resilience emphasises the ability of SESo learn from the past while also planning for possible future scenarios (Hassler & Kohler, 2014). Cities can learn from their own past as well as the history of other cities. This allows them to better plan for similar circumstances (Barnes & Nel, 2017). Advances in technology including sensors, communication technology and remote sensing can provide cities with real-time data. Other advances, such as artificial intelligence (A.I.) and machine learning, can aid cities in making sense of the all the information as well as providing deeper insights into the functioning of the city. Overall, smart cities build resilience as they enable more informed decisions to be made by studying past information, understanding the current situation, and helping to plan for the future with the information at hand.

6. Adaptability

Adaptability is one of the defining characteristics of a resilient system. Broadly speaking, adaptability is the ability of the system to adjust to changes in the environment. This is due to the ability of the components to either change their behaviour or structural characteristics in response to changes in other system components or in the environments (Holland, 1996). The response of the system to change can vary greatly and is largely dependent on the initial stimulus. Adaptive capacity is the ease with which the various system component can respond to an event or even anticipate future possible events (Coaffee & Lee, 2016; Folke et al., 2010). For example, some cities are slowly adapting their existing building stock to better deal with the increasing impact of climate change, or seismic events. By providing incentives to speed up the adaption, governments are improving cities' adaptive capacity. Smart cities can use advanced sensors to aid in identifying which areas need what type of adaption, or even developing buildings that are more responsive to the real-time needs of the inhabitants. However, caution should be taken to not over-adapt to a specific threat as this can reduce the systems overall capacity to respond to unknow threats (Walker & Salt, 2012)

Because the focus of resilience is on adaption, it shifts the attention away from an 'end state' to now be more focussed possible futures which are built on principles and not pragmatism (Eraydin & Taşan-Kok, 2013, p. 6). With this in mind, the next section introduces a set of principles for the governance of smart resilient cities

3. Principles of resilient governance in smart cities

While 'government' pertains to formal institutions and their right to use force, the concept of governance extends beyond the state and includes stakeholders from business, communities and other organisations (Healey, 2004; Stoker, 2008). It also includes the norms and standards of a society that inform and determine how decisions are made and how resources are allocated. Consequently, value judgements and their resulting impacts on investment choices, social justice and the environment are important and raise issues of accountability, participation and representation (Galaz, Duit, Eckerberg, & Ebbesson, 2010; Goodspeed, 2015; Kemp, Parto, & Gibson, 2005; Lebel et al., 2006).

Governance includes authority and constraint, but can also be generative and creative (Healey, 2004). Pierre, (2005: 452) defines urban governance as the "the pursuit of collective goals through an inclusive strategy of resource mobilisation". Appropriate structures and institutions are required, that can uphold a long-range commitment to resilience and regeneration using appropriate technologies to achieve this goal. As change is an intrinsic element of SES, strengthening the ability of all stakeholders to adapt and innovate and build their resilience is an essential role of governance. In this section we consider principles or policy approaches that can assist a smart city becoming more resilient

1. Smart cities are for people (not only technology)

Cities are created by people for people: technology is a tool to ensure health, safety and liveability of citizens. Consequently, technology should be used to enhance the quality of life of all residents. Connectivity does not necessarily equate with inclusion, particularly in environments where not all residents are literate or can afford the hardware required to access a city's e-services (Odendaal, 2003). Furthermore, smart cities cannot rely on private companies to meet all needs as they may not have the necessary local knowledge, or it may not be profitable for them. In such circumstances, the onus is on local government to find innovative ways of serving poor and marginalised citizens.

Smart, sustainable and resilient cities involve their residents in participatory planning and inclusive decision-making. This promotes commitment to the proposals as well as enriching their experiences and encouraging stakeholders and citizens to creatively solve their problems (Kemp et al., 2005; Kummitha & Crutzen, 2017; Lebel et al., 2006). Technology can be useful in collaborative planning, using social media and through improved methods of data sharing (Brabham, 2009; Goodspeed, 2015; Silva, 2013).

2. Social inclusion

Smart cities not only include smart people, but others who have not had the opportunity to learn the skills and knowledge valued in technically advanced cities. Research conducted by Baud et al, (2014) in the global South indicates that the application of ICT and knowledge management focussed more on the middle class but excluded the poor. "The ICT-based perspective, before it is adopted more universally, needs to address questions about how ICTs negotiate between social realities and the utopian promises of achieving an inclusive social order" (Kummitha & Crutzen, 2017:46). It is therefore essential that smart, resilient cities acknowledge crucial social issues such as housing and essential services, to ensure that they do not become more unequal which entails negotiating between the requirements of business, government and social needs.

3. Sustainability and regenerative development

An unsustainable city cannot be smart; hence, smart, resilience cities should strive to be sustainable and regenerative (Du Plessis, 2012; Kemp et al., 2005). Smart technology can play an important role in conserving resources, reducing greenhouse gasses and increasing the efficiency. Furthermore, the innovation and creativity associated with smart cities can develop novel ways of dealing with challenges (Bibri & Krogstie, 2017; De Jong, Joss, Schraven, Zhan, & Weijnen, 2015). Critically, sustainable development must address social issues of equity and economic opportunity (Jabareen, 2008).

4. Learning, foresight and planning in the context of complexity

Innovation and learning contribute to resilience, while systems are at their most resilient where there is flexibility and creativity (Holling, 2001; Trembaczowski, 2012). Acknowledging uncertainty and the reality of change is crucial, given the nature of urban challenges, the volatility of financial markets and unpredictability of climate change (Jabareen, 2013). Knowledge systems and artificial intelligence can contribute to prediction and appropriate planning to enhance sustainability, improve resilience and prevent disasters.

Accepting complexity and uncertainty implies new ways of planning and governance, where the focus of control should only be on the critical, permitting emergence of new self-organised social and governance structures. Where possible, self-regulation should be encouraged. Control must be balanced to permit flexibility, adaptability and transformation to a desired situation (Meerow et al., 2016).

5. Managing vulnerabilities

Smart cities need to manage their vulnerabilities. Besides the risks related to natural disasters, economic vagaries and social calamities that must be avoided or mitigated, there are also risks pertaining to smart cities. Hyper-efficiencies can lead to the loss of redundancy and thus resilience. Heavy reliance on ITC and connectivity rather than paper-based information (e.g. transport time-tables, maps and books) can leave people stranded if the system is unavailable for any reason (Yigitcanlar & Kamruzzaman, 2018). Moreover, the ability to restore infrastructure and services rapidly after disruptions, manmade or natural is critical in a smart city. Foresight and planning are pertinent in this regard. Additionally, the fear of "surveillance, technocratic and corporate forms of governance, technological lock-ins, profiling and social sorting, anticipatory governance, control creep, the hollowing out of state" (Kitchin, 2015: 132) must be managed. Collaborative planning and participatory, accountable governance are suggested as a means of reducing citizens' concerns.

4. Conclusion

Although there is a significant literature on smart cities and sustainable cities, as well as sustainable smart cities, there is very little literature on resilient, smart cities. This paper has made a small contribution to filling this gap. We have briefly described resilience and the building blocks for developing resilience and explained them in relation to smart cities. Building on this understanding of resilience we suggest five principles that can contribute to the sound governance of resilient smart cities. However, there are still many avenues of research open around the building of resilience in smart cities. These include the design of the urban form, the infrastructure and buildings for robustness, and the ability to restore ecological infrastructure, support greater inclusion and equity of access to the city as well and a prosperous and healthy economy.

5. References

Ahern, J. (2011). From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. *Landscape and Urban Planning at 100*, *100*(4), 341–343.

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities*, *60*, 234–245.

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10/gcv8xx

Barnes, A., & Nel, V. (2017). Putting Spatial Resilience into Practice. *Urban Forum*, *28*(2), 219–232.

Baron, M. (2012). Do we need smart cities for resilience. *Journal of Economics & Management*, *10*, 32–46.

Batty, M. (2013). *The new science of cities*. Cambridge, Massachusetts: Cambridge, Massachusetts : MIT Press.

Baud, I., Scott, D., Pfeffer, K., Sydenstricker-Neto, J., & Denis, E. (2014). Digital and spatial knowledge management in urban governance: Emerging issues in India, Brazil, South Africa, and Peru. *Habitat International*, *44*, 501–509.

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society*, *31*, 183–212.

Brabham, D. C. (2009). Crowdsourcing the Public Participation Process for Planning Projects. *Planning Theory*, *8*(3), 242–262. https://doi.org/10.1177/1473095209104824

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? *Ecosystems*, *4*(8), 765–781.

Cilliers, P. (2002). Complexity and postmodernism: Understanding complex systems. Routledge.

Coaffee, J., & Lee, P. (2016). Urban resilience: Planning for risk, crisis and uncertainty. Palgrave.

Cumming, G. S., Wilson, J., Walker, B., & Ostrom, E. (2008). Diversity and Resilience of Social-Ecological Systems. In J. Norberg & G. S. Cumming (Eds.), *Complexity theory for a sustainable future* (pp. 46–80). New York: Columbia University Press.

De Jong, M., Joss, S., Schraven, D., Zhan, C., & Weijnen, M. (2015). Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production*, *109*, 25–38.

Du Plessis, C. (2012). Towards a regenerative paradigm for the built environment. *Building Research & Information*, *40*(1), 7–22.

Elmqvist, T., Barnett, G., & Wilkinson, C. (2014). Exploring urban sustainability and resilience. In L. Pearson, P. Newton, & P. Roberts (Eds.), *Resilient Sustainable Cities* (pp. 19–28). New York: Routledge.

Eraydin, A., & Taşan-Kok, T. (2013). Introduction: Resilience Thinking in Urban Planning. In A. Eraydin & T. Taşan-Kok (Eds.), *Resilience Thinking in Urban Planning* (pp. 1–16). Dordrecht: Springer.

Eskom. (n.d.). What is loadshedding. Retrieved from http://loadshedding.eskom.co.za/LoadShedding/Description

Ferreira, A. (2016). *Exploring The Meaning Of Functional And Response Diversity In The Urban Context* (Masters Dissertation). University of Pretoria, Pretoria.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Resilience, Vulnerability, and Adaptation: A Cross-Cutting Theme of the International Human Dimensions Programme on Global Environmental Change Resilience, Vulnerability, and Adaptation: A Cross-Cutting Theme of the International Human Dimensions Programme on Global Environmental Change, 16(3), 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002

Folke, Carl, Carpenter, S., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society*, *15*(4).

Galaz, V., Duit, A., Eckerberg, K., & Ebbesson, J. (2010). Special Issue: Governance, complexity and resilience. *Global Environmental Change*, *20*(3), 363–422.

Gao, H., Barbier, G., Goolsby, R., & Zeng, D. (2011). *Harnessing the crowdsourcing power of social media for disaster relief*. Arizona State Univ Tempe.

Goodspeed, R. (2015). Smart cities: moving beyond urban cybernetics to tackle wicked problems. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 79–92. https://doi.org/10.1093/cjres/rsu013

Gunderson, Lance H, & Holling, C. S. (2002). Panarchy: understanding transformations in human and natural systems. Island press.

Gunderson, L.H., & Holling, C. S. (2001). *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press. Retrieved from http://books.google.co.za/books?id=DHcjtSM5TogC

Hassler, U., & Kohler, N. (2014). Resilience in the built environment. *Building Research & Information*, *42*(2), 119–129. https://doi.org/10/gd9bct

Healey, P. (2004). Creativity and urban governance. *Policy Studies*, *25*(2), 87–102. https://doi.org/10.1080/0144287042000262189

Holland, J. (1996). *Hidden Order: How Adaptation Builds Complexity*. Basic Books. Retrieved from http://books.google.co.za/books?id=3eDOuA5pHDoC

Holland, John. (1998). *Emergence: From Chaos to Order*. New York: Basic/Helix.

Holling. (1986). The Resilience of Terrestrial Ecosystems: Local Surprise and Global Change. In W. C. Clark & R. E. Munn (Eds.), *Sustainable Development of the Biosphere* (pp. 292–317). Cambridge: Cambridge University Press.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, *4*(5), 390–405.

Jabareen, Y. (2008). A new conceptual framework for sustainable development. *Environment, Development and Sustainability*, *10*(2), 179–192.

Jabareen, Y. (2013). Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk. *Cities*, *31*, 220–229.

Kemp, R., Parto, S., & Gibson, R. B. (2005). Governance for sustainable development: moving from theory to practice. *International Journal of Sustainable Development*, *8*(1–2), 12–30.

Kitchin, R. (2015). Making sense of smart cities: addressing present shortcomings. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 131–136.

Kummitha, R. K. R., & Crutzen, N. (2017). How do we understand smart cities? An evolutionary perspective. *Cities*, *67*, 43–52.

Lebel, L., Anderies, J. M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T. P., & Wilson, J. (2006). Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society*, *11*(1).

Lu, P., & Stead, D. (2013). Understanding the notion of resilience in spatial planning: A case study of Rotterdam, The Netherlands. *Cities*, *35*, 200–212.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49.

Mora, L., Bolici, R., & Deakin, M. (2017). The First Two Decades of Smart-City Research: A Bibliometric Analysis. *Journal of Urban Technology*, *24*(1), 3–27. https://doi.org/10.1080/10630732.2017.1285123

Odendaal, N. (2003). Information and communication technology and local governance: understanding the difference between cities in developed and emerging economies. *Computers, Environment and Urban Systems*, *27*(6), 585–607.

Page, S. E. (2010). *Diversity and complexity*. Princeton University Press.

Peres, E, Landman, K., & du Plessis, C. (2016). Unpacking a sustainable and resilient future for Tshwane. Presented at the Urban Transitions Global Summit, Shanghai, China: Procedia Engineering (under review).

Peres, Edna. (2016). *The translation of ecological resilience theory into urban systems* (Thesis (PhD)). University of Pretoria, Pretoria. Retrieved from http://hdl.handle.net/2263/56100

Pierre, J. (2005). Comparative Urban Governance: Uncovering Complex Causalities. *Urban Affairs Review*, *40*(4), 446–462.

Salat, S. (2011). *Cities and forms on sustainable urbanism*. Hermann: CSTB Urban Morphology Laboratory.

Salat, S. (2017). A systemic approach of urban resilience: power laws and urban growth patterns. *International Journal of Urban Sustainable Development*, *9*(2), 107–135.

Salat, S, & Bourdic, L. (2012). Systemic resilience of complex urban systems. *TeMA-Trimestrale Del Laboratorio Territorio Mobilità e Ambiente-TeMALab*, *5*(2), 55–68.

Silva, C. N. (2013). Citizen E-Participation in Urban Governance: Crowdsourcing and Collaborative Creativity: Crowdsourcing and Collaborative Creativity. IGI Global.

Simone, A. (2004). People as infrastructure: intersecting fragments in Johannesburg. *Public Culture*, *16*(3), 407–429.

Simone, A. (2010). City life from Jakarta to Dakar: movements at the crossroads. Routledge.

Stoker, G. (2008). Governance as theory: five propositions. *International Social Science Journal*, *50*(155), 17–28. https://doi.org/10.1111/1468-2451.00106

Trembaczowski, Ł. (2012). Learning regions as driving forces for urban economic resilience–Two subregional examples of post-industrial city transition. *Journal of Economics & Management/University of Economics in Katowice*, *10*, 137–150.

United Nations and Asian Development Bank. (2012). *Green Growth, Resources and Resilience: Environmental Sustainability in Asia and the Pacific*. Bangkok: United Nations and Asian Development Bank.

Walker, B., & Salt, D. (2012). Resilience thinking: sustaining ecosystems and people in a changing world. Island Press.

Yigitcanlar, T., & Kamruzzaman, M. (2018). Does smart city policy lead to sustainability of cities? *Land Use Policy*, *73*, 49–58.

Zhang, X., & Li, H. (2018). Urban resilience and urban sustainability: What we know and what do not know? *Cities*, *72*, 141–148.