The resilient – smart city development: a literature review and novel frameworks exploration

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Abstract

Purpose – This paper aims to develop a framework that could establish and further the terminology of smart city/resilient city discourse in that resilience could support urban "smartness", a term that is widely argued being not easily measured nor quantifiably assessed.

Design/methodology/approach – The qualitative approach was employed, and based on selected keywords, a systematic literature review was carried out to understand the main themes within the smart city and resilient city concepts databases. Upon screening, 86 papers were used and synthesised through the meta-synthesis method using both synthesis approach, meta-aggregation and meta-ethnography that systematically identifies both properties and characteristics, to build an innovative framework as an indicator-based smart/resilience quantification model.

Findings – Two novel frameworks are proposed, smart resilient city (SRC) and resilient smart city (RSC), as guidelines regulatory that establish a city's smartness and resilience.

Research limitations/implications – The quantitative research phase is not provided as the framework builds on the exploratory approach in which the model is proposed through the postulation of data definitions.

Practical implications – Although the study's scope was limited to the city, proposed frameworks may be interpreted for other contexts that deal with the topic of resilience and smart.

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Originality/value – The established framework proposal would encourage further exploration in context, serving as an inspiration for other scholars, decision-makers, as well as municipalities to keep strengthening smart city through resilience factors.

Keywords Smart city, Resilient city, Smart resilient city, Resilient smart city, Conceptual frameworks

Paper type Research paper

1. Introduction

City growth is unprecedented in human history that plays central governance in the world's economy and most of our existence's social facets to the degree that it contributes to the pressing impact on the environment (Mori and Christodoulou, 2012). In 2005, the concentrated population in cities reached 3.2 billion. The total urban population exceeding 50% marked a significant development in human settlement history (UN, 2008). In line with this trend, our planet is expected to mass migrate from rural areas, spiking an increase of five billion human settlers, further increasing human growth at around 1.8% per annum (Bassi, 2017). This widens the range and complexity of citizens' demands, and environmental issues require a change to new and more effective ways of maintaining urban areas (Sharifi, 2019). Solutions for such urban issues have encouraged interest in technology as one of the solutions for urban growth through its technological potential in handling urban services that also enhance the quality of urban livelihood (Harrison *et al.*, 2010).

Consequently, the rollout of technology has highlighted the possible urban gain through smart cities, a contemporary urban development and a planning concept (Angelidou, 2014; Kitchin, 2014). As a result, cities all over the world are progressively dependent on information and communication technologies (ICTs) to build up smart solutions to improve the efficiency and effectiveness of service delivery and management (Angelidou, 2015; Sharifi, 2019; Huovila *et al.*, 2019). Scientists believe that the use of ICT is the central aspect of a smart city, whereas its concept is still being developed (Lim *et al.*, 2019; Anthopoulos, 2015). The central idea of the smart city is innovation through ICT's application that would revolutionise and rewire the traditional ways of managing urban systems by ways of technologically enhancing urban infrastructures, improve the quality of life and is solvent for sustainability issues (Vanolo, 2016; Edge *et al.*, 2020). Scholars expect that by 2025, the number of smart cities all around the globe will climb from 21 in 2013 up to 88 (Council, 2015).

Meanwhile, concepts of resilience accompany the rise of smart city ideologies (Medd and Marvin, 2005; Birkmann, 2007; Leitner *et al.*, 2018; Odiase *et al.*, 2020b; Sweya and Wilkinson, 2020; Pelling, 2003). About 2,100 cities all over the world have joined the "Making Cities Resilient" initiative, launched in 2010 (Unisdr, 2012), and, in December 2014, through the Rockefeller Foundation Initiative, 100 cities were selected for the "100 Resilient Cities Challenge" (Rockefellerfoundation, 2015). While the smart city concept relies on the rollout of technology to improve urban standards, the idea of resilience prepares the city against any catastrophic events allowing it to absorb, adapt and transform external pressures to guarantee public safety (Rus *et al.*, 2018). Smart city and urban resilience are both contemporary concepts that evolved as solutions to further sustain urban livelihood by offering strategic solutions against arising urban issues from population growth and human activities. However, despite their everyday use in the urban discourse, there is a lack of shared interpretations that concisely capture each of these definitions. The connotation being that neither smartness nor resilience has been formalised (Negre *et al.*, 2015; Albino *et al.*, 2015). However, an agreed notion is that a smart city is prepared to remain resilient at all times to deal with unexpected predicaments, like disasters (Seta *et al.*, 2015). Hence, Baron (2012) tried to conceptualise the relationship between theory and concept of smart city and resilience. Papa *et al.* (2015) also looked at the synergies and inconsistencies between the smart city concept and resilience city through the identification of critical characteristics of the smart

city and urban resilient systems. The resilience city model is expected to serve as an invaluable framework for planners and decision-makers in strengthening the capacity of responses from complex urban systems in mitigating climate change. However, Viitanen and Kingston (2014) criticised smart cities as profiteering from green concepts to achieve resiliency, marketed by big companies through public and private partnerships. The authors argued that it might result in dubious decisions that profit technology rollout, but the city may not necessarily be resilient in facing climatic concerns at the urban level.

Because urban smartness and its resilience are still vague concepts, this study aims to develop a framework that can significantly define smart and resilient city characteristics to address urban issues in a comprehensive approach.

The research is first structured to define both smart and resilient terminologies for city development to determine the similarities that the study can hinge on to further the discourse in understanding "resilience" that can support urban "smartness" concepts. The characteristics of both concepts are unpacked, first by using the smart city wheel by Cohen (2013) for the smart city, while the resilience concept adapts Bruneau *et al.* (2003) study. These characteristics are translated into building a framework to measure the concepts simultaneously. Since the literature showed that these city concepts are interchangeable, two new frameworks are proposed and discussed:

(1) Smart resilient city conceptual framework (SRCCF); and

(2) Resilient smart city conceptual framework (RSCCF).

Therefore, the study uses both meta-synthesis approaches to develop a significant model that answers the essential qualification for both smart and resilience characteristics.

2. Methodology

This study uses a systematic literature review methodology by sampling Tranfield *et al.* (2003), who developed evidence-informed management knowledge. The method integrates in-depth data presentation of researched concepts (Perry, 2000). The first stage of the systematic review process involves the identification of research papers and reports that were broadly concerned with smart cities and urban resilience concepts. After an initial survey of related articles and references, appropriate electronic databases and websites were selected for this purpose, extending to Scopus, Science Direct (Elsevier) and Web of Science. To assess the relevance and size of the literature, the scope of the literature review process was filtered through keywords and the quality of the research sources. The search included full-text articles from the past ten years that focused on "smart and resilient city" topics. A combination of three keywords was used to form a search string. All searches, therefore, included the key terms "smart", "resilient" and "city" in the publication titles. The initial search acquired 86 articles. Screening of relevant articles was executed to ascertain whether the documents were likely to meet pre-determined inclusion and exclusion criteria.

The inclusion criteria included:

(1) Published papers/articles from 2000;

(2) Papers/articles in the English language;

(3) Papers/articles that specifically address smart AND resilient cities;

(4) Papers/articles with empirical and non-empirical evidence; and

(5) Scholarly and non-scholarly papers/articles.

In addition, the following exclusion criteria were applied:

(1) Papers/articles published in magazines and newspapers; and

(2) Papers/articles that only provide a review of a conference.

Table 1 summarises the screening and review process of the search results.

The 86 papers are then synthesised using narrative or qualitative techniques to summarise the earlier descriptive qualitative analysis (Arafah and Winarso, 2017) using meta-synthesis. Research utilising a meta-synthesis uses two methods, i.e. meta-aggregation and meta-ethnography (Lewin, 2008). Meta-aggregation synthesises the collected data, while meta-ethnography aims to establish a new theory to add value (Arafah and Winarso, 2017). The study, therefore, synthesises using meta-ethnography, as the approach is focused on generating new theoretical frameworks from the primary research rather than just "aggregating" knowledge (Lockwood *et al.*, 2019). There are five steps taken after the systematic review process: (1) rereading the findings, (2) determining how the concepts are related, (3) translating the studies into one another, (4) synthesising the translations, (5) expressing the synthesis. It also uses the meta-aggregation method to "aggregate" various studies with the same theme in defining (1) terminology of smart and resilience city concept and (2) characteristics of both cities in relevant literature findings.

Meta-aggregation is used to build characteristics from synthesised data into smart or resilience, and then the data conceptualise a new model through a meta-ethnography approach.

3. Literature review

3.1 Smart city

The word "smart" of urban terminology began sporadically in the 1990s that began adapting ICTs in modern urban infrastructures. The California Institute for Smart Communities was among the first to concentrate on how societies could become intelligent by way of building a city to incorporate the advancement of information technology (IT) (Alawadhi *et al.*, 2012). Following the early conception, the University of Ottawa Governance Centre began to critique smart cities' concept as too technologically driven (Albino *et al.*, 2015). However, researchers recently started to recognise the different aspects of smart city (Hollands, 2008). Ultimately, the discourse continued to define it in technical perspectives of "information city" and "a digital city" in which ICT is the key driver for the urban revolutionary electronic services (Chourabi *et al.*, 2012). Meanwhile, Yovanof and Hazapis (2009) opined that a "digital city" is a community that connects through communication infrastructures with creative-oriented services that are enhanced through digital delivery and are based in open networking South Korea developed a u-City that is managed through a digital network and services to its equally digitally connected community (Lee *et al.*, 2013; Park *et al.*, 2010). This example suggests that a smart city is developed on ideals previously established through urban digitalism and ubiquitous data already accessible in the city infrastructure. Lee *et al.* (2008) stressed that the concept of the u-City is actually a fusion of urban IT infrastructure, available regardless of time and place. Initially, the idea of an "intelligent city" accomplished by technology was intended to lead to

Table 1. Summary of the screening and reviewing process

Screening and review process	Search results
Initial search	86
Duplicate removal	63
Abstract screening	48
Full-text screening	32
Final in-depth review	12

a significant, structural shift in the nature of city life and function, rather than a place for small incremental changes that are mostly packaged as smart city concepts (Komninos and Sefertzi, 2009). In 2010, there has been an increase in scholarly discourse since the European Union started to use the "smart" term to outline sustainable developments in the context of ecological maintenance (Dameri, 2013). Innovative technology is fundamental to the smart city, which places the idea as similar to the "knowledge city", which encourages knowledge nurture. This exploration has shown that the definition of the contemporary smart city originates directly from different points of view catalyst from "information city" perspectives. Nevertheless, the term has gradually evolved into a techno-centric city idealising ICT performance. Since its evolution, there is no apparent theoretical framework that constitutes the basic definition of the smart city concept (Dameri, 2013). Consequently, Nam and Pardo (2011) argued there are several smart city theoretical variants and were able to recognise three key factors, namely, (1) technology (hardware and software facilities), (2) citizens (creative, multicultural, educational) and (3) institutions (governance and policy). Additionally, the smart city, as posited by Bakıcı *et al.* (2013), is an active and advanced high-tech city that brings its inhabitants' knowledge and elements of the city together by using innovative technologies. This development creates a sustainable, safer environment, improves efficiency that would further attract creative businesses and eventually promotes a higher quality of life. Barrionuevo *et al.* (2012) emphasise that being a smart city necessitates the intelligent and organised use of all available technology and resources to create urban centres that are interconnected, functional and sustainable at once. The smart city develops digitised infrastructures to boost city services, promotes flexibility, competent delivery, improve energetic consumption of resources (Nam and Pardo, 2011). Also, Harrison *et al.* (2010) identified the smart city as instrumented towards smart interconnectivity that can collect, as well as incorporate live real-world data through devices, detectors, applications and smart devices. "Interconnectivity" means that these data integrates into a computational service that allows such data communication between the various city networks. "Intelligent" refers to the use of advanced analysis, simulation, computation and design services to make better functional judgements. Public sectors and institutional organisations then echo their conception of smart cities. Barcelona City Hall terms it as an "intensive and advanced high-tech city that connects people, data and urban elements using new technologies to build [a] sustainable greener city, efficient and creative exchange and eventually life's betterment" (Bakıcı *et al.*, 2013). Meanwhile, Amsterdam City Hall conceptualised it as "innovative-technology" city that tackles energy consumption through behavioural change towards meeting climate goals (Lee *et al.*, 2014). It is evident that, although "smart city" is the umbrella term consistently used in contemporary discourse to label all positive techno-centric possibilities, however, the concise and consistent definition still alludes its concept. The main characteristic of a smart city with updated concepts reached from synthesising literature reviews are identified as below:

(1) Information System (IS)-centric urban management with Information and Communication Technology (ICT) usage within an interconnected network to provide advanced and creative services to its people, improving the quality of life and sustainable natural resource management (Ismagilova *et al.*, 2019).

(2) An efficiently managed city with systematic ICT enhancement such as sensors, intensification of camera surveillance and digital information platform (Komninos and Mora, 2018).

(3) Knowledge enhanced city with innovative and creative-driven community, knowledge-building institutions, enhanced digital networking and knowledge management infrastructure (Komninos, 2011).

3.2 Unpacking a smart city

This research aims to create a framework that connects conceptual variations of the smart city concepts, essential aspects for being smart and tactical principles for improving city management towards smart goals. Therefore, it is imperative to explore smart city components to compare their similarities to develop its definition.

First of all, Jucevičius *et al.* (2014) clarified that city systems have three main types: (1) services systems, (2) city user systems and (3) city infrastructure systems. The digitisation and interconnection of city structures allow people to become more educated in which the level of knowledge will increase, and there will be favourable conditions to a learning community. Henceforth, Giffinger *et al.* (2007) pointed out the concept as having six key "aspects", which are (1) smart economy, (2) smart mobility, (3) smart climate, (4) smart people, (5) smart living and (6) smart governance. Nam and Pardo (2011) presented strategic concepts that fit with smart city's three key dimensions, the primary one being technology, then people and institutions. These dimensions constitute infrastructure convergence and technology-mediated systems, social learning to enhance public infrastructure and organisational development institutions rooted in citizen participation.

Furthermore, Chourabi *et al.* (2012) describe eight critical factors of smart city initiatives based on the analysis of a broad and wide variety of literature from various academic fields. These are the following factors: (1) management and organisation, (2) technology, (3) governance, (4) policy context, (5) people and communities, (6) economy, (7) built infrastructure and (8) natural environment. Lee *et al.* (2014) presented six main theoretical dimensions and 18 sub-dimensions. The six main categories include (1) urban openness, (2) service innovation, (3) partnerships formation, (4) urban proactiveness, (5) smart city infrastructure integration and (6) smart city governance. Therefore, all these exploratory concepts that can illustrate smart city domains is achieved through Cohen (2013) proposal; the Smart City Wheel (Soe, 2017), shown in Figure 1.

The wheel exemplified the idea of the smart city then central outwards to represent its six main components, which are (1) smart environment, (2) smart economy, (3) smart governance, (4) smart people, (5) smart living and (6) smart mobility.

All these elements effectively integrate the components of a city. All smart cities' attempts and aims are to convert the current cities to a better and smarter ones, ideally at a minimum cost and changes. To enable this, the internet of things (IoT), a technological concept attached to big data, is at the centre of attention (Stratigea *et al.*, 2019).

3.3 Resilient city

The word resilience simply means to "bounce back" rooted in a system's ability to return to a normal state after an event occurs, disrupting its former condition (Hosseini *et al.*, 2016). It was C S Holling, who introduced the city concept of resilience in 1973 (Odiase *et al.*, 2020c). Holling (1973) considered the term; "a measure of systems resiliency and their adaptability towards change and disruption while retaining the same relationships between populations or state variables". In specifying the term, The National Science Challenge defines resilience as the capacity to absorb the impact of an adverse occurrence, mitigate negative effects, respond properly following a significant incident. It also preserves or restores performance and adjusts to promote progress or prosperity while minimising future developments' deleterious effects (Stevenson *et al.*, 2015). Meanwhile, Cimellaro *et al.* (2010) provide a structure for the empirical concept of resilience using an analytic method to suit both technological and organisational problems. Some latest definitions for the notion of resilience are as below:

(1) A city's ability, individuals, communities, institutions, businesses and structures to survive, adapt and evolve regardless of the type of chronic stress and acute shocks they face (Spaans and Waterhout, 2017).

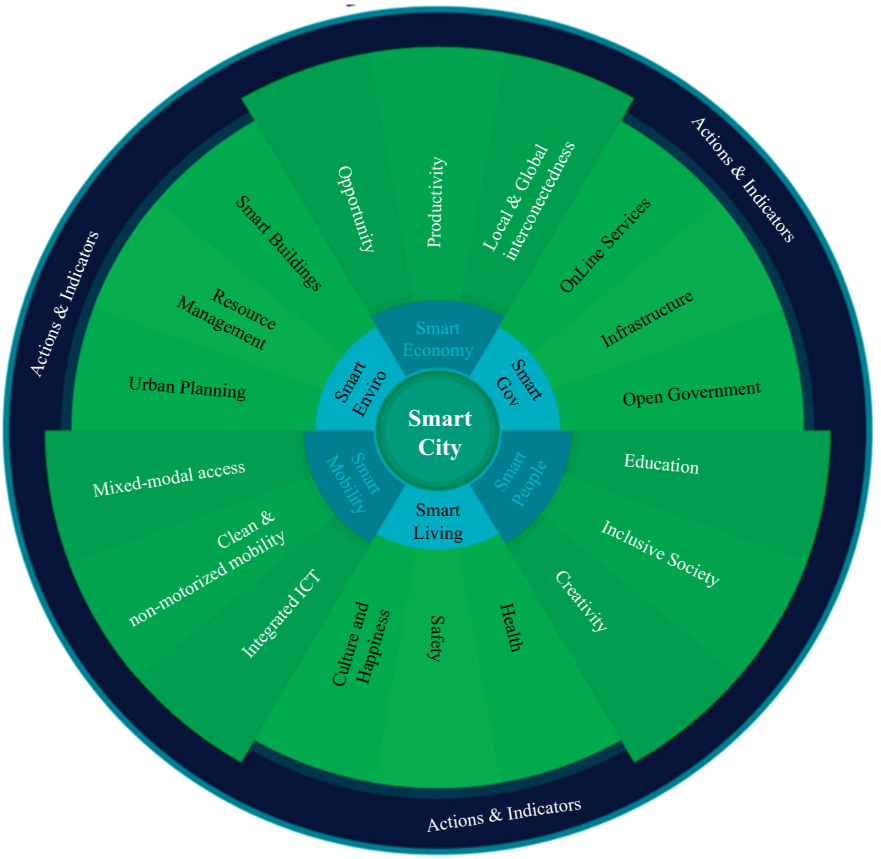

Figure 1.
The Smart City Wheel by Boyd Cohen (Soe, 2017)

(2) An urban environment and all its socio-ecological and socio-technical network's ability to sustain or rapidly recover functionality from disruption, is adaptable, quickly transform structures that constrain current or future adaptive capability (Meerow *et al.*, 2016).

(3) Urban resilience is an ecosystem that supports living conditions and urban health (Mcphearson *et al.*, 2015).

3.4 Unpacking resilience

This paper adopts Allenby and Fink (2005) exploration of resilience to further the urban resilience discourse, in which its definition stems in a system that preserves its functionality and cleanly deteriorates in the context of changes both internally and externally. Before so, Bruneau *et al.* (2003) identified four types of resilience that should be adequately measured: (1) technical, (2) organisational, (3) social and (4) economical (TOSE). Foremost, the technical dimension of resilience refers to physical systems' ability to carry out appropriate/required rates of unacceptable natural catastrophes such as natural disasters. The organisational aspect of resilience relates to organisations' capability to operate essential facilities to conduct crucial crisis-related functions to make choices and necessary measures to maintain

resiliency through dimensions of robustness, redundancy, resourcefulness and rapidity regain a systems' faculty. Meanwhile, the extension of the social aspect of resilience reduces the extent of systems' disruption from unwarranted climatic factors, affecting governmental jurisdictions and communities.

Moreover, economic resiliency is the ability to, directly and indirectly, absorb economic damages resultant from disastrous changes. From the established framework regarding resilience, different metrics quantifying resilience followed and expanded (Bruneau *et al.*, 2003) work further. First of all, Berkes *et al.* (2008) describe resilience as an emergent property that combines several dimensions. Wamsler *et al.* (2013) defined a resilient city as a city that can effectively promote efforts to improve people, societies and organisations. Such a city should: (a) mitigate or prevent future risks, (b) minimise present and future risk resistance, (c) develop disaster response mechanisms and functional structures, and (d) create functional disaster recovery mechanisms and structures. Jabareen (2013) conceptualised an innovative framework known as the Resilient City Planning Framework (RCPF). The framework concerned urban communities' actions towards achieving a state of resiliency soon involving a wide range of stakeholders subjected to a multitude of matters, namely, economic, social, spatial and physical factors. Meanwhile, Cimellaro Gian *et al.* (2016) suggests a novel framework that measures the dimension of resiliency at different scales. He determined seven significant groups of characteristics, which follows: (1) population and demographics, (2) environmental and ecosystem, (3) organised governmental services, (4) physical infrastructure, (5) lifestyle and community competence, (6) economic development and (7) social-cultural capital, making up the acronym PEOPLES. Balaei *et al.* (2018) proposed a novel framework called Comprehensive Aggregated Resilience Estimation (CARE) that identifies the social variables influencing water supply resiliency impacted by disasters through an indicator-based resilience quantification model. In addition to this, Odiase *et al.* (2020c), through their research in Nigeria, created the Community Resilience Index (CRI) that calculates the community resilience status. His study opined that the future resilience of a community is highly dependent on the strategies from the governmental body at community reliance planning. Ribeiro and Pena Jardim Gonçalves (2019), through their scientific and technical reviews of urban resilience, founded resiliency focusing on four fundamental foundations. (1) resistance, (2) recovery, (3) adaptation and transformation, and (4) urban resilience. Such foundations have been examined in several other domains: physical, environmental, cultural, institutional and social. Eleven basic characteristics further support the evaluation tool to regard resilience optimisation; redundancy, variety, flexibility, robustness, interconnectivity, versatility, capital, autonomy, innovation, inclusion, integration, enabling operational and implementable construction.

4. Synthesis

Smart cities and urban resilience are operationalised based on similar or even the same systems, having similar trajectories of development and dilemmas to be solved, i.e. climate change. Both can either be purely technical (core, traditional understanding) or societal (sophisticated, modern understanding). Both of them apply to city users and municipal public services, not to individuals neither dispersed networks (Baron, 2012). Then, the governance for resilient smart city is a topic discussed by Nel and Nel (2019), who propose different principles to link smart and resilient concepts. They consider various approaches that can help the smart city to become more resilient. Since the first smart city project was developed in Los Angeles in the 1970s (Hutchison, 2020), numerous disasters are striking the world; for instance, earthquakes in Iran in December 2003, Indonesia in December 2004, Japan in March 2011, New Zealand in February 2011; floods in North India in June 2013, in Pakistan in 2019, Iran in 2019; and some famous hurricanes like Wilma 2005 and IKE 2008. Also, human-made disasters such as terrorist attack and pandemic diseases like the latest COVID-19 have caused

significant harm to cities. Notably, modern and smart cities like Wuhan, Auckland, London were locked-down due to the pandemic. Such disasters might be anywhere, any time, and smart cities are highly vulnerable. Therefore, smart cities must have a resilient plan as an ability to restore their systems rapidly. In short, resilience refers to the capacity of cities to adapt and bounce back from changes. Therefore, local cities must improve their resiliency as they optimise smart city concepts' potentiality, particularly in risk-averse regions. While natural or human-made disasters are often catastrophic, post-disaster recovery and restoration will offer a prime opportunity for communities to address critical systemic challenges to avoid future damages. Urban resiliency can be accomplished by multiple long-term initiatives or mid- or short-term programmes and task forces, where applicable, assisted by emerging smart city technologies (Baron, 2012).

Conversely, the primary discourse above mainly concerns the connection of both concepts in the context of soft infrastructure in so far that there are few studies done that link the smart city concept and resilience explicitly in the context of disaster with a soft infrastructure approach. Nonetheless, the literature shows considerable efforts have increased to develop a smart and resilient framework to measure its performance; however, most of the existing frameworks and indicator systems focus on one significant notion, either resilience or smart, as indicated in Table 2.

In summary, these frameworks address urgent urban issues that can potentially converge as both of the conceptual approaches of smart city and resilient city are run based on similar systems or structures, with near developmental trajectories while addressing similar dilemmas to be resolved.

This paper will further explore a new approach to add discussion focusing on two different concepts. Through the experimental method, the authors believe that RSC and SRC are two various frameworks with a different mission, depending on which theory preceded the other within the compositional narrative.

(1) As a smart city, it is vital to provide the resilience infrastructure for it (Abreu *et al.*, 2017; Yoon, 2016; Zhu *et al.*, 2019; De Falco *et al.*, 2019; Haarstad and Wathne, 2019), sufficing resilient smart city (Zhu *et al.*, 2019).

(2) When the city is already known as a resilient city, it then eventually needs the infrastructure for being smart as well (Baron, 2012; Roggema, 2020; Yun *et al.*, 2020). By providing the smart foundations for a resilient city, it is then termed as SRC.

By establishing this symbiotic relationship, both the RSC and SRC are defined, by which two initial, conceptual and innovative frameworks are proposed. The novelty of these frameworks is focusing on the current status of the city. If the city is smart, the RSC framework confirms the city's smartness and evaluates it for the resilience notion. The same scenario with SRC. The current resiliency status is verified, and the city will be assessed for smart properties.

The proposed frameworks will help researchers, decision-makers and government to identify whether a smart city is resilient or a resilient city is smart to achieve the contemporary development agenda of cities framework. Then, urban optimisation that caters to both techno-centrism (smart) and resilience (sustainability) is achieved. At the very least, these proposed frameworks would catalyst further discourse of smart city terminologies that is still evidently ambiguous.

4.1 Resilient smart city conceptual framework (RSCCF)

Primarily, the smart city provides all the necessary infrastructures to make it resilient, which is the study's main criteria. Through this viewpoint, RSC means a city that is conceptualised

Table 2.
Samples of established smart city and resilient city indicator systems (Khatibi *et al.*, 2021)

Frameworks		Key indicators											
		Economy	People	Governance	Mobility	Living	Environment	Society	Culture	ICT	Institutional	Recovery	Infrastructure
Smart city	UCLG	✓	✓	✓	✓	✓	✓	✓					
	MSC-EU	✓	✓	✓	✓	✓	✓	✓					
	Boyd-Cohen	✓	✓	✓	✓	✓	✓	✓					
	UNECE–ITU	✓						✓	✓				✓
	City-IQ	✓		✓	✓		✓			✓			
Resilient city	PEOPLES	✓	✓			✓	✓	✓			✓		✓
	Hyogo			✓				✓			✓	✓	✓
	USAID		✓	✓	✓		✓	✓	✓			✓	✓
	NIST	✓	✓			✓	✓	✓	✓			✓	✓
	UNISDR	✓		✓							✓	✓	✓

through technological means of the smart city is smart when it is structured to be resilient as well. The authors define RSC as below:

The city is expected to be RSC when it is based on ICT-centric infrastructures, sensors and intelligent devices to improve all the aspect of human lives at the urban level. Resilient smart is achieved through its components' ability to maintain its system and all its data in-store to recover and return quickly to its optimal functions when faced with a disturbance that could potentially threaten urban livelihood.

The proposed framework is composed of two main parts, which are illustrated in Figure 2. The smartness of a city is confirmed in the first part of the framework. The second part of the framework starts to work when the smartness of the city is approved. This part aims to identify the resilience of the smart city. By way of explanation, the smart city is examined for resilience characteristics that were established in Table 2 discussed above. Therefore, the suggested framework firstly tries to identify the smart city, and secondly, to label it as RSC through the measurement of resilience properties.

The starting point of the framework is evaluating a city from the evaluation of characteristics that make it smart and rank it as a smart city. The initial framework is focused on the whole idea and describes the framework in general. According to the novel framework, if the measurement results show that the city is not qualified to be a smart one, then enhancement methods will be implemented. This stage may be used to re-evaluate the current "smart cities" as well to make sure that the city is still smart since technology and ICT are improving rapidly. Suppose the city smartness stands in the acceptable range. In that case, the city can be categorised as a smart city, and the next round of the framework is activated, wherein the resilience of the established smart city is then measured through an indicator-based resilience quantification model. As the title of this framework has indicated, the goal is to make the smart city resilient, or in other words, the conclusion reached would be RSC. If the resilience of the smart city can qualify the standards of the framework, the city is then quantified as the model RSC. Otherwise, the smart city is considered as (none) resilient city by easing it to recognise properties for future enhancement in its resilience infrastructure.

4.2 Smart resilient city conceptual framework (SRCCF)

The main idea of SRC is that an established resilient city has the potentials to be smart as well. Through the establishment of resilience characteristic reached in literature review and further drawing upon Holling's theory in 1973, this study quantifies SRC as defined below:

The city is termed as smart resilient city when it is able:

(1) To warn against disruption;

(2) To predict the type of disruption;

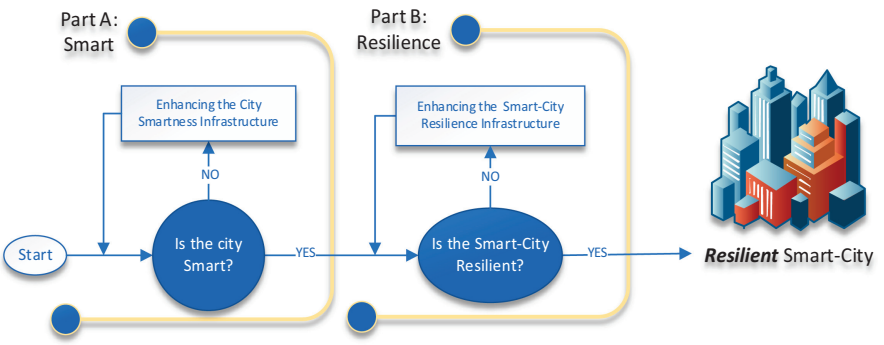

Figure 2.
RSCCF

(3) To choose the best method to absorb the disruption;

(4) To take the fast, economic and straightforward recovery plan; and

(5) To select the best technic to bounce back better.

By taking advantage of intelligent devices, sensors, real-time data and ICT integration that is the foundation of smart city framework of reference, its resiliency should also be integrated to optimise urban livelihood towards all human aspects. All systems within the urban structure are resilient to avoid degeneration and can meet challenges of urban sustainability.

The framework may be used to measure conventional cities that as yet non-smart and non-resilient city as well. In the first stage, the framework makes the city qualify for being resilient right after the smartness evaluation; the determined, resilient city could then be established. If the city satisfies the specification of resiliency characteristics, later it is identified as a resilient city whereby the second phase of the framework could be measured. If the municipality then passes the evaluation process to determine technological smartness, then the resilient city is smart; similarly, it can then be labelled as SRC. Figure 3 shows the overall view of the proposed SRC conceptual framework. The framework may also be used as standards for current resilient cities to re-evaluate their resilience index. The first part of the framework may help the decision-makers update the city resilience features and ensure that the city is resilient by satisfying the latest methods and resilience indicators. As soon as the city's resilience is confirmed, the second part of the framework to qualify its smartness would then undergo smart characterisation identification. This initial framework is focused on the exploratory idea to establish the general framework descriptions.

5. Conclusions

Given the development of the smart city in the urban discourse, the resilience city concept is gaining momentum before its introduction in 1973 by Holling to supplicate the hollowness of smart city techno-centric conception. However, the resiliency concept is implemented in a broad spectrum, is still in progress and not univocal, especially when it comes to specifying sectors such as urban (Sweya *et al.*, 2018; Odiase *et al.*, 2020a). Similarly, the smart city is not a new concept despite its current marketability, as, throughout times, society has always shaped its cities through appropriate and most available technologies.

In summary, through its methodology, this paper introduced two frameworks, in which the first novel framework is RSC, where smart city model is made resilient. The second model,

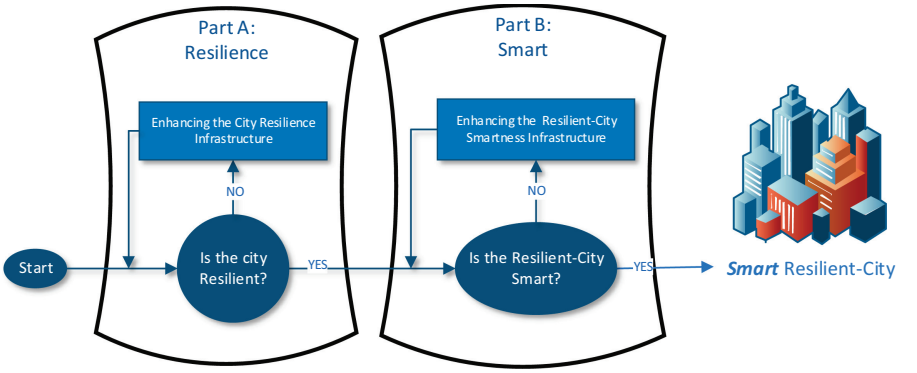

Figure 3.
Proposed SRCCF

SRC, is a resilient city made smart. Both frameworks are cyclic in conception wherein traditional city framework could reach these potential innovative urban concepts, whereby smart and resilience crutches each other and further galvanised its sustainable design.

These frameworks assist the experts in labelling cities as:

(1) Smart city;

(2) Resilient city;

(3) Smart resilient city; and

(4) Resilient smart city.

The SRCCF and RSCCF ease the proses for relevant stakeholders and city administrators to successfully manage and identify the level of smart and resilience determinants that will simultaneously provide ways to improve the city's infrastructure to meet smart and resilient objectives. These frameworks are a proponent of the top-down approach that will enable a city administrator to measure resiliency and smartness. It then can address issues to achieve the desired state of smart and resiliency targeted by a particular region, in the best interests of all stakeholders involved and governing bodies. Hence, the novel framework proposed can reassess current smart city or resilient city concepts from a revised and updated indicators bank. The resulting assessment may indicate that the city evaluated does not meet the smart or resilient indicator standards by which city planners can be informed to improve the infrastructure standards accordingly (Figure 4).

Due to smart city concepts' ambiguous nature, these frameworks may define their core concepts better that update city database concurrent to rapid improvement in the smart and resilience-building industry. These novel approaches amalgamate these broads concepts of urban planning towards recognising its critical characteristics in more concise terms for innovative urban initiatives to be developed in standardised vision. Therefore, the frameworks would help local management practices and stakeholders evaluate a city's smartness and resilience in all dimensions and domains to strengthen urban sustainability efforts.

The frameworks may assist other scholars or city planners to assess the smartness of a resilient city. Likewise, if a smart city is under the evaluation for resilience notion, then the framework is used for making the smart city resilient. The system is used for a typical city that can develop towards smart and resilient objectives. The proposed frameworks can evaluate a city and identify the necessary changes or enhancement to convert the non-smart and non-resilient cities into smart and resilient ones. Stakeholders may begin to formulate cities' strategies and action to be somewhere "half-way" towards smartness or resilience to find out whether these strategic orientations are important to them and the expected trajectories of development (Baron, 2012). The research paper's schematic idea to develop the frameworks for urban administration to operationalise their target development at different scales, comparing urbanised territories in regions and cities according to the broader scope of the needed area of background study so that sustainable objectives may be targeted systematically.

6. Limitation and recommendations

One inherent limitation relates to the area of study in which authors have focused on the smart and resilient notion in urban concept. Research recognises this paper exploration on soft infrastructure approach; thereby, the authors maintain these frameworks are novel proposals as preparatory guidelines for future studies. The other limitation is that detailed measurement procedures are out of this study's scope as it is exploratory in method to define

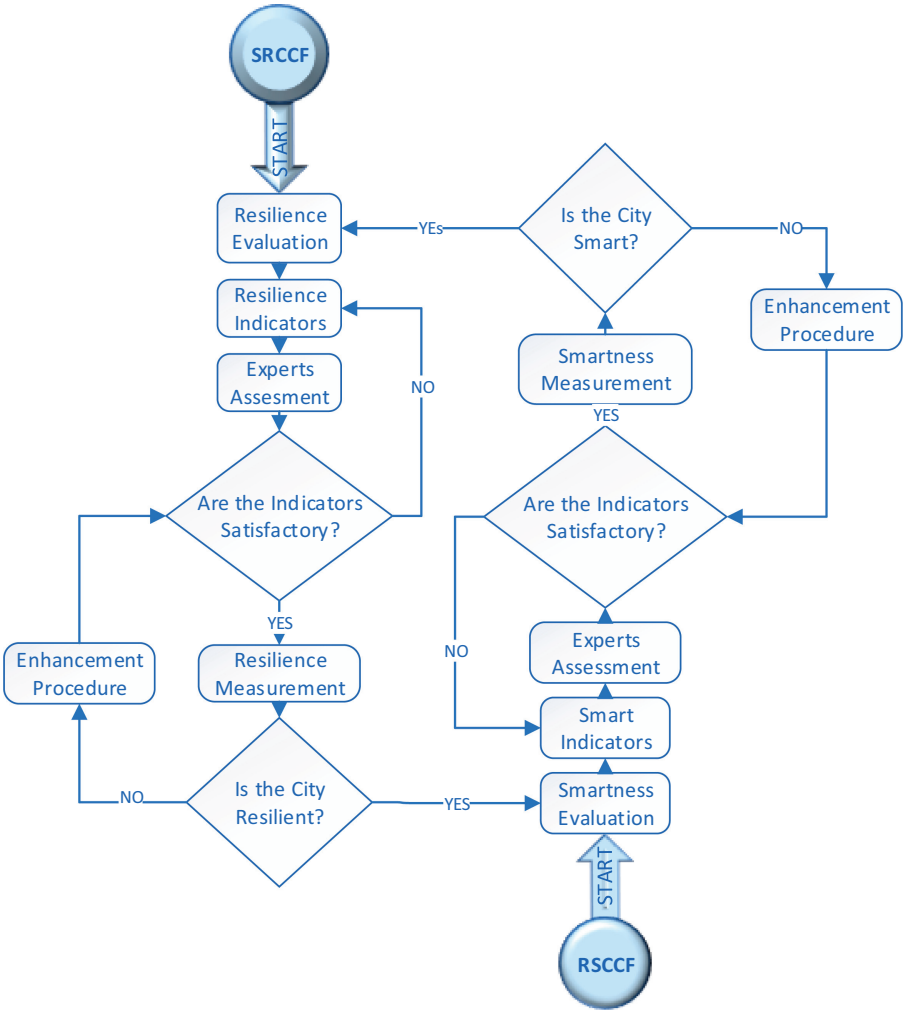

Figure 4.
Performance assessment towards SRCCF and RSCCF

concepts. Further research on developing these two frameworks is necessary and utmost recommended. The frameworks can be expanded in detail with the output that would satisfy both SRC and RSC index, respectively.

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