sustainability

MDPI

Review

Characterising Smartness to Make Smart Cities Resilient

Aravindi Samarakkody *, Dilanthi Amaratunga and Richard Haigh

Department of Biological and Geographical Sciences, University of Huddersfield, Huddersfield HD1 3DH, UK
* Correspondence: aravindi.samarakkody@hud.ac.uk

Abstract: In broader terms, a Smart City improves the quality of life of its citizens through the effective use of innovative (digital) solutions. While innovative Smart City solutions keep growing, attention has been paid to resilience-making within Smart Cities, recognising that disasters are unavoidable. In light of the characteristics of a Smart City (smartness requirements) being inchoate and vague, different Smart Cities develop their own smartness criteria. Regardless of the Smart City type, smartness criteria need to adequately embed resilience. Integrating the resilience concept provides a strategic direction for Smart Cities and there is a significant positive relationship between the two concepts, Smart Cities, and urban resilience. Although Smart Cities are increasingly growing in popularity all around the world, there is a lack of research to guide a Smart City to define its smartness reflecting on disaster resilience. This paper intends to address this research gap by setting out a set of smartness criteria (with particular reference to urban (city) resilience) which should compulsorily feature in any type of Smart City that desires to be resilient. The study undertakes a systematic literature review to provide a new dimension, depth, and value to existing research discoveries. The findings are presented by structuring ten urban (city) resilience dimensions built upon six Smart City dimensions: smart economy, smart governance, smart people, smart mobility, smart living, and smart environment. Our findings make a niche contribution to knowledge by guiding Smart Cities that intend to build, enhance, and/or sustain resilience, to develop smartness criteria/smart characteristics reflecting on urban resilience. The research outcomes will be of large importance to Smart City policymakers, administrators, project managers, etc. to efficiently manage extreme events timely with optimal resource allocation and will be of specific interest to all the stakeholders (for instance, the innovators) in a Smart City ecosystem who may use the research outcomes as a decision-making tool.

Keywords: smartness; smart city; urban (city) resilience

check for updates

Citation: Samarakkody, A.; Amaratunga, D.; Haigh, R. Characterising Smartness to Make Smart Cities Resilient. *Sustainability* **2022**, *14*, 12716. https://doi.org/10.3390/su141912716

Academic Editors: Anna Visvizi and Miguel Amado

Received: 2 August 2022
Accepted: 2 October 2022
Published: 6 October 2022

1. Introduction

In light of the extent of damage caused to health and economic developments, the world after COVID-19 demanded that the future arrive faster [1]. The COVID-19 catastrophe revealed the fragility of the dominant influence on the environment and the rate at which all the developed urban systems could collapse [2]. As a result, the collective global attention has focused on expediting the use of digital technologies for improving the lives of the people, and consequently inducing a boost on Smart City development policies [3]. This could provide a rationale for the projected growth of the global Smart Cities market to USD 2.5 trillion by 2026 growing at a compound annual growth rate of 18.22% over the period of 2021–2026, amid the COVID-19 crisis [4]. Meanwhile, there is an upward trend in unplanned urbanisation and it is expected that 68% of the world's population will live in urban areas by 2050 [5]. Continuing to provide solutions to various problems associated with urbanisation including overcrowding, poor health conditions, unemployment, unplanned human settlements, degradation of the environment, resource scarcity, etc., Smart Cities keep growing, reasserting they are the future of urban development [6].

Notwithstanding the innovative Smart City solutions that upgrade the quality of life of their citizens, disasters can be inescapable, and evidently, resilience cannot be built overnight [7]. There remains the challenge to build resilience within the Smart City context as resilience-building demands a long-term strategy that takes demographic changes and all other city contextual changes into account [8]. Representing many definitions, Arup International Development and The Rockefeller Foundation [9] describe city resilience as a city's capacity to continue functioning regardless of shocks/stresses so that its citizens, particularly vulnerable communities, thrive and survive. Notwithstanding the impact of hazards, cities themselves are highly complex and adaptive systems, and thus urban (city) resilience has become a mainstream topic [10]. In the future era of uncertainties, greater development, the well-being of society and the effectiveness of complex systems amidst disasters can be sustainably achieved by synchronising the resilience concept and the Smart City concept [11]. To embed resilience within Smart Cities, fundamentally, resilience should be reflected in smartness criteria.

According to the holistic definition administered by the International Organisation for Standardisation (ISO), a Smart City is a city that expedites the provision of economic, social, and environmental sustainability outcomes while responding to challenges (like rapid population growth, climate change, and political and economic instability) by primarily improving how it works across city's disciplines and systems, engages society, uses information (and data) with modern technologies, and applies collaborative leadership methods in order to deliver better services and increase the quality of life of citizens (including residents, visitors, and businesses), without the unfair disadvantage of others or degradation of the natural environment, planning for the present times as well as the foreseeable future. While it is paramount that smartness criteria reflect disaster resilience, a review of current Smart City frameworks (or conceptual models that provide an overall understanding of what a Smart City constitutes) revealed that disaster resilience does not feature as a direct dimension [12–20]. In fact, most of the research that looked at the convergence of the two concepts of resilience and the Smart City have focused either on product development (i.e., developing a smart solution for one of a few aspects of a city) [21–24] or have been monocentric towards the technology dimension [25–27]. Several other studies that engaged with the discourse integrated resilience and Smart Cities concepts by merely linking the resilient city concept with the Smart City concept; for instance, Khatibi et al. [28] discussed a smart resilient city indicator bank which is ambitious on developing indicators. It is important to distinguish between the smart resilience city concept and operationalising the resilience concept within Smart Cities. The research undertaken by Khatibi et al. [29] exemplifies the former scenario while this study intends to operationalise resilience within a Smart City having an identity. This can be described with the example 'grapple', an apple that imparts the flavour of grapes, in which case, the Smart City is the apple that has its identity known. Accordingly, this research intends to establish a set of Smart Characteristics that imparts resilience requirements. Alternatively, the smart resilient city concept is for cities that are not established as Smart Cities, as per the grapple example: having apples together with grapes, but not as one fruit. Thus, there is a clear research gap to characterise the smartness in a Smart City reflecting on urban resilience.

According to Zhu et al. [30], there is a 'significant positive' relationship between resilience and Smart Cities, and it is important that smartness criteria in Smart Cities complement the urban disaster resilience efforts. However, the systematic expositions of smartness in a Smart City (or the characteristics of a Smart City) are unsatisfactory; in fact, Smart City is a rather nebulous term in research conducted so far. A likely explanation for the diverse approach to the subject of Smart Cities is that the concept encompasses a number of city domains including sociology, technology, ecology, etc. Given that each city's needs are not the same, there cannot be a one size fits all Smart City model. Hence, modelling the city's future with its own Smart City strategy, based on the assessment of the current condition, is an essential step a city should not leave out in the journey to become smart [31]. A Smart City's strategy involves its competitive advantage relative to other Smart Cities, and multiple other smart features that go beyond competitiveness/distinctiveness [32]. Incidentally, all Smart City strategies should harness innovations and unique smart features that offer significant potential to build, enhance, and sustain resilience in the event the advanced and complex infrastructure (especially, the ICT infrastructure) fails either due to unescapable natural disasters or a technical/man-made disaster [7].

In the absence of a well-defined set of smart characteristics, Smart Cities axiomatically pose a lot more complications than a basic city does. According to [1], having a resilience strategy in place provides Smart Cities with a strategic direction. Tzioutziou and Xenidis [33] argued that both the concepts of resilience and Smart Cities serve sustainability goals by sharing the operational framework of systems' thinking, while the systemic capacities of efficiency, adaptation, and knowledge creation are commonplace. Similar justifications have been presented in [34,35]. Therefore, it is important to construe the Smart City characteristics with particular reference to disasters without merely considering it as an add-on. The research need has been often justified based on the value of the technology dimension, validating the instrumental role of the Smart City model in operationalising resilience [36–39]. While most of the Smart City research are monocentric towards the technology aspect, this study argues that all the other inherent features including smart people, smart governance, and smart living have a significant potential to make Smart Cities resilient compared to making a basic city resilient, and therefore the resilience needs to be rooted through all the key Smart City dimensions. Therefore, this research proposes making Smart Cities disaster-resilient through their own key smartness requirements.

This research paper seeks to make a niche contribution to knowledge by identifying a set of smart characteristics/smartness criteria for making Smart Cities resilient. In other words, this research provides guidance for any type of Smart City (a planned or an established one) to define its smartness through criteria reflecting on the city's resilience efforts. While there have been limited previous attempts to integrate the two concepts of 'urban resilience' and 'Smart Cities', none of the studies looked at the importance of introducing smartness criteria/smart characteristics reflecting on urban resilience. Encouraging conceptual coherence in urban planning, this research highlights the importance of understanding the uniqueness of the Smart City as city conceptualisation and how resilience can be operationalised within that city conceptualisation; this has been overlooked by previous Smart Cities and/or urban resilience researchers. Making use of the contributed knowledge through this study, Smart Cities can build, enhance, and sustain resilience in all its dimensions. Findings of the research will be of specific interest to policymakers, project managers, administration and governing bodies in Smart Cities to define, monitor, control, and enhance the integrated smart and resilient policy priorities, ultimately managing the extreme events timely with optimal resource allocation. Further, the findings will be of large practical relevance to all the stakeholders in a Smart City ecosystem who may use the research outcomes as a decision-making tool, for instance, the innovators, including IT professionals. The outcomes of this paper will also contribute to the evaluation and development of future resilience-enhancing tools like Making Cities Resilient 2030 and other urban development agendas aimed at Smart Cities.

2. Research Method

Defining the resilience in Smart Cities commenced with a review of the urban (city) resilience dimensions using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) technique. Agreeing with Donthu et al. [40], three major review methods, including (1) bibliometric analysis, (2) meta-analysis and (3) systematic literature review were carried out for three different scenarios. Accordingly, the systematic literature review is undertaken when the scope of the literature review is specific and when the dataset (or the results of the review) is manageable to manually review. Compared to a conventional literature review, a systematic literature review allows the construction of a holistic and comprehensive review followed by a series of steps to select the most relevant studies in the search area [41]. With PRISMA, the methodological review process can be a reinforced method where an unbiased analysis can be performed in obtaining the most relevant information under a specific selection criterion. For instance, to identify the urban (city) resilience dimensions, the search strategy involved search terms, ('urban disaster resilience' OR 'city disaster resilience') AND ('dimensions' OR 'measures' OR 'categories' OR 'components' OR 'themes'), using the respective Boolean operators. That way, only the articles that presented frameworks/models on urban (city) resilience (which elaborated its dimensions, limiting readers' subjective interpretations) for the specific urban units 'cities', in the three databases Scopus, Emerald Insight, and Science Direct were selected for review. A further validation search was carried out through Google Scholar. Figure 1 illustrates the PRISMA steps in detail.

Alongside this, the Smart City dimensions were reviewed. In mapping the two sets of dimensions, it was found that the urban (city) resilience dimensions can liaise with Smart City dimensions, and that they take the shape of the same mould. Hence, each urban (city) resilience dimension was detailed to another level (sub-dimension level) against the corresponding Smart City dimension. Building upon that work, resilience was identified as one of the urban (city) resilience dimensions. To ascertain the resilience strategies, together with the identified articles from the PRISMA review, a desk review was carried out across academic research, institutional reports, and policy reports in the focus area: disaster resilience in Smart Cities.

3. Results

3.1. Urban Resilience Dimensions

Urban resilience has frequently been referred to as a multifaceted concept and is articulated through different dimensions. As an ideal way of organising scattered ideas, research on urban resilience as well as resilient cities has presented its findings under different themes/categories/dimensions. In seeking those themes/categories/dimensions (hereinafter referred to as urban (city) resilience dimensions), the initial step in the PRISMA (steps are shown in Figure 1) was the 'identification' of 2216 peer-reviewed journal articles following a broad search in the selected databases (after the duplicated articles in those databases were removed). The titles and abstracts in those 2216 articles were then screened and the articles that were limited to disaster types and urban areas (for example coastal areas) were removed. Next, the eligibility of the remaining 2209 articles was checked to employ two conditions and this involved reviewing the whole paper. With the first condition, only the studies that distinguished cities from other urban areas and considered them as the unit of focus in the study were selected, and accordingly 2202 articles were removed. This major elimination was a result of limiting the focus of this study to Smart Cities. While this is a novel study in the Smart City research area, there were no similar studies on Smart Cities. Therefore, urban (city) dimensions were limited to the city urban system and therefore urban resilience studies on any other urban system than cities (countries, regions, etc.) were excluded from the study. The resilience concept for cities has been widely stimulated by many international institutions, as cities are commonly understood as driving forces that reduce global environmental changes and facilitate sustainable development [42]. While cities are increasingly becoming vulnerable to natural disasters and climate change impacts as a result of population density and poorly planned urbanisation, building urban resilience is vital to prevent the consequent social, human and economic losses [43].

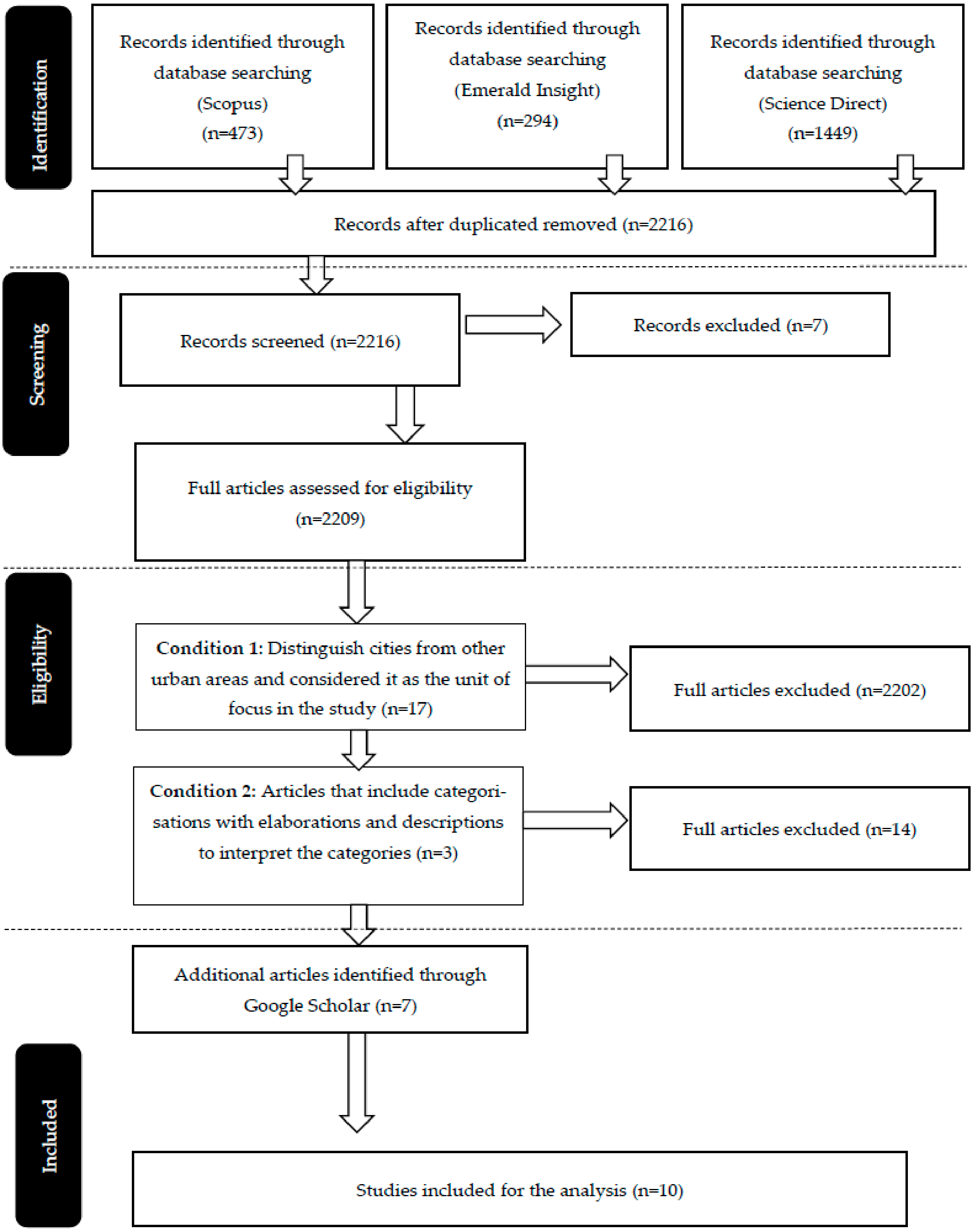

Figure 1. PRISMA steps to identify studies with urban (city) resilience dimensions.

Out of the remaining 17 articles, the articles that did not include categorisations (with elaborations and descriptions to interpret the categories) were removed. Although only three articles remained after applying conditions 1 and 2, the rest of the articles were found by searching the cited original articles in those reviewed 10 articles. For instance, the 'The Resilience to Emergencies and Disasters Index: Applying big data to benchmark and validate neighbourhood resilience capacity' article by Arup International

Development and The Rockefeller Foundation [9] article was found. The PRISMA steps are illustrated in Figure 1.

Accordingly, ten articles were analysed to investigate their outcomes in the form of distinct urban (city) resilience dimensions. Table 1 demonstrates a comprehensive list of dimensions (in the y-axis, column 1) and which of these dimensions were looked at in the analysed articles (in the x-axis/columns 2–11).

Table 1. Urban (city) resilience dimensions.

Sources **Dimensions**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**
Infrastructure	x	x	x	x	x	x	x	x	x	x
Ecosystem	x			x	x		x	x	x	x
Society/social (organisation)	x	x		x	x	x	x	x	x	x
Economy	x	x		x	x		x	x	x	x
Health and wellbeing of individuals (people)	x	x		x	x	x	x	x	x	x
Leadership and strategy (knowledge)	x	x	x	x	x	x	x	x		x
Emergency services and preparedness		x	x	x		x	x			
Cooperation			x				x			
Spatiality										x
Information, communication and technology	x	x								

a = [9], b = [44], c = [45], d = [46], e = [47], f = [48], g = [49], h = [50], i = [51], j = [52]

As Table 1 reveals, the infrastructure dimension was mentioned in all the reviewed studies. This could be due to the paradigm shift of infrastructure research from 'critical infrastructure protection' to 'critical infrastructure resilience', spotlighting the importance of infrastructure resilience [53]. Parizi et al. [54], representing the opinion of many researchers, highlighted the physical dimension of cities as one of the most important dimensions to enhance disaster resilience and resistance, as it is the city's physical system that withstands the pressures initially and functions properly to absorb the risk. Disruption to the built environment can cause dysfunction in the society at large, undermining social and economic development, given the strong link between the physical environment and human activities within the city's ecosystem [55]. In the event that the city's physical system suffers losses and defects which are impossible to repair, the post-disaster recovery process will be negatively affected [56]. Nine out of the ten studies discussed the dimensions of society/social (organisation), health and wellbeing of individuals (people), and leadership and strategy (knowledge); while ecosystem and economy were also popularly cited in eight out of the ten reviewed studies.

Arup International Development and The Rockefeller Foundation [9] categorised urban resilience based on four factors: people, place, knowledge, and organisation. Deciphering its categorisation, Arup International Development and The Rockefeller Foundation [9] describes a city that is not resilient using the terms poor quality infrastructure, social conflict, weak governance, and poverty. Categorisation by Morley et al. [44], includes factors related to the adaptive capacity or coping capacity of a community which are specific to natural hazards. Similarly, Labaka et al. [45] showed preparedness as a priority area in thematising resilience in the city, following a thorough review of development agendas such as the Sendai Framework for Disaster Risk Reduction 2015–2030 and the 10 essentials of the Making Cities Resilient initiative [57]. Classification by Labaka et al. [45] includes an infrequent dimension, cooperation, which is referred to as the combined efforts in achieving common goals for a purpose or benefits. Cooperation has been considered as part of the discussion in some of the studies reviewed in the table. Cooperation, by means of alliances with other cities, among city stakeholders, etc., is explained through the interdependencies among the components discussed in Renschler et al. [47] study. It is prominent and hence taken as a priority area that studies considered. Renschler et al. [47] framework, although named a community resilience framework, was built based on the consideration of cities as fundamental community organisational units, and their study entails systematic thinking in perceiving resilience. Notably, Elburz et al. [52] introduced the spatiality dimension, substantiating that urban resilience dimensions vary across space affecting neighbouring spatial units.

Understandably, the ten reviewed articles (following the PRISMA process) present urban resilience dimensions differently. For instance, the main category (dimension) in one study may be a sub-dimension in another study. Emergency services and preparedness is one of such dimensions that at times is presented as the main dimension while the rest are included as a sub-dimension. For example, the twelve goals under Arup International Development and The Rockefeller Foundation's [9] four categories reflect the city's preparedness for disastrous events, yet were not mentioned straightforwardly.

Following an in-depth analysis of the dimensions, extended up to the most detailed level (for instance, up to the indicator level), the ten dimensions were identified, namely: (1) ecosystem (natural environment), (2) infrastructure, (3) spatiality, (4) society and living (organisation), (5) people, (6) cooperation, (7) economy, (8) leadership and strategy (knowledge), (9) information and technology, (10) emergency/disaster management and preparedness.

3.2. Smart City Dimensions

As mentioned in the introduction, these dimensions are the smart features that go beyond competitiveness/distinctiveness in a well-thought-out Smart City strategy and they have been repeated in many conceptual frameworks. A number of studies have been conducted to identify and organise the dimensions of Smart Cities, out of which the major parts are conducted to determine performance indicators of Smart Cities [15–17,19]. Following a study of the research on the classification of domains in a Smart City, Anthopoulos [58] identified two main classifications based on the infrastructure type and city development, which are illustrated in Figure 2.

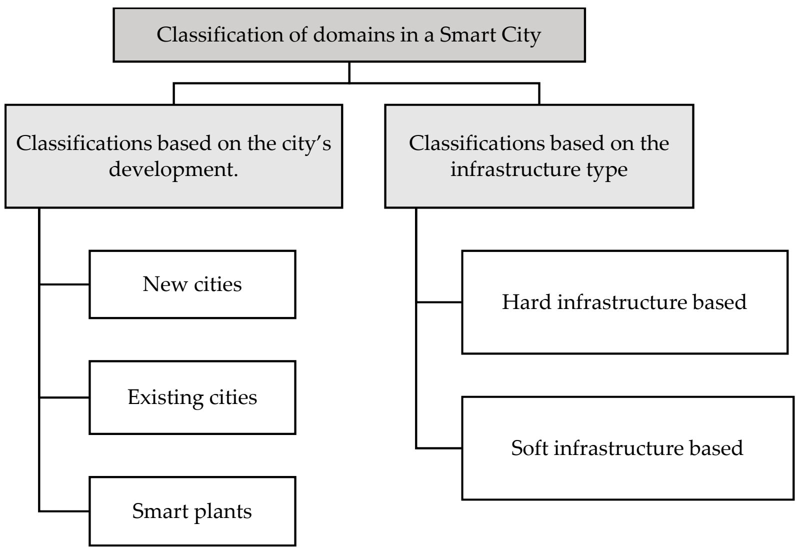

Figure 2. Classification of Smart Cities. Adapted from [58].

Figure 2 illustrates two classification criteria to analyse Smart Cities, which are based on the city's development and infrastructure type. The three categories under the classification, based on the city's development, are new cities, existing cities, and smart plants. Accordingly, a Smart City that is built from ground zero is called a new city, while an existing city refers to when innovative solutions are introduced to an existing city's infrastructure. Smart plants are projects developed from scratch inside existing cities (including new neighbourhoods, etc.). Classifications based on the infrastructure type identify two categories, hard infrastructure-based and soft infrastructure-based, which are described relating to innovations; for instance, the innovations related to Smart City's hard infrastructure systems that were made efficient with technological advancements (i.e., waste, transport, water, energy) and innovations related to the Smart City's soft infrastructure (and the people), that were made efficient with technological advancement (i.e., social and human capital, knowledge, social equity, participation, inclusion, etc.) [58].

Based on the classifications, the authors derived five dimensions to analyse a Smart City: soft infrastructure, hard infrastructure, natural environment, ICT-based innovative solutions, and non-ICT-based innovative solutions [58]. One of the early studies that holistically looked at Anthopoulos's [58] hard infrastructure categorisation can be traced back to Giffinger et al. [12] study which identified smart economy (competitiveness), smart governance (participation), smart people (social and human capital), smart mobility (transport and ICT), smart living (quality of life), and smart environment (natural resources). Giffinger et al. [12] findings have been of fundamental support for developing successive Performance Measurement Systems for Smart Cities, and have been widely cited; examples include [59,60], etc. Relating to the aspects of city life, namely industry, logistics and infrastructures, education, efficiency and sustainability, e-democracy, and security and quality, Lombardi et al. [15] have also presented smart economy, smart governance, smart people, smart mobility, smart living, and smart environment as the main dimensions of a Smart City. However, as a result of Lombardi et al. [15] framework they identified the clusters of smart human capital, smart governance, smart environment, smart economy, and smart living to classify Smart City performance indicators. Building on the projects of the European Smart City Project, the Smart City model developed by europeansmartcities [61] includes the same dimensions. Noteworthily, the quality of life, although realised as a base for many definitions of Smart Cities, was not identified as a separate dimension. Shapiro's [62] view on the quality of life dimension implies that all the actions taken with respect to the Smart City dimensions should be out of interest for raising the quality of life of its citizens.

Several other studies that have looked at the Smart City dimensions from different angles include:

- The eight clusters of factors include (1) management and organisation, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment [63].
- Smart City components by Gil-Garcia et al. [64]: (1) public services, (2) city administration and management, (3) policies and other institutional arrangements, (4) governance, engagement and collaboration, (5) human capital and creativity, (6) knowledge economy and pro-business environment, (7) built environment and city infrastructure, (8) natural environment and ecological sustainability, (9) ICT and other technologies, and (10) data and information.
- Nam and Pardo's [65] key conceptual components of a Smart City: technology factors (physical infrastructure, smart technologies, mobile technologies, virtual technologies, and digital networks), institutional factors (governance, policy, regulations/directives), and human factors (human infrastructure, social capital), etc.

Manville et al. [66] cited Nam and Pardo's [65] work and the main dimensions, and argued that these dimensions and components are distinguishable yet need to be analysed together to understand the relationship between the characteristics (dimensions) and the components.

Moreover, de Santana et al.'s [67] study, which reviewed the maturity models of Smart Cities, referred to the ISO 37122 Model: Indicators for Smart Cities as the 'international reference point for Smart Cities and as the best fit to evaluate the development of Smart Cities'. This idea was more or less similar to Mahrooqi and Backhouse's [68] findings. Huovila et al. [69] also mentioned the scope of the ISO 37122 Model and argued for the importance of using it in conjunction with ISO 37120 and ISO 37123. The main domains in the ISO 37122 Model are economy, governance, finance, education, transportation, telecommunication, energy, urban agriculture and food security, environment and climate change urban planning, water, wastewater, solid waste, population and social conditions, housing, culture, health, security, and leisure [70]. Overall, all the dimensions and domains could be presented as a recapitulation using the six dimensions of smart economy, smart governance, smart people, smart mobility, smart living, and smart environment. Therefore, it is realistic to argue that the aforementioned six dimensions realised from the systematic literature review represent the characteristics of a Smart City at all the different Smart City development stages.

4. Discussion

The resilience element within the Smart Cities remains a case to explore, as Smart Cities can be looked at through different lenses. For instance, Obringer and Nateghi [71] argued that Smart City definitions put forward with the centre of focus on technology do not reflect on social and environmental impacts on climate change, whereas Smart City concepts based on social well-being and sustainability do. The scientific literature on resilient cities and Smart Cities evidenced that both city types fundamentally aim to improve the quality of life of their citizens and enhance sustainability, even though each concept pursues that aim by following different paths [72]. Given that the two concepts go hand in hand, defining Smart City dimensions in the resilience mould also is logical. Therefore, it is argued that a meaningful smartness criterion in a Smart City should be eloquent of that city's view on disaster resilience.

Both the urban (city) resilience dimensions and Smart City dimensions of the urban unit 'city' can be mapped against each other, adding a new depth and value to the information individually presented. Noteworthily, the most cited urban (city) resilience dimension in Table 1 can be matched with the popularly cited Smart City dimensions described in the Smart City dimensions section. To prevent subjective interpretations, the elaborations and sub-dimensions for each urban (city) resilience dimension were scrutinised. As shown in Table 2, the city resilience dimensions are mapped against the six Smart City dimensions to characterise Smart Cities with particular reference to disaster resilience in cities.

Table 2. Mapping urban (city) resilience against Smart City dimensions.

Urban (City) Resilience Dimensions	Smart City Dimensions
Ecosystem (natural environment)	Smart environment
Infrastructure Spatiality Society and living (organisation)	Smart living, Smart mobility (transportation)
People	Smart people
Cooperation	Internal and external relationships and learning within/between cities
Economy	Smart economy
Leadership and strategy (knowledge)	Smart governance
Information and technology	Smart mobility (ICT infrastructure) (for Emergency/disaster management and preparedness)
Emergency/disaster management and preparedness	Emergency/disaster management and preparedness in Smart Cities

In mapping the two types of dimensions, the six Smart City dimensions, smart economy, smart governance, smart people, smart mobility, smart living, and smart environment, have been restructured. In other words, the concise units/themes (dimensions) were elaborated and detailed. The main changes include itemising Smart mobility (which includes the transportation element and infrastructure element of a Smart City) into two further categories, Smart mobility (transportation) and ICT infrastructure. It can be seen that dimensions like ecosystem (natural environment), infrastructure, spatiality, society and living (organisation), people, cooperation, economy, and leadership and strategy (knowledge) are areas upon which both the urban (city) resilience concept and Smart City concept built their characteristics/discussions. Given that the two concepts go hand in hand, the prioritisation of these attributes can be justified. Having information and technology as an urban (city) resilience dimension provides a reason to determine Smart City characteristics in reference to smart mobility (ICT infrastructure) (for emergency/disaster management and preparedness). Although 'Emergency/disaster management and Preparedness' is separately identified as an urban (city) resilience dimension, it is not commonly identified as a dimension in Smart Cities. Given that the urban (city) resilience dimension 'cooperation' represents internal and external relationships and learning, both within and between cities, being a rather underpinning attribute that supports all the Smart City dimensions, it is not sufficiently comprehensive to define smartness with particular reference to urban resilience. Based on the key observations obtained from reviewing the literature tabulated in Table 2, it can be argued that environment, people, economy, governance, urban living (including infrastructure, transportation, services, societal, and sociological aspects), and technology (ICT infrastructure) will be the key pillars on which the Smart City's disaster resilience is constructed.

Accordingly, below are the six dimensions that can holistically be seen through the lenses of both the Smart City and the urban resilience city (hereinafter called as Smart City dimension/urban (city) resilience dimension in this study).

- Smart environment/ecosystem(natural environment)
- Smart people/people
- Smart governance/leadership and strategy (knowledge)
- Smart economy/economy
- Smart living and smart mobility (transportation)/infrastructure, spatiality, society and living (organisation)
- ICT infrastructure

These six aspects will be the areas through which disaster resilience in a Smart City needs to be understood and disaster resilience efforts/strategies/plans in a Smart City need to be operationalised.

The comprehensive review of the urban (city) resilience dimensions using the aforementioned PRISMA review was next extended to another level (a more detailed level), that identified a set of key sub-dimensions for each urban (city) resilience sub-dimension. Urban (city) resilience sub-dimensions can also be termed as smartness criteria in a further detailed level operationalising resilience within a Smart City. Table 3 illustrates the subdimensions for the six urban (city) resilience dimensions/Smart City dimensions.

As aforementioned in the PRISMA review, the urban (city) resilience dimensions/Smart City dimensions in the reviewed articles can be detailed further to identify urban (city) resilience sub-dimensions/smartness criteria that reflect resilience. Accordingly, the urban (city) resilience sub-dimensions/smartness criteria that reflect resilience listed in Table 3 are the detailed subcategories of the main categories (i.e., urban (city) resilience dimensions/Smart City dimensions) of the reviewed articles. It can be observed that some of these main categories, for example, ICT infrastructure, are less detailed, compared to the main category, e.g., 'Smart living and Smart mobility (transportation)/Infrastructure, Spatiality, Society and living (organisation)'. One reason for this is the complexity of the main category. For instance, Smart living and Smart mobility (transportation)/infrastructure, spatiality, society and living (organisation) represent several aspects that need to be thematised and looked into in detail. Alternatively, ICT infrastructure is more straightforward, and the authors of the reviewed articles looked at only four aspects: reliable mobility and communication, broadband access, mobile phone coverage, and use of technology for all stages in disaster risk reduction/resilience. While it is typical to argue that ICT infrastructure could reflect on more aspects in a broader scope, it can also be argued that the four aspects listed provide an overall idea of what urban resilience attributes would reflect through the four smartness criteria within the ICT infrastructure dimension. Therefore, it can be argued that the extent to which the main category (dimension) is detailed provides an understanding of the vital aspects to be understood through 'smartness criteria that reflect on the resilience', and that unnecessary detail is omitted. Thus, it is fair to argue that a Smart City wishing to be resilient should at least try and achieve the requirements reflected in the listed 'smartness criteria that reflect on the resilience'. The below paragraphs explore this further.

Table 3. Urban (city) resilience sub-dimensions/Smartness criteria which reflect the resilience.

Smart City Dimension/Urban (City) Resilience Dimension	Urban (City) Resilience Sub-Dimensions/Smartness Criteria Which Reflect the Resilience
Smart environment/ecosystem (natural environment)	Ecosystem management Hazard risk, exposure, intensity, and Severity Environment policy Hazard Risk, exposure, intensity and severity Sustainability Protective resources Degradation Available green space per capita
Smart people/people	Collective identity and empowerment Community and social engagement and support Skills for leaning/language competency/population literacy rate Trust Satisfaction Worldview Collective action and decision making Psychosocial preparedness Communication capacity Educational equity Social character (sex, age, migration, education, employment, family composition, language, need for assistance)
Smart governance/leadership and strategy (knowledge)	Risk knowledge Community competence Effective leadership and management Policy and legislation Integrated development planning Cross-sectorial and multi-governance collaboration Learning culture/learning and dissemination/research and development Institutional character and diversity Service centres
Smart economy/economy	Sustainable economy Asset ownership Income/wealth generation Employability and employment diversity Economic diversity Population growth The financial status of the local government Economic development and prosperity Financial services Industry–employment–services and production Commercial centres Innovation Economic Relations Economic Recovery Single sector employment dependence Equality and female Employment Sector capacity Labour market Business sizes and cost of defraying

Table 3. *Cont.*

Smart City Dimension/Urban (City) Resilience Dimension	Urban (City) Resilience Sub-Dimensions/Smartness Criteria Which Reflect the Resilience
Smart living and smart mobility (transportation)/infrastructure, spatiality, society and living (organisation)	Infrastructure Critical infrastructure Reliable infrastructure and mobility Reduced exposure to disaster and fragility Land use planning for hazards Age and type of dwellings Resources to build up resilience Lifelines Shelter capacity Access/evacuation potential Transportation network Structure continuity of critical services Connection diversity with other areas (air, rail, and road) Fire stations City physical integrity (population density and balanced residential density) Spatiality Urban size Urban sprawl Urban form Society and living (organisation) Comprehensive security and rule of law Minimal human vulnerability Diverse livelihoods and employment Effective safeguards to human health and life Child and elderly services Quality of life Cultural and heritage services Place attachment Social stability Public health services Education services Religion and culture Social services (volunteers and registered non-governmental organisations)
ICT infrastructure	Reliable mobility and communication Broadband access Mobile phone coverage Use of technology for all stages in disaster risk reduction/resilience

Broadly explained, the above findings construct a relationship between urban (city) resilience sub-dimensions and smartness criteria, concluding this as 'smartness criteria that reflect on the resilience'. This can be justified through Smart City studies (these studies have not looked at the resilience element) like [12–20] which developed similar smartness criteria. Understandably, the subdimensions looking through the lens of Smart Cities set out an overall understanding of the resilience within the Smart City. Therefore, attention was largely given to set out the key urban resilience dimensions/subdimensions to reflect on smartness, and vice versa. It is fundamental to argue that the study findings (smartness criteria with particular reference to Smart City resilience) need to be either part of or reflected through the smartness criteria of any type of established Smart City that needs to be resilient.

Smart Cities characteristics/smartness criteria in this study refer to the features and attributes belonging to a Smart City that make them unique and smart compared to basic cities. These are commonly presented under the Smart City dimensions in the Smart City models/frameworks [12–20]. Extending the study, the smart characteristics/smartness criteria that are developed with particular reference to urban resilience through Table 2 were detailed in Table 3, identifying subdimensions under each of the five, Smart City dimensions.

As the next step, smart characteristics (smartness criteria required to make Smart Cities resilient) can be detailed for each subdimension identified in order to exemplify the lengthy work. Table 4 illustrates the smart characteristics/smartness criteria that are required to make Smart Cities resilient, under the Smart City dimension Smart Environment.

Table 4. Smart Characteristics/smartness criteria required to make Smart Cities resilient under the Smart Environment dimension.

Smart City Dimension	Corresponding Urban (City) Resilience Dimension	Corresponding Urban (City) Resilience Sub-Dimension/Smartness Criteria that Reflect the Resilience	Smart Characteristics/Smartness Criteria Required to Make Smart Cities Resilient	Sources
Smart Environment	Ecosystem (natural environment)	Ecosystem Management	Smart ecosystem management or technoecology	[73,74]
		Environment policy	Adoption of resilience as a policy goal should not be allowed to justify interventions that will have a negative impact on biodiversity	[75]
		Hazard risk, exposure, intensity and severity	Relocation of particularly vulnerable parts of cities could be integrated into the planning of future development/redevelopment opportunities	[76]
		Sustainability	Smart energy management (including inclusive distribution of Sustainable Energy Generation Hubs)	[77]
			Smart waste management	[78]
			Minimizing carbon emissions, Measuring and alleviating carbon emissions resulting from technology consumption, Imposing sustainability fees for visitors	[79–81]
		Protective resources	Nature-based solutions	[82,83]
		Degradation	Public policies aiming at territorial planning	[84]
		Available green space per capita	"Smart urban forest" applications	[73]

According to Vinod Kumar [85], Smart Cities developed with an aim of environmental sustainability and social well-being may have commonalities with initiatives/policies including climate change mitigation/adaptation, resilience, etc. Natural hazards become disasters when the community fails to cope with the hazardous impacts using of its own resources [86]. Natural resources like forests, wetlands, and coastal systems that serve as protective barriers or buffers have the ability to minimise the physical exposure of urban systems to natural hazards [87]. Urban green spaces offer communities a number of direct and indirect physical and mental health benefits [88]. The ecosystem-based disaster risk reduction (Eco-DRR) approach is widely recognised within global policy frameworks, like the Sendai Framework for Disaster Risk Reduction [89], Convention on Biological Diversity [90], and the Ramsar Convention on Wetlands [91]. Therefore, the smart characteristics should reflect Eco-DRR, including nature-based solutions for disaster resilience.

While it is important to incorporate resilience into environmental policy goals, it is equally important to ensure policy coherence and prevent policy conflicts, for instance when the value of ecosystem service (for example timber, carbon storage, food production, etc.) is higher than the biodiversity, policy conflicts occur [92,93]. Newton [75] suggested reaching a consensus on how resilience to be defined and measured as a solution to those policy conflicts.

Potentially vulnerable natural systems (such as low-lying islands, coastal zones, mountain regions, drylands, small islands, and developing states) poses severity risks due to hazards exposure [94,95], and these geographical features can be in Smart Cities as well. The UN/HABITAT (2001) report highlights the need for relocation and strategic planning of urban developments in such situations. Territorial planning helps minimise desertification and degradation, which are some known drivers of disaster risks [84]. While it can be observed that sustainability and climate resilience in the Smart Cities context is explained to a certain extent, direct disaster resilience efforts within the smart environment are hardly explored [79–81]. Likewise, resilience can be identified and evaluated through the other dimensions in Table 3, such as smart economy, smart people, smart living, smart mobility, and ICT infrastructure.

5. Conclusions

Given that different Smart City initiatives account for different contexts, people, objectives and relationships, it is not cogent to establish a standard set of characteristics to determine the smartness of a Smart City. However, a comprehensive set of characteristics, which is not limited to a particular type of Smart City, could possibly guide Smart Cities to ascertain their levels of smartness or develop their own smartness measures. These smartness measures should reflect on the disaster resilience of the Smart City. In other words, an eloquent set of smartness measures will help construct and strategise the resilience efforts of that Smart City. However, most of the studies on Smart Cities lack attention to disaster resilience. To narrow that gap, this study sets out the smartness criteria of a Smart City with particular reference to disaster resilience. A fundamental argument of this study is operationalising resilience within Smart Cities without merely linking the two concepts.

Following a systematic literature review on urban (city) disaster resilience, ten urban (city) disaster resilience dimensions were found and are listed below:

(1) Ecosystem (natural environment),
(2) Infrastructure,
(3) Spatiality,
(4) Society and living (organisation),
(5) People,
(6) Cooperation,
(7) Economy,
(8) Leadership and strategy (knowledge),
(9) Information and technology,
(10) Emergency/disaster management and preparedness.

Similarly, smartness in a Smart City can be looked at through six dimensions, namely:

- Smart economy,
- Smart governance,
- Smart people,
- Smart mobility,
- Smart living,
- Smart environment.

To characterise smartness in making Smart Cities resilient, the identified urban (city) resilience dimensions were reviewed with the six Smart City dimensions. This process involved detailing urban (city) resilience dimensions to the urban (city) resilience subdimensions. Urban (city) resilience subdimensions can also be referred to as 'smartness criteria (of a Smart City) that reflect resilience'. In other words, the smartness of a Smart City should be presented in a way implying its resilience. The outcome of the mapping of Smart City dimensions against urban (city) resilience dimensions advised summarising six dimensions that can holistically be seen through the lenses of both the Smart City and the urban resilience city. They include:

- Smart environment/ecosystem(natural environment)
- Smart people/people
- Smart governance/leadership and strategy (knowledge)
- Smart economy/economy
- Smart living and Smart mobility (transportation)/infrastructure, spatiality, society and living (organisation)
- ICT infrastructure

For each of the above dimensions, sub-dimensions were reorganised. These subdimensions were referred to as 'urban (city) resilience sub-dimension' or 'smartness criteria that reflect the resilience in a Smart City'. This implies that these subdimensions (when they are detailed to an extent where they represent a unique (compared to a basic city) attribute in a Smart City) allow the (re)defining of Smart City's smartness reflecting on urban resilience. Detailing each sub-dimension to 'smart characteristics/smartness criteria required to make Smart Cities resilient' involves an exhaustive list. Therefore, to exemplify the lengthy work, an extended analysis was demonstrated for the 'Smart Environment/Ecosystem(natural environment)' dimension.The extended analysis performed was summarised for the smart environment dimension, citing smart characteristics/smartness criteria, justifying with Smart City- and resilience-related studies. Findings imply that a Smart City with an aim to be resilient (regardless of the resilience maturity/knowledge) needs to define its smartness by reflecting on six key aspects (smart environment/ecosystem(natural environment), smart people/people, smart governance/leadership and strategy (knowledge), smart economy/economy, smart living and smart mobility (transportation)/infrastructure, spatiality, society and living (organisation), and ICT infrastructure. Considering the contextual challenges, resources, and priorities, each Smart City should develop their own criteria to ensure the disaster resilience measures are placed under each of the aforementioned aspects. These six key aspects not only advise a Smart City on strategizing the smart characteristics to manage disasters, but also to manage them in a resilient manner.

These findings will be of large importance to any established/proposed Smart City that desires building/enhancing/sustaining resilience, and will characterise its smartness with particular reference to urban resilience. While this study is limited to the findings of the literature reviews, the findings will be further improved with empirical data. Building upon the current findings this research will be extended to define smart characteristics/smartness criteria (required to make Smart Cities resilient) for the remaining dimensions, smart people/people, smart governance/leadership and strategy (knowledge), smart economy/economy, smart living and smart mobility (transportation)/infrastructure, spatiality, society and living (organisation), and ICT infrastructure.

Author Contributions: Conceptualization, A.S. and D.A.; methodology, A.S. and D.A.; validation, A.S., D.A. and R.H.; formal analysis, A.S. and D.A.; writing—original draft preparation, A.S. and D.A.; writing—review and editing, A.S., D.A. and R.H.; supervision, D.A. and R.H. All authors have read and agreed to the published version of the manuscript.

Funding: The work was conducted as part of Aravindi Samarakkody's doctoral programme, supervised by Dilanthi Amaratunga and Richard Haigh.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Quatrini, S. Challenges and opportunities to scale up sustainable finance after the COVID-19 crisis: Lessons and promising innovations from science and practice. *Ecosyst. Serv.* **2021**, *48*, 101240. [CrossRef]
2. Horton, R. *The COVID-19 Catastrophe: What's Gone Wrong and How to Stop It Happening Again*; John Wiley & Sons: Hoboken, NJ, USA, 2021.
3. Kunzmann, K.R. Smart Cities after COVID-19: Ten Narratives. *Disp. Plan. Rev.* **2020**, *56*, 20–31. [CrossRef]
4. The Business Research Company. *Global Smart Cities Industry*; Global Industry Analysts Inc.: San Jose, CA, USA, 2022.
5. United Nations. *2018 Revision of World Urbanization Prospects*; Population Division of the United Nations Department of Economic and Social Affairs (UN DESA): New York, NY, USA, 2018.
6. Winters, J.V. Why are smart cities growing? who moves and who stays. *J. Reg. Sci.* **2011**, *51*, 253–270. [CrossRef]
7. Arafah, Y.; Winarso, H. Redefining Smart City Concept with Resilience Approach. In Proceedings of the IOP Conference Series: Earth and Environmental Science 3rd International Conference of Planning in the Era of Uncertainty, Malang, Indonesia, 6–7 March 2017. [CrossRef]
8. De Falco, S.; Angelidou, M.; Addie, J.-P.D.J.E.U.; Studies, R. From the "smart city" to the "smart metropolis"? Building resilience in the urban periphery. *Eur. Urban Reg. Stud.* **2019**, *26*, 205–223. [CrossRef]
9. Arup International Development; The Rockefeller Foundation. In *City Resilience Framework*; The Rockefeller Foundation and ARUP: London, UK, 2015. Available online: https://www.rockefellerfoundation.org/report/city-resilience-framework/ (accessed on 1 October 2022).
10. Meerow, S.; Newell, J.P.; Stults, M. Defining urban resilience: A review. *Landsc. Urban Plan.* **2016**, *147*, 38–49. [CrossRef]
11. Ramirez Lopez, L.J.; Grijalba Castro, A.I. Sustainability and Resilience in Smart City Planning: A Review. *Sustainability* **2021**, *13*, 181. [CrossRef]
12. Giffinger, R.; Fertner, C.; Kramar, H.; Kalasek, R.; Pichler-Milanović, N.; Meijers, E. Smart Cities: Ranking of European Medium-Sized Cities. Vienna, Austria: Centre of Regional Science (srf), Vienna University of Technology. 2007. Available online: https://www.researchgate.net/publication/261367640_Smart_cities_-_Ranking_of_European_medium-sized_cities (accessed on 1 October 2022).
13. Komninos, N. *Intelligent Cities and Globalisation of Innovation Networks*; Routledge: London, UK, 2008.
14. Ambrosetti, F. Smart Cities in Italy: An Opportunity in the Spirit of the Renaissance for A New Quality of Life. ABB-The European House Ambrosetti. 2012. Available online: https://search.abb.com/library/Download.aspx?DocumentID=9AKK106103A4536&LanguageCode=it&DocumentPartId=&Action=Launch (accessed on 1 August 2022).
15. Lombardi, P.; Giordano, S.; Farouh, H.; Yousef, W. Modelling the smart city performance. *Innov. Eur. J. Soc. Sci. Res.* **2012**, *25*, 137–149. [CrossRef]
16. Merli, M.Z.; Bonollo, E. Performance measurement in the smart cities. In *Smart City*; Springer: Berlin/Heidelberg, Germany, 2014; pp. 139–155.
17. Bosch, P.; Jongeneel, S.; Rovers, V.; Neumann, H.; Airaksinen, M.; Huovila, A. Deliverable 1.4 Smart City KPIs and Related Methodology—Final. CITYkeys Project. 2016. Available online: http://espresso.espresso-project.eu/wp-content/uploads/2017/03/D4-29221.4-Smart-City-indicator-platform.pdf (accessed on 1 August 2022).
18. Australian Government. *Smart Cities Plan: National Cities Performance Framework—Final Report*; Commonwealth of Australia: Canberra, Australia, 2017. Available online: https://www.infrastructure.gov.au/sites/default/files/migrated/cities/national-cities-performance-framework/files/National_Cities_Performance_Framework_Final_Report.pdf (accessed on 1 August 2022).
19. Shen, L.; Huang, Z.; Wong, S.W.; Liao, S.; Lou, Y. A holistic evaluation of smart city performance in the context of China. *J. Clean. Prod.* **2018**, *200*, 667–679. [CrossRef]
20. Qayyum, S.; Ullah, F.; Al-Turjman, F.; Mojtahedi, M. Managing smart cities through six sigma DMADICV method: A review-based conceptual framework. *Sustain. Cities Soc.* **2021**, *72*, 103022. [CrossRef]
21. Konecny, M. Smart Solutions for Disaster Risk Reduction: Big Data Concepts for Disaster Risk Reduction (DRR). *ISPRS Int. J. Geo-Inf.* **2017**. Available online: https://www.mdpi.com/journal/ijgi/special_issues/disaster_risk (accessed on 1 August 2022).
22. Alazawi, Z.; Alani, O.; Abdljabar, M.B.; Altowaijri, S.; Mehmood, R. A Smart Disaster Management System for Future Cities. In Proceedings of the 2014 ACM International Workshop on Wireless and Mobile Technologies for SMART Cities, Philadelphia, PA, USA, 11 August 2014; pp. 1–10.
23. Nikhil, N.; Shreyas, S.M.; Vyshnavi, G.; Yadav, S. Unmanned Aerial Vehicles (UAV) in Disaster Management Applications. In Proceedings of the 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 20–22 August 2020; pp. 140–148.
24. Saidani Neffati, O.; Sengan, S.; Thangavelu, K.D.; Dilip Kumar, S.; Setiawan, R.; Elangovan, M.; Mani, D.; Velayutham, P. Migrating from traditional grid to smart grid in smart cities promoted in developing country. *Sustain. Energy Technol. Assess.* **2021**, *45*, 101125. [CrossRef]
25. Boukerche, A. Smart Disaster Management and Responses for Smart Cities: A new Challenge for the Next Generation of Distributed Simulation Systems. In Proceedings of the 2019 IEEE/ACM 23rd International Symposium on Distributed Simulation and Real Time Applications (DS-RT), Cosenza, Italy, 7–9 October 2019; pp. 1–2.
26. Sakurai, M.; Murayama, Y. Information technologies and disaster management—Benefits and issues. *Prog. Disaster Sci.* **2019**, *2*, 100012. [CrossRef]

27. Takemoto, S.; Shibuya, N.; Kuek, S.C.; Keeley, A.R.; Yarina, L. *Information and Communication Technology for Disaster Risk Management in Japan*; The World Bank: Washington, DC, USA, 2019.
28. Khatibi, H.; Wilkinson, S.; Dianat, H.; Baghersad, M.; Ghaedi, K.; Javanmardi, A. Indicators bank for smart and resilient cities: Design of excellence. *Built Environ. Proj. Asset Manag.* **2021**. *ahead-of-print*. [CrossRef]
29. Khatibi, H.; Wilkinson, S.; Baghersad, M.; Dianat, H.; Ramli, H.; Suhatril, M.; Javanmardi, A.; Ghaedi, K. The resilient—Smart city development: A literature review and novel frameworks exploration. *Built Environ. Proj. Asset Manag.* **2021**, *11*, 493–510. [CrossRef]
30. Zhu, S.; Li, D.; Feng, H. Is smart city resilient? Evidence from China. *Sustain. Cities Soc.* **2019**, *50*, 101636. [CrossRef]
31. Naydenov, K. Smart Cities—The Future of Urban Planning. In Proceedings of the 5th SGEM International Multidisciplinary Scientific Conferences on SOCIAL SCIENCES and ARTS SGEM 2018, Albena, Bułgaria, 26 August–1 September 2018.
32. Barbehön, M.; Münch, S. The 'distinctiveness of cities' and distinctions in cities: Boundaries of belonging in comparative perspective. *Urban Res. Pract.* **2016**, *9*, 37–55. [CrossRef]
33. Tzioutziou, A.; Xenidis, Y. A Study on the Integration of Resilience and Smart City Concepts in Urban Systems. *Infrastructures* **2021**, *6*, 24. [CrossRef]
34. DesRoches, R.; Taylor, J.J.T.B. The Promise of Smart and Resilient Cities. 2018, Volume 48. Available online: https://www.nae.edu/Publications/Bridge/183082/183114.aspx (accessed on 1 August 2022).
35. Baron, M. Do we need smart cities for resilience. *J. Econ. Manag./Univ. Econ. Katowice* **2012**, *10*, 32–46.
36. Abdel-Basset, M.; Mohamed, R.; Elhoseny, M.; Chang, V. Evaluation framework for smart disaster response systems in uncertainty environment. *Mech. Syst. Signal Process.* **2020**, *145*, 106941. [CrossRef]
37. Jung, Y. Smart disaster response through localized short-term cooperation. *Appl. Future Internet* **2017**, *179*, 12–21.
38. Angelidou, M. The Role of Smart City Characteristics in the Plans of Fifteen Cities. *J. Urban Technol.* **2017**, *24*, 3–28. [CrossRef]
39. Stratigea, A.; Papadopoulou, C.-A.; Panagiotopoulou, M. Tools and Technologies for Planning the Development of Smart Cities. *J. Urban Technol.* **2015**, *22*, 43–62. [CrossRef]
40. Donthu, N.; Kumar, S.; Mukherjee, D.; Pandey, N.; Lim, W.M. How to conduct a bibliometric analysis: An overview and guidelines. *J. Bus. Res.* **2021**, *133*, 285–296. [CrossRef]
41. Keong Choong, K. The fundamentals of performance measurement systems. *Int. J. Product. Perform. Manag.* **2014**, *63*, 879–922. [CrossRef]
42. Acuti, D.; Bellucci, M. Resilient Cities and Regions: Planning, Initiatives, and Perspectives. In *Climate Action*; Leal Filho, W., Azeiteiro, U., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 1–12. [CrossRef]
43. United Nations. Sustainable Development Goals: 11: Sustainable Cities and Communities. Available online: https://www.un.org/sustainabledevelopment/news/communications-material/ (accessed on 1 August 2022).
44. Morley, P.; Parsons, M.; Marshall, G.; Hastings, P.; Glavac, S.; Stayner, R.; McNeill, J.; McGregor, J.; Reeve, I. The Australian Natural Disaster Resilience Index. In Proceedings of the Conference: 5th International Conference on Building Resilience, Newcastle, Australia, 15–17 July 2017; The University of Newcastle: Newcastle, Australia, 2015.
45. Labaka, L.; Maraña, P.; Giménez, R.; Hernantes, J. Defining the roadmap towards city resilience. *Technol. Forecast. Soc. Chang.* **2019**, *146*, 281–296. [CrossRef]
46. Ostadtaghizadeh, A.; Ardalan, A.; Paton, D.; Jabbari, H.; Khankeh, H.R. Community disaster resilience: A systematic review on assessment models and tools. *PLoS Curr.* **2015**, *7*, ecurrents.dis.f224ef8efbdfcf1d508dd0de4d8210ed. [CrossRef]
47. Renschler, C.S.; Frazier, A.E.; Arendt, L.A.; Cimellaro, G.P.; Reinhorn, A.M.; Bruneau, M. *A Framework for Defining and Measuring Resilience at the Community Scale: The PEOPLES Resilience Framework*; MCEER Buffalo: Buffalo, NY, USA, 2010.
48. Khazai, B.; Anhorn, J.; Burton, C.G. Resilience Performance Scorecard: Measuring urban disaster resilience at multiple levels of geography with case study application to Lalitpur, Nepal. *Int. J. Disaster Risk Reduct.* **2018**, *31*, 604–616. [CrossRef]
49. Li, K.; Chen, Y.; Luna-Reyes, L.F. City Resilience as a Framework to Understand Smart Cities: Dimensions and Measurement. In Proceedings of the 18th Annual International Conference on Digital Government Research, Staten Island, NY, USA, 7–9 June 2017; pp. 568–569.
50. Molavi, M. Measuring Urban Resilience to Natural Hazards. *TeMA-J. Land Use Mobil. Environ.* **2018**, *11*, 195–212.
51. Chen, Y.; Huang, Y.; Li, K.; Luna-Reyes, L.F. Dimensions and Measurement of City Resilience in Theory and in Practice. In Proceedings of the 12th International Conference on Theory and Practice of Electronic Governance, Melbourne, Australia, 3–5 April 2019; pp. 270–280.
52. Elburz, Z.; Kourtit, K.; Nijkamp, P. Urban Resilience and Spatial Economics. In *Spatial Economics Volume II*; Colombo, S., Ed.; Springer: Berlin/Heidelberg, Germany, 2021; pp. 3–34.
53. Pursiainen, C. Critical infrastructure resilience: A Nordic model in the making? *Int. J. Disaster Risk Reduct.* **2018**, *27*, 632–641. [CrossRef]
54. Parizi, S.M.; Taleai, M.; Sharifi, A. Integrated methods to determine urban physical resilience characteristics and their interactions. *Nat. Hazards* **2021**, *109*, 725–754. [CrossRef]
55. Abdulkareem, M.; Elkadi, H. From engineering to evolutionary, an overarching approach in identifying the resilience of urban design to flood. *Int. J. Disaster Risk Reduct.* **2018**, *28*, 176–190. [CrossRef]
56. Godschalk, D.R. Urban Hazard Mitigation: Creating Resilient Cities. *Nat. Hazards Rev.* **2003**, *4*, 136–143. [CrossRef]

57. United Nations Office for Disaster Risk Reduction. Making Cities Resilient 2030 (MCR2030). Available online: https://mcr2030.undrr.org/proposal (accessed on 1 August 2022).
58. Anthopoulos, L. Defining smart city architecture for sustainability. In Proceedings of the 14th Electronic Government and 7th Electronic Participation Conference (IFIP2015), Thessaloniki, Greece, 30 August–3 September 2015; pp. 140–147.
59. Batty, M.; Axhausen, K.W.; Giannotti, F.; Pozdnoukhov, A.; Bazzani, A.; Wachowicz, M.; Ouzounis, G.; Portugali, Y. Smart cities of the future. *Eur. Phys. J. Spec. Top.* **2012**, *214*, 481–518. [CrossRef]
60. Schuurman, D.; Baccarne, B.; De Marez, L.; Mechant, P. Smart Ideas for Smart Cities: Investigating Crowdsourcing for Generating and Selecting Ideas for ICT Innovation in a City Context. *J. Theor. Appl. Electron. Commer. Res.* **2012**, *7*, 49–62. [CrossRef]
61. Europeansmartcities. Europeansmartcities 4.0. 2015. Available online: http://www.smart-cities.eu/?cid=01&ver=4 (accessed on 1 August 2022).
62. Shapiro, J.M. Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital. *Rev. Econ. Stat.* **2006**, *88*, 324–335. [CrossRef]
63. Chourabi, H.; Nam, T.; Walker, S.; Gil-Garcia, J.R.; Mellouli, S.; Nahon, K.; Pardo, T.A.; Scholl, H.J. Understanding Smart Cities: An Integrative Framework. In Proceedings of the 2012 45th Hawaii International Conference on System Sciences, Maui, HI, USA, 4–7 January 2012; pp. 2289–2297.
64. Gil-Garcia, J.R.; Pardo, T.A.; Nam, T. What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization. *Inf. Polity* **2015**, *20*, 61–87. [CrossRef]
65. Nam, T.; Pardo, T.A. Conceptualizing smart city with dimensions of technology, people, and institutions. In Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, College Park, MD, USA, 12–15 June 2011; pp. 282–291.
66. Manville, C.; Cochrane, G.; Cave, J.; Millard, J.; Pederson, J.K.; Thaarup, R.K.; Liebe, A.; Wissner, M.; Massink, R.A.; Kotterink, B. *Mapping Smart Cities in the EU*; European Parliament; Directorate General for Internal Policies, Policy Department Economic and Scientific Policy A: Brussel, Belgium, 2014.
67. de Santana, E.d.S.; de Oliveira Nunes, É.; Santos, L.B. The use of ISO 37122 as standard for assessing the maturity level of a smart city. *Int. J. Adv. Eng. Res. Sci* **2018**, *5*, 309–315. [CrossRef]
68. Mahrooqi, S.A.; Backhouse, J. Selecting indicators for the Smart City Pilot in Knowledge Oasis Muscat (KOM), Sultanate of Oman. In Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance, Athens, Greece, 23–25 September 2020; pp. 791–794.
69. Huovila, A.; Bosch, P.; Airaksinen, M. Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? *Cities* **2019**, *89*, 141–153. [CrossRef]
70. *ISO 37122:2019*; Sustainable Cities and Communities—Indicators for Smart Cities. ISO: Geneva, Switzerland, 2019.
71. Obringer, R.; Nateghi, R. What makes a city 'smart' in the Anthropocene? A critical review of smart cities under climate change. *Sustain. Cities Soc.* **2021**, *75*, 103278. [CrossRef]
72. Papa, R.; Galderisi, A.; Vigo Majello, M.C.; Saretta, E. Environment. Smart and resilient cities. A systemic approach for developing cross-sectoral strategies in the face of climate change. *TeMA J. Land Use Mobil. Environ.* **2015**, *8*, 19–49.
73. Nitoslawski, S.A.; Galle, N.J.; Van Den Bosch, C.K.; Steenberg, J.W.N. Smarter ecosystems for smarter cities? A review of trends, technologies, and turning points for smart urban forestry. *Sustain. Cities Soc.* **2019**, *51*, 101770. [CrossRef]
74. Allan, B.M.; Nimmo, D.G.; Ierodiaconou, D.; VanDerWal, J.; Koh, L.P.; Ritchie, E.G. Futurecasting ecological research: The rise of technoecology. *Ecosphere* **2018**, *9*, e02163. [CrossRef]
75. Newton, A.C. Biodiversity Risks of Adopting Resilience as a Policy Goal. *Conserv. Lett.* **2016**, *9*, 369–376. [CrossRef]
76. UN/HABITAT. *Cities in a Globalizing World: Global Report on Human Settlements 2001*; Earthscan: London, UK, 2001.
77. Ejaz, W.; Naeem, M.; Shahid, A.; Anpalagan, A.; Jo, M. Efficient Energy Management for the Internet of Things in Smart Cities. *IEEE Commun. Mag.* **2017**, *55*, 84–91. [CrossRef]
78. Rachmawati, R.; Imami, Q.; Nasution, L.A.; Choirunnisa, U.; Pinto, R.P.A.; Pradipa, H. Urban environmental management: An effort toward Magelang smart city. *IOP Conf. Ser. Earth Environ. Sci.* **2020**, *451*, 012029. [CrossRef]
79. Mora, L.; Deakin, M.; Reid, A. Strategic principles for smart city development: A multiple case study analysis of European best practices. *Technol. Forecast. Soc. Chang.* **2019**, *142*, 70–97. [CrossRef]
80. Naden, C. Tearing down the Carbon Footprint of Buildings with New International Standard; ISO, Switzerland. 2020. Available online: https://www.iso.org/news/ref2480.html (accessed on 1 August 2022).
81. Teoh, R.; Schumann, U.; Majumdar, A.; Stettler, M.E.J. Mitigating the Climate Forcing of Aircraft Contrails by Small-Scale Diversions and Technology Adoption. *Environ. Sci. Technol.* **2020**, *54*, 2941–2950. [CrossRef] [PubMed]
82. Cavallo, M.; Ferraro, S. Nature-based solutions for smarter cities. Bringing cities to life, bringing life into cities. *Rev. Int. Des Gouv. Ouvert.* **2020**, *9*, 93–104.
83. Brink, E.; Aalders, T.; Ádám, D.; Feller, R.; Henselek, Y.; Hoffmann, A.; Ibe, K.; Matthey-Doret, A.; Meyer, M.; Negrut, N.L.; et al. Cascades of green: A review of ecosystem-based adaptation in urban areas. *Glob. Environ. Chang.* **2016**, *36*, 111–123. [CrossRef]
84. Gabella, J.I.; Zimmermann, F.M. Territorial management, environmental degradation and resilience in rural areas of the Argentinian temperate arid diagonal. *Am. J. Rural Dev.* **2016**, *4*, 49–58.
85. Vinod Kumar, T.M. Smart Environment for Smart Cities. In *Smart Environment for Smart Cities*; Vinod Kumar, T.M., Ed.; Springer: Singapore, 2020; pp. 1–53. [CrossRef]

86. Murti, R. *Nature-Based Solutions to Address Global Societal Challenges*; IUCN: Gland, Switzerland, 2016.
87. Arkema, K.K.; Griffin, R.; Maldonado, S.; Silver, J.; Suckale, J.; Guerry, A.D. Linking social, ecological, and physical science to advance natural and nature-based protection for coastal communities. *Ann. N. Y. Acad. Sci.* **2017**, *1399*, 5–26. [CrossRef]
88. Huma, Z.; Lin, G.; Hyder, S.L. Promoting Resilience and Health of Urban Citizen through Urban Green Space. *Water Environ. Sustain.* **2021**, *1*, 37–43.
89. UNISDR. *Sendai Framework for Disaster Risk Reduction 2015–2030*; UNISDR: Geneva, Switzerland, 2015. Available online: http://www.wcdrr.org/uploads/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf (accessed on 1 August 2022).
90. The Secretariat of the Convention on Biological Diversity. Convention on Biological Diversity. Available online: https://www.cbd.int/ (accessed on 1 August 2022).
91. A Reporting Service for Environment and Development Negotiations. Ramsar Convention on Wetlands. 2015. Available online: https://enb.iisd.org/vol17/ (accessed on 1 August 2022).
92. Putz, F.E.; Redford, K.H. The importance of defining 'forest': Tropical forest degradation, deforestation, long-term phase shifts, and further transitions. *Biotropica* **2010**, *42*, 10–20. [CrossRef]
93. Ingram, J.C.; Redford, K.H.; Watson, J.E. Applying Ecosystem Services Approaches for Biodiversity Conservation: Benefits and Challenges. *S.A.P.I.E.N.S.* **2012**, *5*. Available online: https://journals.openedition.org/sapiens/1459 (accessed on 1 August 2022).
94. Parthasarathy, K.S.S.; Saravanan, S.; Deka, P.C.; Devanantham, A. Assessment of potentially vulnerable zones using geospatial approach along the coast of Cuddalore district, East coast of India. *ISH J. Hydraul. Eng.* **2022**, *28*, 422–432. [CrossRef]
95. Volkova, I.I.; Callaghan, T.V.; Volkov, I.V.; Chernova, N.A.; Volkova, A.I. South-Siberian mountain mires: Perspectives on a potentially vulnerable remote source of biodiversity. *Ambio* **2021**, *50*, 1975–1990. [CrossRef]