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Redefining the Smart City: Culture, Metabolism and Governance

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Abstract: The Smart City concept is still evolving and can be viewed as a branding exercise by big corporations, which is why the concept is not being used by the United Nations (U.N.). Smart Cities tend to represent the information, communication, and technological (ICT) industry alone without considering the values and cultural and historical profiles that some cities hold as legacies. However, the technology inherent in Smart Cities promises efficiencies and options that could allow cities to be more "inclusive, safe, resilient, and sustainable" as required by the U.N. agenda including cultural heritage. There is a notable lack of Smart City application to cultural and historical urban fabrics. Instead, the modernist new town approach has emerged under this new rubric leading to many problems such as urban decay and unsustainable car dependence. This study therefore presents a review of the literature on the nature, challenges, and opportunities of Smart Cities. A new Smart Cities framework is proposed based on the dimensions of culture, metabolism, and governance. These findings seek to inform policy makers of an alternative viewpoint on the Smart City paradigm, which focuses on urban outcomes rather than technology in isolation.

Keywords: smart cities; culture; metabolism; governance

1. Introduction

A multitude of contrasting views on Smart Cities have emerged since their proposal. Some researchers visualise the Smart City approach as a potential solution to the issues pertaining to enhanced urbanisation and the need for sustainability [1–3]. Other studies claim that Smart Cities may lead to a dystopian world regulated by technocratic governments that propel citizens to subaltern roles [4,5]. Some authors highlight the unsustainability of this novel urban concept [6]. However, despite the differing viewpoints, the concept of Smart Cities is gaining momentum around the world as shown in Figures 1 and 2, though Figure 1 suggests this may have peaked in 2015.

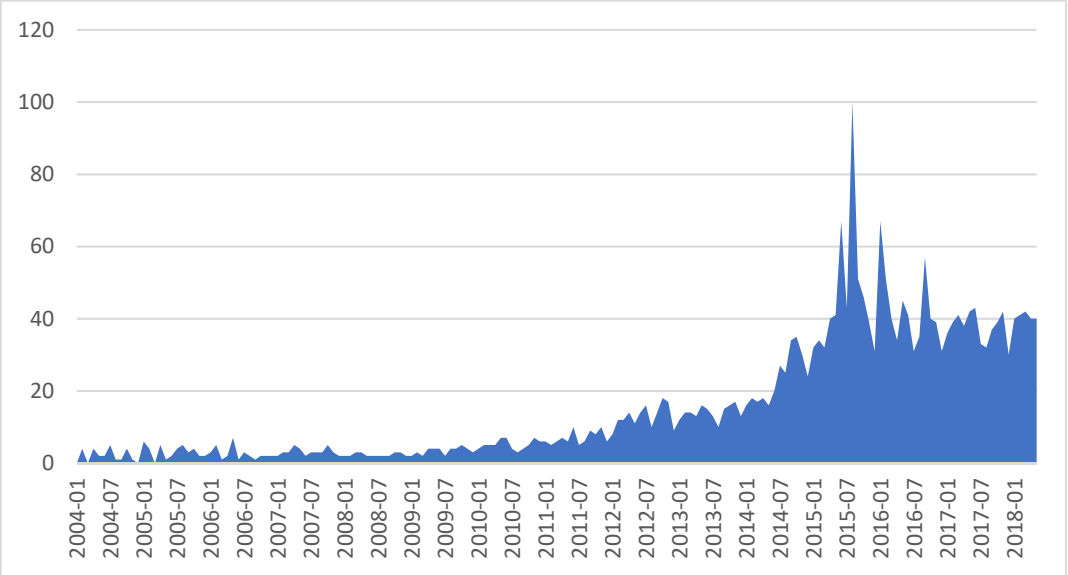

Figure 1. Relative number of hits for Smart Cities searches in Google between 2004 and 2018 [7].

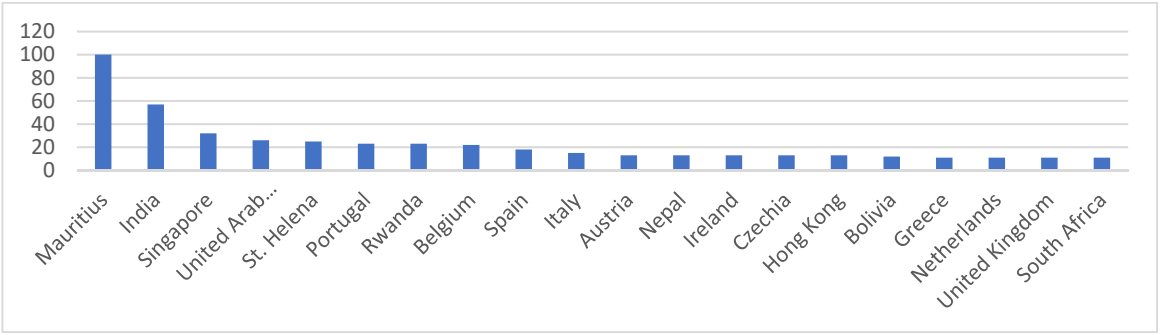

Figure 2. Countries with most searches for Smart Cities between 2004 and 2018 (Source: Google Trends Explore).

The popularity of Smart Cities projects and programs has increased across the globe, such as in India, China, U.A.E., South Korea, and even in Small Island Developing States like Mauritius [8–12]. Data from 2004 to 2018 were sourced from Google Trends [7] and the *y*-axes on both Figures 1 and 2 highlight the popularity (ranging from 0 to 100). A study of the term "Smart Cities" highlights that Smart Cities were most popular in Mauritius (Figure 2) and a case study on these smart cities is presented below.

The Smart City paradigm is associated with the Internet of Things, sensors, and big data, leading to informed and data-led governance [10,13]. Despite the rather permanent association of Smart Cities with big data computation [14,15], the notion of this paradigm is not new. Shelton et al. [16] argued that, from a historical perspective, the idea of Smart Cities, in the form of a scientific approach to study and manage the cities, is a century-old concept sought after by planners and engineers. From a big data computational perspective, Light (2005) highlighted the role of computer models in solving urbanization-related issues dating back to the post-World War 2 era, but LeGates, et al. [17] demonstrated the relative unpopularity and debatable success, if any, of such approaches.

Smart Cities are often painted as the "magic bullet" to all urbanisation issues by proponents [16,18,19]. Notably, most of the proponents of the Smart City paradigm in this digital era refer to newly built Smart Cities such as Masdar City in Abu Dhabi, Songdo and Hwaseong Dongtan in South Korea, and PlanIT Valley in Portugal [20,21]. However, these initiatives were designed in isolation and tend to operate

in silos, having a negative effect on other surrounding cities in the form of business loss and cultural erosion [21,22]. Moreover, the viability of erecting new Smart Cities is being questioned due to their restricted affordability and inability to attract inhabitants.

Before continuing this analysis on the future of the Smart Cities concept in response to these criticisms, the United Nations (U.N.) has been very guarded. The global debate about future cities has many dimensions and contributors and much has been written about the importance of the U.N. Sustainable Development Goals (SDG) for 2015–2030, which now includes an urban goal: "inclusive, safe, resilient, and sustainable cities". The urban SDG has 10 targets and 14 indicators, but throughout all these instructions for cities, none say that we should have Smart Cities, despite the increasing use of the term. The reason for this omission is apparently that Smart Cities are seen to be essentially a branding war between different multinational corporations in the information, communication, and technological (ICT) space. The solution, as set out in this paper, is for cities to adopt the SDG goal, targets, and indicators and determine how to integrate the technological opportunities that are emerging as the Smart City. Perhaps the Smart City can be revised into being more than a corporate branding war.

Some literature is pushing in this direction. Studies have highlighted the potential application of smart technologies to existing cities rather than building new cities just for an ICT branding opportunity [16]. Others have called for the use of smart infrastructures and policies with better public-private partnerships and citizen participation aiming at a more sustainable and livable city [16,23–26]. Thus, the literature is suggesting that the Smart City concept requires further investigation and values directing the outcomes of smart technologies. This is the basis of our paper; we attempt to provide some substance and direction to the concept of Smart Cities, so they are less focused on smart technologies for its own sake and more about solving the core problems in cities and their regions. Our research suggests that there are three primary issues that need attention in cities with which smart technologies should be able to assist in solving: (1) culture, in terms of how cities can build on their urban history and create the meanings behind why people and place are associated in the city; (2) metabolism, which is how the excessive resource consumption and waste production of cities can be significantly reduced; and (3) governance, which involves how can cities create new partnerships between local and regional governments, business, and community to enable urban solutions to be delivered.

As such, this study seeks to review the literature about the Smart City paradigm in terms of culture, metabolism, and governance. These findings are then used to propose a theoretical framework for the Smart City paradigm. The proposed paradigm includes a citizen-centered outcome-oriented approach rather than a technology-based, corporate-centered solution. The findings of this study add to existing knowledge about the Smart City paradigm. We further expect that this study may act as a guide for policy makers from emerging cities who aspire to leapfrog into the 21st century without the need to invest heavily in ICT, but want to work more on human capital and governance building for ICT where necessary, but not viewing ICT as a necessary and over-riding project for development.

2. Smart Cities as a Brand

It is interesting to study the perceived popularity of Smart Cities in contrast to its less popular counterparts like Sustainable Cities, and Resilient Cities. The term "Sustainable Cities" emerged with the need for cities to address sustainable development [27], whereas "Resilient Cities" emerged by planners and designers questioning how to quickly and efficiently recover from urban perturbations, often linked with climate change [28]. A comparative analysis (Figure 3) of the terms Smart Cities, Sustainable Cities, and Resilient Cities [29], shows that Sustainable Cities was more popular until late 2010. Following this, the term Smart Cities emerged as most popular though it peaked in 2015. In August 2015, the term Resilient Cities was factored at 3% and Sustainable Cities at 5% in comparison to the popularity of Smart Cities, which was at its highest point. This trend inspired questions as to how and why Smart Cities increased in popularity compared to its counterparts.

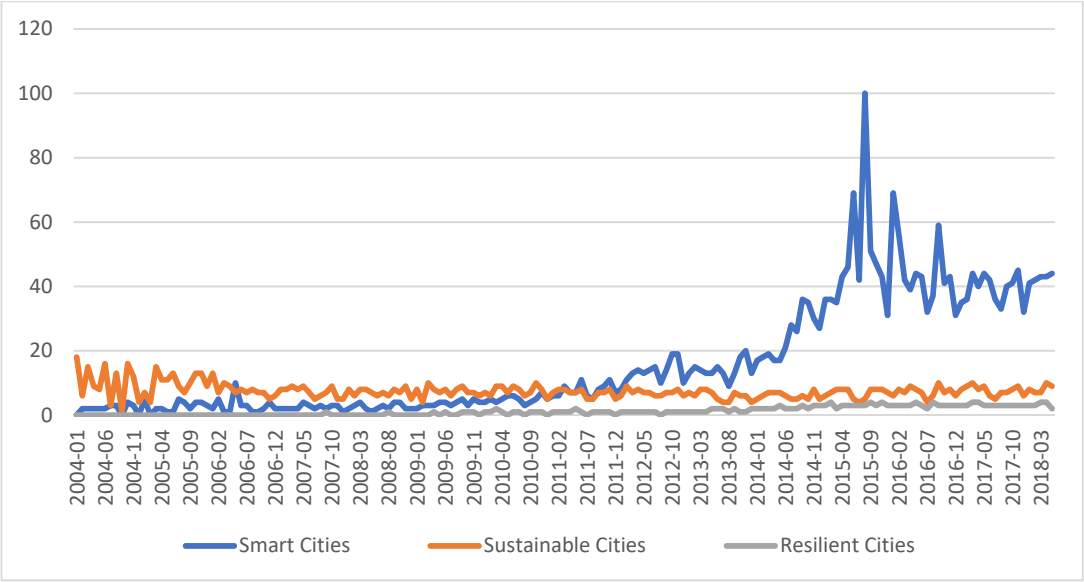

Figure 3. Number of searches for three types of cities worldwide [29].

The Smart City approach to solving urbanisation issues is not a standalone concept, being backed and supported by corporations with substantial financial resources [30,31]. A highly competitive market exists where companies compete to tap into this profitable market. In a previous analysis [32], the two main leaders are Cisco and Siemens, which were closely followed by a set of contenders including IBM, Hitachi, Microsoft, GE, Schneider Electric, and Bosch, among others (Figure 4) [32]. Sadowski [33] warned about the potential agenda of Smart City corporations in supporting a stand-alone profit-making agenda through the implementation of Smart City solutions. These commentators suggest that if cities invest in these corporations as part of their branding exercise rather than investing based on the values and visions derived from participatory approaches to governance, as outlined by Nam and Pardo [10], then smart technology may simply be a wasted investment.

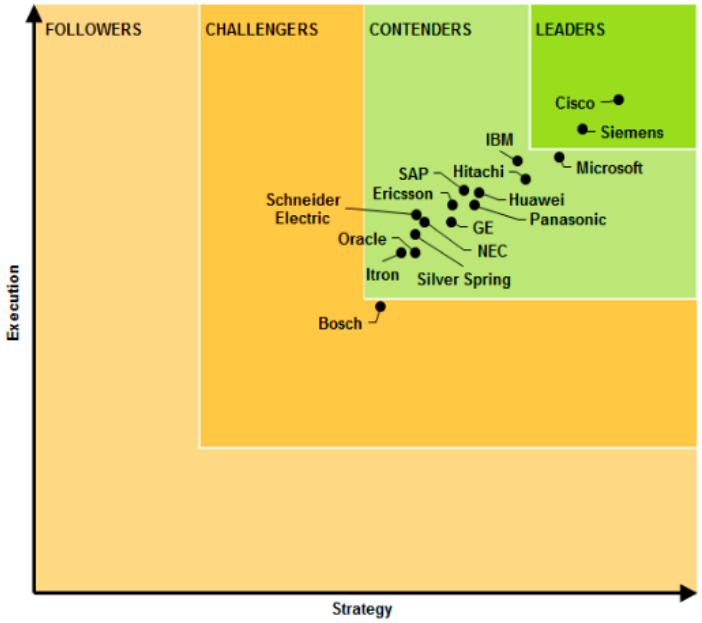

Figure 4. Corporate leaders in Smart City solution suppliers [32].

Hollands [34] reflected on the relative popularity of the term Smart City and questioned the labelling process. The author pointed out that although the application of ICT tools are a prominent facet of a Smart City, a hidden agenda appears to be intricately linked to e-governance and a promotion of "informational business interests". Later, the same author warned about the growing popularity of corporate-led Smart Cities where the prime focus is on profit alone, with little room for ordinary people to participate in the smart development and governance of the city [35]. This view has been shared by Kitchin [12] who highlighted the lack of collaboration and engagement from various stakeholders in contributing to the city in a Smart City approach. These authors are identifying how the Smart City paradigm is being viewed and proposed by corporates as a one size fits all approach, which has been the basis of a long tradition of technology policy and critique [36,37]. Such technology is feared because it begins to control us rather than us controlling it. With Smart Cities, there is legitimate fear that such a paradigm may devolve into mass biometric surveillance and a form of data-led manipulation [30]. This is easily linked to the concept of "big brother" as prophesied by Orwell [38]. It is therefore suggested there is a need for more participatory and citizen-centered revamping of cities through the Smart City paradigm [35]. So, what is a Smart City and what could it become?

3. Defining Smart Cities

Smart Cities as a term is well used in popular and academic literature, but a proper definition is still lacking [39,40]. Table 1 sets out six definitions based mostly on the reviews completed by Chourabi et al. [40] and Cocchia [41]. Often, the definitions only explain the characteristics of a "good" city, whereas others emphasize technology.

Table 1. Proposed definitions of smart city adapted from Chourabi et al. [40] and Cocchia [41].

Author(s)	Definition
Giffinger, et al. [42]	"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."
Hollands [34]	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens."
Harrison, Eckman, Hamilton, Hartswick, Kalagnanam, Paraszczak and Williams [13]	A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city"
Natural Resources Defense Council [43]	"A city striving to make itself "smarter" (more efficient, sustainable, equitable, and livable)"
Toppeta [14]	A city "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and livability."
Washburn, Sindhu, Balaouras, Dines, Hayes and Nelson [21]	"The use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient"

Table 1. *Cont.*

Author(s)	Definition
Setis-Eu (Cited in Cocchia [41])	"Smart City is a city in which it can combine technologies as diverse as water recycling, advanced energy grids, and mobile communications in order to reduce environmental impact and to offer its citizens better lives"
Dameri [44]	"A Smart City is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development"
Northstream [15]	"Concept of a Smart City where citizens, objects, utilities, etc., connect in a seamless manner using ubiquitous technologies, so as to significantly enhance the living experience in 21st century urban environments"
Hall, et al. [45]	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens"
Su, et al. [46]	"Smart City is the product of Digital City combined with the Internet of Things"
IBM [47]	"Smart City is defined by IBM as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities"
California institute (2001 cited in Cocchia, (2014 #287))	"A smart community is a community that has made a conscious effort to use information technology to transform life and work within its region in significant and fundamental rather than incremental ways"

4. Review of Smart City Frameworks

Despite an absence of consensus for a universal Smart City definition, several authors highlight key dimensions for establishing a Smart City framework (Table 2). However, just as with the definition, desired key dimensions for a Smart City vary considerably. Key indicators, such as smart governance, smart people, and smart infrastructure, are popular in the proposed frameworks but pillars of smart education and public safety seem to be less present (Washburn, Sindhu, Balaouras, Dines, Hayes and Nelson [21] and Neirotti, et al. [48]). Notably, the concept of smart living can be interpreted as a coupling with livability, where the key dimensions of livability include public safety, education, and access to proper healthcare [49]. Hence, despite not being apparent in some of the frameworks as standalone pillars, these dimensions have been integrated into technological approaches by a few commentators. Nonetheless, despite the fact that UNESCO acknowledges the central role that culture plays in city regeneration [50], only the study of Neirotti, De Marco, Cagliano, Mangano and Scorrano [48] assigns the concept of culture a prominent place in the Smart City framework. As can been seen from Table 2, the Smart City frameworks include several overlapping and non-overlapping themes, which underlines the lack of a universal framework or consensus as to the required dimensions for Smart Cities.

Table 2. Key dimensions in Smart City frameworks.

Indicator	Petrolo, et al. [51]	Nam and Pardo [10]	Chourabi, Nam, Walker, Gil-Garcia, Mellouli, Nahon, Pardo and Scholl [40]	Washburn, Sindhu, Balaouras, Dines, Hayes and Nelson [21]	Dameri [44]	Neirotti, De Marco, Cagliano, Mangano and Scorrano [48]	Balakrishna [52]	Mosannenzadeh and Vettorato [53]
Smart Governance	X	X	X	X	X	X	X	X
Smart People	X	X	X		X	X	X	X
Smart Economy	X		X			X	X	X
Smart Living/Livability	X			X	X	X	X	
Smart Environment	X		X		X	X	X	X
Smart Mobility	X			X		X	X	X
Smart Infrastructure	X	X	X	X		X	X	X
Smart Education				X		X		
Smart Healthcare				X		X		
Public safety				X		X		
Culture						X		

The most common terms used in the frameworks are Smart Governance, Smart People, and Smart Infrastructure, with most assuming that these concepts lead to better economic outcomes. These terms will be outlined to explain some of the key ideas that help frame Smart Cities.

No common consensus exists as to how Smart Governance should be defined in Smart Cities despite many countries having Smart Cities ProgramsMeijer and Bolívar [54]. Rather than just allowing as much ICT investment as possible, commentators have suggested ICT can be directed into creating a much more inclusive governance system. Paskaleva [24] highlighted the salient feature of Smart Governance as be the ability to promote a collaborative digital milieu based on promoting business competitiveness in a conducive environment of partnership and collaboration through digitally established knowledge networks. Others have shown how Smart Governance could be the key to enabling citizen engagement in a Smart City to ensure decision-making and implementation activities are transparent and explained clearly [10,24]. Moreover, Kitchin [12] highlighted how Smart Governance could become the central role of policy development based on rigorous data analysis, which forms the core of technocratic decision-making, designed to empower its citizens within a transparent framework.

Smart People is also a popular concept with commentators who suggest that smart technologies can help integrate the social and human capital within a city. Such aspects cater to a pronounced drive for life-long education and a collaborative role in social life within a creative and adaptable setup [55]. The Smart People concept merges with governance through the participative role of citizens in the urban milieu within a smart but transparent decision-making process [12]. Neirotti, De Marco, Cagliano, Mangano and Scorrano [48] further demonstrated the need to address the human capital in the Smart City not only as end-users but as actual contributors to the process of change.

Smart Infrastructure goes beyond ICT for its own sake, suggesting that infrastructure is needed to solve the problems faced by urbanisation, which must now use ICT to become more efficient and sustainable [56]. Balakrishna [52] analysed the potential of smart mobile devices in terms of built-in sensors and proposed three key indicators of Smart Infrastructure: (1) real world awareness through real-time big data capture and analysis, (2) knowledge engineering that translates big data into exploitable knowledge, and (3) interconnectivity that proposes a network of data-driven knowledge sharing across all domains of the city. This could join with the concept of urban metabolism that proposes a rigorous control of inputs within cities to achieve more rapid sustainability outcomes [49,57].

The literature in these three main dimensions invariably fails to bridge the gap between existing and new cities. The whole impetus of the Smart City is toward establishing new cities rather than existing ones with existing infrastructure and often rich and different urban fabric. This process is in the tradition of modernist town planning since the 1930's, which aimed to create a singular, modern urban fabric either replacing old cities or creating new towns and suburbs [16]. This geographical tension between building new smart cities or regenerating existing cities through application of smart solutions requires further analysis [16].

5. Dichotomy between Bringing Smart Technology to Old Cities or Building New Cities: A Case Study from Mauritius Smart Cities

Smart Cities are usually created in new locations on the outskirts of present cities in the modernist tradition of New Towns. The emergence of new cities in close locality to existing cities poses the risk of encouraging urban sprawl and the resulting automobile dependence, fossil fuel consumption, and unhealthy lifestyle [57–59]. Literature is scarce about how to apply smart technology to existing cities and the literature seems to uniquely favor the emergence of new cities through a series of off-the-shelf plug and play solutions offered by specialised information technology (IT) companies as elaborated above.

Mauritius, for example, has established several Smart Cities on the outer edge of its historic capital city, Port Louis. Figure 5 showcases the planned Smart Cities in a 10 km radius from the Central

Business District of Port Louis. Out of the nine planned Smart Cities, five have gained approval from government and are being built, while four are under evaluation.

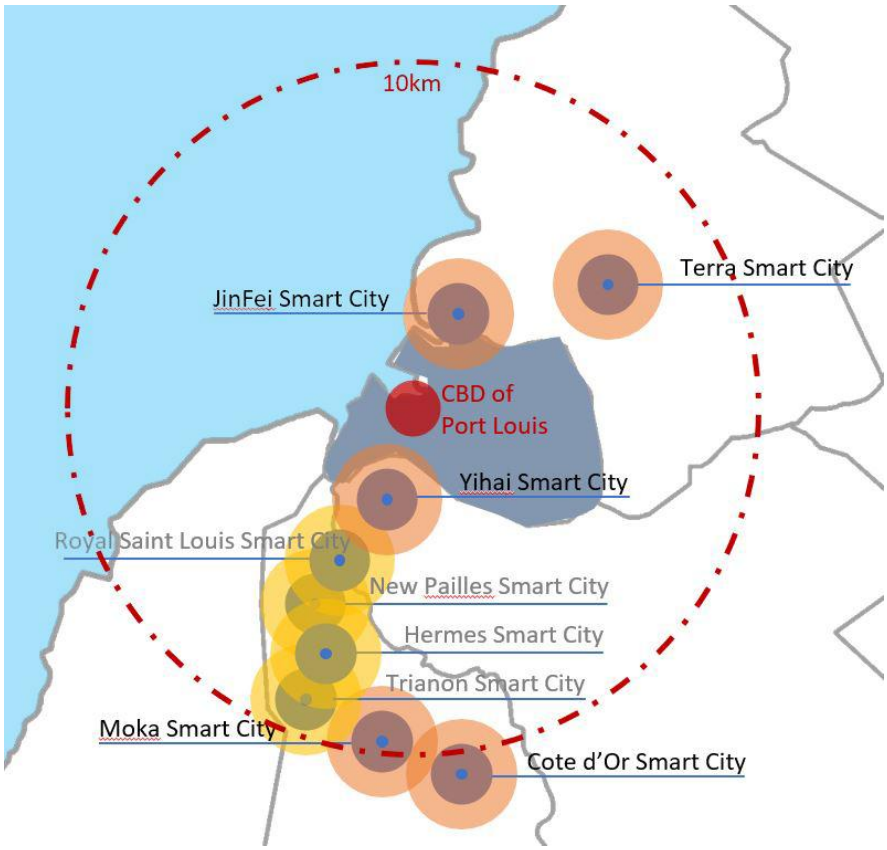

Figure 5. Planned Smart Cities in a 10 km radius from the Central Business District (CBD) of Port Louis, Mauritius.

Figures 6–9 show the modernist architectural language adopted by Smart Cities to support a heavy branding by competing companies.

Figure 6. Cote d'Or Smart City, Highlands, Mauritius [60].

Figure 7. Jin Fei Smart City, Baie du Tombeau, Mauritius [61].

Figure 8. Yihai Smart City, Pailles, Mauritius [62].

Figure 9. Moka Smart City, Moka, Mauritius [63].

These new Smart City towns are part of the long history of New Towns created as part of the modernist tradition [64]. This tradition, with its roots in Le Corbusier's Congrès Internationaux d'Architecture Moderne (CIAM) movement, aimed to start from a clean slate and use modern high rise and freeway architecture to create a new kind of urban experience. The problems that developed from this included automobile dependence and urban decay in the old cities where development declined [16,65,66]. Many cities have been moving away from the modernist urban paradigm, but the Smart City movement is at least in part trying to revive it. This may also be because the emphasis on ICT alone provides a vacuum in planning and policy values, enabling any agenda to be set, as long as it is "smart". This paper suggests that Smart Cities will fail to deliver better cities unless clearly driven by an agenda that can explain the definition of a "better" city.

Portions of the Smart City paradigm are realising that new technology needs to not only set an agenda as outlined here, but must be able to recognise, respect, and regenerate the various parts of the urban fabric. India, for instance, has pledged to build 100 Smart Cities based on four different strategies: (1) retrofitting existing facilities to achieve Smart City objectives, (2) redevelopment of existing areas by replacing amenities better aligned within a Smart City framework, (3) greenfield development aiming at building new smart areas in vacant areas, and (4) pan-city development that proposes technology applications to existing city networks [67]. However, according to Bosch [68], the 100 Smart Cities mission is flawed as it focuses on business opportunities by international Smart City developers, such as IBM, that want to create a market estimated to be worth $1.56 trillion by 2020 [68]. Bosch warns against this trend in Indian urban realities and instead suggests a focus on cultural awareness of the urban fabric that exists and the potential mushrooming of "smart enclaves" within cities [68].

This same approach was proposed by Shelton et al. [18] who postulated that focusing on the application of a Smart City paradigm in more mature cities rather than building new cities will be more productive. These authors discussed the nature of big data-driven governance that should be analyzed within the historical and spatial boundaries of the actual city. This approach caters to people rather than forcing the people to cater to the Smart City vision. However, this focus would still require new kinds of governance [69].

Although building from a fresh start is perhaps easier, though usually t around three times more expensive than regenerating old areas [57,59], Smart City technology can be adapted to existing cities. This will need to be tailored to address contextual and governance challenges, but all issues in urban regeneration lend themselves to being more easily solved by using Smart City technology [15,70]. To create more appreciation and accountability in the Smart City paradigm, a simpler framework is proposed that can be applied to new and more mature cities and indeed all forms of urban fabric to show how a Smart City can achieve more of the broader goal specified in the U.N. SDG of creating "inclusive, safe, resilient and sustainable" cities.

6. Creating a Smart City Framework

The most conspicuous aspect of the proposed Smart City framework set out in Figure 10 is the absence of smart ICT-based infrastructure as its own dimension. This has been shown throughout the paper as a major problem and its lack of a values base has undermined the economy of many cities, as this has led to isolated Smart City modernist New Towns. The model being proposed in Figure 10 has the values base firmly set in the three driving forces: culture, metabolism, and governance. These values provide a focus for the Smart City to address the issues of urbanization [16,18,19] and to welcome urbanization as an essential condition for growth [71]. These values also allow policy-makers to distinguish between different types of cities and different urban fabrics and to highlight the need for different developmental agendas [57,64]. This approach is far from the "one-size fits all, modernist model presented by Smart City suppliers, suggesting that smart infrastructure, as an isolated item, places an additional financial burden on the city's governing bodies despite most cities struggling to find finance for their multiple socio-economic problems [65]. Instead, this approach applies smart

infrastructure to each of the three fundamental values of a city in order to show how smart culture, smart metabolism, and smart governance can be created.

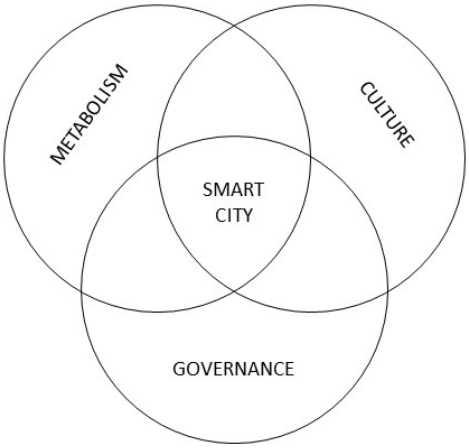

Figure 10. The proposed Smart City framework supporting dimensions of Culture, Metabolism and Governance.

This model places the human values dimension at the core of urban Smart City policy. It is able to replace the kind of trickle down approach that Smart City policies have been using based on a belief that ICT will somehow automatically lead to the right outcomes and avoid the wrong ones. This is likely to lead to the fulfilment of the U.N.'s SDG agenda rather than viewing the agenda as secondary to new smart technology. Each of these three factors overlap in their ability to create a better notion of a Smart City.

6.1. Culture

In urban terms, culture can include urban cultural heritage [66] or urban creative industries [67] or can also simply mean a focus on the needs of the citizen by promoting livability within cities. All three elements are considered part of culture in this framework and all three can benefit from ICT if constructed to do so. This would therefore create something that could be called smart culture.

All three dimensions shown in Figure 10 provide possible viewpoints for urban policy. Urban policy can be viewed through a cultural dimension [50,68,69] and this approach is recognized by UNESCO [70], which views cities as cultural microcosms that cater to innovation, creativity, and economic development while ensuring access to the highest standards of healthcare, education, and social facilities [48,72].

Cultural heritage is an industry that can contribute significantly to the economic growth of a city as millions of visitors are drawn to cultural events, art galleries, monuments, and even historical centers and museums [66]. The potential that cultural heritage represents must be revamped by adopting pervasive solutions that lead to smart cultural heritage [66]. The application of smart technology to cultural heritage in cities can optimize the economic potential of these unique resources. For instance, implementation of innovative museum visitor guides within a novel ICT-based approach may enhance the user experience when visiting museums, any gallery, or even walking around historic cities. The same role of culture as a driver for sustainable development has been proposed by Rutten [67], who dissected the role of culture as a pillar of urban regeneration and highlighted the key role of creative industries in successfully revamping urban areas. This author defined creative industries as a medium of communication that conveys specific messages. These messages could be oral, auditory, or visual, originating from both individual creativity or as a result of group dynamics. Moreover, citizens are keen to acquire these creative goods or services for their meanings, experiences, or emotions they inspire in their users [67,73]. Creative industries have three main pillars: (1) arts, crafts,

and cultural heritage; (2) media and entertainment industries; and (3) creative business-to-business services [67]. Cultural and creative industries form the pillars of the cultural economy, which, in some countries, contribute significantly to economic development and jobs creation [73]. Such activity can be assisted by the use of ICT to increase its significant in any city's economy.

Culture-led urban rejuvenation is a prominent facet of cities in China [74], Europe [75,76], South Korea [77–79], Japan [80], South Africa [81], Taiwan [82], and Latin America [83]. Wang [74] highlighted that culture can play an important role in the rejuvenation of decayed urban areas. One example is the Guggenheim Museum in Bilbao which, despite attracting negative publicity due to the relatively hefty initial investment, exceeded expected return on investment and is successfully contributing to the rejuvenation of a previously decaying urban area [84]. However, the author warned that using the Guggenheim Museum as a culture-led policy can be highly risky. The success of the museum was not entirely based on its signature architecture but was also due to the continuous attempts of the Museum Director to make the project appealing to visitors [84]. ICT is part of this vision. Broader urban regeneration, through cultural industries with ICT assistance, requires partnership with local government [85]. Much remains to be completed to fully access the potential of culture-led urban regeneration and to determine how the Smart City technologies can contribute to how it shapes the future of old urban fabric [86]. Demonstrations are needed to create smart cultural heritage that is respectful of urban culture.

The overlap between smart culture and the other major parts of the Smart City framework are quite obvious. Metabolism changes driven entirely by technology will not work unless they are also part of an urban culture that must occur in both the old and new parts of cities [57]. This approach to cities is also coupled with resilience [87], Allam and Jones [88] showed that resilience must be integrated with local challenges and the impacts of climate change, which are part of an urban culture. These situations also highlight the essential role of governance in the pathway to the implementation of culture as an urban policy in a Smart City.

6.2. Metabolism

Metabolism is essentially a biological term that traces how materials and energy flow through a living system to create all the activities of life and then convert the materials into waste and the energy into waste heat [89]. Metabolic reactions ensure life is maintained and optimized. Urban metabolism builds on this analogy by showing how the resource consumption inevitably converts into waste [90], but an Extended Metabolism Model by Newman [49] showed how livability had to be integrated with the flow of resources and that the goal of cities should be to simultaneously reduce their metabolism and increase their livability. Achieving this goal can be considerably helped by ICT providing smart systems for energy efficiency, renewable energy, and waste management [57]. Data on the decoupling of Gross Domestic Product (GDP) growth and the decline in the use of fossil fuels provides evidence that these technological systems are beginning to work [91].

However, some suggest that cities are becoming a bigger part of the problem rather than part of the solution. Kennedy, et al. [92] stated that many cities are showing an increasing trend in their consumption of water, energy, and materials, leading to changes in ground water levels, depletion of resources, building up of noxious substances, and urban heat islands effects [92]. A better understanding of energy and materials flow is thus needed. To this end and to cater to the lack of high resolution data at the household level and in real-time, the introduction of sensors was suggested by Shahrokni, et al. [93]. These authors proposed an approach called Smart Urban Metabolism [94]. This model for assessing metabolism within cities has three key approaches: (1) the use of sensors at all levels, such as smart meters; (2) real-time data flow streams toward information management system (IMS) for analysis; and (3) informing different stakeholders about the actual status of metabolism through the use of pervasive technology, such as smartphones and computer terminals. Smart Urban Metabolism also provides mitigating measures to control the flow of energy, materials, and wastes.

In fact, ICT integration within cities can increase the efficiency of data analysis [95]. The informed solutions that are proposed often have a mitigating effect on sustainability issues [96].

This kind of temporal and spatial resolution can only be made possible within an ICT-infused infrastructure provided by Smart City paradigms [93]. This approach aligns with the proposal of Zaman and Lehmann [97] for promoting a Zero-Waste city concept on the pathway to sustainability.

Newman et al. [98] developed an urban fabrics theory that highlights the need to consider urban policies for three different fabrics: the old walking city, the transit city (from the late 19th century to the mid-20th century), and the automobile city (from the mid-20th century). Each have different metabolism and livability characteristics and hence need different ICT approaches to provide assistance during the transition to the next decarbonized economy, while maintaining economic productivity and human livability [99].

Smart metabolism, as mentioned here, overlaps with culture and governance to provide direction for these resource and waste technologies required for a Smart City, which also includes clear improvements in livability. Demonstrations of how Smart Cities can use smart metabolism are needed in all parts of the city, from its old centers, through medium density corridors, to new suburbs on the fringe.

6.3. Governance

One essential component of the proposed Smart City framework is governance, which is the institutional factor that transcends data analysis and management to encompass appropriate change Dixit [100]. Governance forms the central core whose responsibility is to connect citizens with businesses and the living environment to foster a culture of innovation and sustainable economic development [10,101]. Parycek and Pereira [102] highlighted the essential dimension added by smart governance to the Smart City paradigm. We outline below the implications of smart governance on the Smart City paradigm.

Smart governance is not a standalone entity only for ICT applications, but is driven by data and collaboration among all stakeholders of the city [102]. The notion of smart governance needs to be applied within an appropriate legal framework interlinked with values, protocols, and human capital showcased within the right ICT infrastructure [102]. Shukla [103] cautioned against the use of ICT devices on their own and proposed further probing into a human-centered sociological study to gain insight into the exact implications of adopting specific smart technologies for specific purposes. Such an endeavor caters to a more effective smart system of governance [103].

Walravens and Ballon [104] pointed out the challenges faced by city governance seeking to cope with fast-changing digital business platforms. These authors called for the need for good governance in Smart Cities to promote the shared interests of the city while creating accountability and trust. This approach promotes the protection of citizens' rights while adopting new technologies that can help solve multiple problems. Technology governance adds to the role of governance in Smart Cities and improves the transparency in data flow and decision-making, while ensuring that no social gaps occur in the access to shared data [104]. The role of governance further includes protocol regulation to facilitate communication between different stakeholders within the city and the external world [10,105,106]. Moreover, governance measures can encourage policies where citizens can bring value to cities through their ideas for the future or by responding to urban development [106]. This forms the essence of participatory governance [105] or citizen-centric governance [10]. Smart planning systems can enable greater visualisation of the future and create greater understanding of the implications in different scenarios [107].

The rationale behind the Smart City paradigm is frequently aimed at sustainability [1,108]. To this end, Adger, et al. [109] and Newman and Kenworthy [57] stressed the need for environmental governance that revolves around integrating economic, social, and environmental dimensions. These authors recognized the participatory role of citizens and political representatives in environmental decisions. They also underlined the complexity of the decision-making processes

for environmental issues and called for the scrutiny of governance outcomes, eventually leading to contextualized policies. ICT can help in each of these areas if it serves the processes rather than being outside.

Smart governance has many overlaps with smart metabolism and smart culture. Governing bodies are responsible for the overall implementation of metabolism and cultural protocols to ensure the smooth running of operations while integrating the ICT dimensions proposed in Smart City paradigms. There is a need to use an appropriate governance foundation, such as the Multi-level Perspective Theory, which offers multiple entry points and allows governing bodies to choose the level at which to introduce the socio-technical change to optimize integration [110]. A Smart City, like any city that needs to change, is likely to require systemic transitions that involve a co-evolution of factors like technology, culture, and governance. As such, a multi-level perspective enables the analysis of these interactions, which then highlight drivers, potential hindrance, and implementation pathways [111].

7. Urban Economy and Smart Cities

The proposed framework highlights that the economic dimension does not require its own focus in the development of Smart Cities, but underlies each of the three dimensions of smart culture, smart metabolism, and smart governance. If, however, Smart Cities progress through isolated ICT branding exercises, economic development may be undermined, just as isolated technologies for energy or transport can undermine cities if not considered as part of the sustainability agenda [112].

The New Urban Agenda that was adopted by the U.N. in 2016 suggests that the urban economy's role is the promotion and consolidation of policies and strategies essentially aiming to develop the economic potential of a city in terms of wealth, job opportunities, and economic resilience. However, the focus aims at economic growth to create equal opportunities for its citizens while empowering municipalities to create a conducive environment for increased work opportunities within an enhanced livability setup [113]. Without this kind of "inclusive, safe, resilient, and sustainable" economic growth, cities can collapse [57,114,115].

Harrison and Donnelly [116] reflected on the rise in popularity of the Smart City paradigm in the late 2000s. These authors concluded that the actual drive toward adopting smart technology, such as those proposed by the technology giant corporations, was not entirely focused on economic outcomes, but rather attempted to achieve a more simplistic approach to economic development. This may undermine economic development. Such a cognizance occurred in the post-economic crash of 2008–2009 when administrative councils of cities realized that, due to the digital culture of the Internet and globalization, they were in direct competition with peers from all over the world [116].

Economic performance is intricately linked to political, institutional, and legal environments. These three dimensions compose the core governing infrastructure of a country or a city [117]. We further postulate that governance infrastructure influences the investment macrocosm, which is so important in providing better opportunities for economic growth. Moreover, Dixit [100] defined economic governance as the intricate interconnectivity between social and legal institutions that back economic activities and transactions, principally by providing the right framework to: (1) protect property rights, (2) enforce contracts, and (3) promote collective action to maintain organizational infrastructure. The only method to achieve this conducive environment is through good governance [100]. Thus, unless we have a framework for policy making that places ICT into smart governance, smart metabolism, and smart culture, we are unlikely to obtain the best economic outcomes.

This approach offers insights on every aspect of economic development. For example, smart metabolism offers insights into the energy usage, waste generation, and water use transitions within different parts of the city, while also increasing the livability for urban residents and city users. Livability also promotes city growth [118,119]. Giap, et al. [120] highlighted the ability of livability and

culture in cities to attract human capital and investors, leading to a positive contribution to a resilient and robust economy that also enhances socio-cultural innovation and lifestyle.

Several key strategies have been proposed to achieve these inclusive and sustainable economic development goals for cities, such as those outlined by the U.N. For instance, there is a particular emphasis on participatory and collaborative governance of local authorities with regional, national, and even key strategic international partners to promote tailor-made policies that encourage innovative sustainable economic solutions [121,122]. Productivity and competitiveness are two major foci of such strategies. These can be further enhanced if they emanate from capacity building using the city's own resources. UN-Habitat [123] further emphasized the need for empowering youth in cities and guiding them toward developing entrepreneurship attitudes based on proven business models adapted to their needs within the city. Such business opportunities must be provided by strategic partners, where strategies can be oriented toward increasing productivity and decreasing unemployment. In every case, a role for smart technologies exists to assist in their achievement.

New smart technologies and systems are being developed for transport with a strong emphasis on autonomous vehicles; however, applying these technologies to better uses is possible by creating new transit systems along corridors and in local shared mobility transit that enables much broader social and environmental goals as well as the productivity gains from the implementation of new technology [124]. A Smart City with considerably improved economic outcomes could emerge with almost no need for private vehicles and improved accessibility if the values of the city were allowed to drive these smart technology options.

Siegel and Kariuki [124] showcased an example from Kenya where the government, in order to address sustainable development and access to adequate public services, encouraged partnerships between distinct economic states, governments, and U.N.-Habitat. The collaborative endeavor depicted the numerous benefits for cities struggling with economic resilience and sustainable development. For instance, the U.N.-Habitat/Kenya partnership demonstrated the need to develop an objective baseline that offered clear guidelines on dimensions that had to be monitored. This approach prevented biased decision making and ensured the integrity of the sustainability of the projects being proposed. Moreover, the collaboration promoted sustainable exploitation of the inherent resources of each county. For Homa County in Kenya, this was in the form of technical expertise and latent financial resources that could be optimized through a multi-level regulatory procedure. These control mechanisms provided feedback to governing bodies about how to anticipate and recalibrate business maneuvers to ensure optimal gains [124]. Although only using basic ICT technology, the same kind of approach to economic development is likely to work in the Smart City framework.

Another example is the Mauritian model of economically incentivizing urban development [125], which underlines how a series of fiscal incentives aimed at the private sector can effectively catalyze attracting both investment and talent. The Smart Cities Scheme [126] proposed by the Government of Mauritius (outlined in Figures 6–9) successfully attracted new developments in greenfield sites and ensured that each emerging Smart City hosts their own niche innovative cluster. This secured Smart City promoters with their own economic model by reducing competition between Smart Cities [22,125,126]. The economic success of Smart Cities in Mauritius, however, as outlined in this paper, require stronger emphasis on smart culture in the old city areas, not just in greenfields. Smart metabolism (as in all cities) and smart governance should outline how ICT can be a part of multiple economic development strategies, instead of being a stand-alone ICT policy.

The critique of Smart Cities has also focused on the limited methodologies used to report investment returns from Smart City technologies [104]. All urban policies are meant to address urbanization issues and to improve the livability of cities, but Smart City policies are, for some reason, often left out of such transparent accountability [15]. This may undermine the Smart City concept as economic accountability will ultimately be needed to shape any policy for the future of cities.

8. Conclusions

The notion of Smart Cities is a major part of how cities across the globe are approaching the future. In the academic literature and practice, Smart Cities are generally focused on heavy investment in state-of-the-art ICT, especially ICT-based sensors, to offer big data that will be analyzed in real-time to lead to informed decision-making. However, some studies have warned about the branding exercise being laid out by Smart Cities' suppliers that are essentially promoting a one-size fits all model without considering broader economic development policies. The history of cities often includes technological change being allowed to build the future as a stand-alone policy and finding that serious issues emerged [36,37]. As such, this study proposed a new framework to optimize the use of ICT as part of the solution to problems rather than causing additional challenges.

The proposed framework aimed at redefining the Smart City paradigm by focusing on the three pillars of metabolism, culture, and governance. Metabolism provides a better understanding of material flows and may be the pathway through which new smart technology can be introduced at the household level, as well as helping to address the massive issues of climate change, traffic, recycling, and other environmental issues, while simultaneously improving livability and economic performance. This would then be known as smart urban metabolism. Cultural and historical attributes of cities create unique and special urban areas for local communities and visitors. Culture can also be a special driver for regenerating economic growth; ICT can enable uniqueness and special qualities to be generated as part of a smart culture approach. Governance shapes economic development in cities and ICT needs to be part of the general approach to improving inclusivity while providing the city with opportunities to change; this would be smart governance. These three elements of a good city are interacting and need to be addressed together.

Thus, the proposed framework provides an alternate vision of a Smart City that goes beyond ICT, allowing it to be a part of the values that cities need to create their future.

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